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Population Trends and the Koala Conservation Debate
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PHILLIPS, STEPHEN S.*

Australian Koala Foundation, GPO Box 9899, Brisbane 4001, Australia
*Current address: School of Environmental and Applied Science, Griffith University, Gold Coast Campus, PMB 50 Gold Coast MC, Queensland 4127, Australia, email stephen.phillips@mailbox.gu.edu.au
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Outline

Graphics

Abstract:^

A critical issue affecting the long-term management of koalas is their perceived conservation status. Koalas still occur in many areas throughout their historical range, but numbers of animals are estimated to vary from <100,000 to at least one order of magnitude higher. Complex factors limit free-ranging koala populations, including food tree preferences, history of disturbance, and *Chlamydia* infection, all of which make longer-term population trends of many populations difficult to predict. Lack of consensus regarding the size and viability of remaining populations and regarding the extent of and reasons for decline, or overabundance in some instances, hinders the conservation task. A reappraisal of population trends suggests that, notwithstanding localized management issues in Victoria and South Australia, overall the species is "vulnerable" on the basis of current World Conservation Union criteria. Recommendations for more effective conservation of koalas include (1) acknowledging the legitimacy of differing perspectives, (2) recognizing the uncertainty and assumptions inherent in population estimates and trends, (3) applying greater rigor and developing better standards for monitoring population trends, and (4) being cautious in assigning conservation status to national, state, and regional populations.

Resumen:^

Un aspecto fundamental del manejo a largo plazo de los koalas es la percepción de su estado de conservación. Los koalas aún existen en muchas áreas de su rango de distribución histórico, pero las estimaciones del número de animales varía entre valores menores de 100.000 hasta por lo menos un orden de magnitud mayor. Entre los factores complejos que limitan las poblaciones de koalas se incluyen una preferencia por determinados árboles como alimento, una historia de perturbaciones, e infecciones con Chlamydia. Todos estos factores dificultan la predicción a mayor plazo de tendencias poblacionales. Una falta de consenso en cuanto al tamaño y la viabilidad de poblaciones remanentes, el grado y las razones de la disminución y, en algunos casos, la sobreabundancia, dificultan las tareas de conservación. Sin embargo, una evaluación de las tendencias poblacionales sugiere que, a pesar de los aspectos de manejo localizados en Victoria y el Sur de Australia, en general, la especie se considera "vulnerable" en base a los criterios actuales de IUCN. Las recomendaciones para una conservación más efectiva de koalas incluyen: 1) reconocer la legitimidad de diferentes perspectivas, 2) reconocer la incertidumbre y conjeturas inherentes a las estimaciones poblacionales y de tendencias, 3) aplicar más rigor y desarrollar normas mejores para el seguimiento de las tendencias poblacionales, y 4) ser cautelosos al asignar un estado de conservación para poblaciones nacionales, estatales y regionales.

Introduction^

Koalas have endured a paradoxical relationship with Europeans. Hunted to near extinction <70 years ago (Pratt 1937), koala populations have arguably recovered, only to suffer fragmentation and alienation of their habitat throughout much of eastern Australia (Hume 1990; Pahl et al. 1990). Community interest in their perceived plight and the long-term security of free-ranging populations has resulted in a number of nominations to have koalas listed nationally as a threatened species, initially to the U.S. Fish and Wildlife Service (USFWS) and more recently to the Australian Commonwealth Government under the auspices of the Endangered Species Protection Act 1992. Similarly, enactment of the Threatened Species Conservation Act 1995 in New South Wales resulted in nominations to have some regionally significant populations listed as endangered. Most of these submissions have been unsuccessful.

The documentation behind rejection of these nominations shows that one key issue on which opinions differ is population size. Estimates of the size of the national koala population vary from under 100,000 (Australian Koala Foundation 1994) to media accounts quoting scientists saying that there are as many as one million animals in

Victoria alone. Such differences have ramifications for the long-term conservation of koalas and have polarized the conservation debate. Thus, our purpose here is (1) to provide an overview of factors limiting the distribution and abundance of koala populations, (2) to evaluate aspects of the conservation debate relating to decline or overabundance, population estimates, and conservation status, and (3) to make practical recommendations about handling uncertainty about conservation status by using criteria established by the World Conservation Union (IUCN).

Factors Limiting the Distribution and Abundance of Koalas^

Complex factors limit the distribution and abundance of koalas. In addition to those matters detailed below, it is also necessary to take into account a given population's management history and relevant sociobiological considerations such as male dominance hierarchies, polygynous social structures, and home-range fidelity (Martin & Lee 1984; Cronin 1987; Lee & Martin 1988; Lee & Carrick 1989; Lee et al. 1990a; Phillips 1990; Sharp 1995).

Food Trees^

Historically, the koala's range probably covered the eastern third of Australia (Phillips 1990). The most obvious limiting factor within this area is availability of adequate food resources (Melzer et al., this issue). Koalas use a wide variety of *Eucalyptus* species (Hindell et al. 1985; Hindell & Lee 1987, 1988; Lee & Martin 1988; Hindell & Lee 1990; Phillips 1990; White & Kunst 1990; Melzer & Lamb 1996; Lunney et al. 1998). Although there is little agreement among researchers on the most preferred food tree species (Phillips 1990), it is generally accepted that in a particular area only a few of the available *Eucalyptus* species are browsed. Other tree species, including some noneucalypt genera, are used opportunistically (Lee & Martin 1988; Hindell & Lee 1990; Phillips 1990; Lunney et al. 1998), and edaphic variables also influence the palatability of some food tree species (Hindell & Lee 1990; Melzer 1995; Cork and Braithwaite 1996).

Loss of key food resources can have profound effects on the population viability and survival of koalas. Martin (1985a) related a decline in the physiological condition of individuals and the growth rate of a koala population at Walkerville, Victoria, to a decline in the abundance of foliage through overbrowsing. Continued overbrowsing was followed by a sharp decline in population density as animals apparently dispersed from the area (Martin 1985b). Every (1986) also attributed the decline of a population in the Ventor Reserve on Phillip Island, Victoria, to a reduction in the amount of available browse. A koala population on Quail Island, Victoria, starved after rapid population growth and overbrowsing of key food resources (Lee & Martin 1988). Koala population declines have also resulted from a loss of food resources during drought (Gordon et al. 1988, 1990).

Other Causes of Mortality^

The effect of stochastic events such as wildfire on koala populations remains largely anecdotal (e.g., Lee & Martin 1988; Phillips 1990; Smith & Smith 1990). Starr (1990), however, described the loss of an entire koala population in a fire near Port Macquarie on the northern coast of New South Wales. (For direct observation of Koala mortality due to wildfire, see Melzer et al., this issue.) In urban and semirural areas, significant mortality from motor vehicles and feral and domestic dogs (Backhouse & Crouch 1990; Canfield 1990a; Smith & Smith 1990; Starr 1990; Nattrass & Fielder 1996) severely limits the ability of populations to recover from stochastic processes such as fire.

Chlamydiosis^

Diseases afflicting wild koala populations are relatively well known (Canfield 1990a, 1990b), especially those associated with the bacterium *Chlamydia.* Once perceived as a threat to their survival (Brown and Carrick 1985; Brown et al. 1987), chlamydiosis is now generally accepted as a normal component of the species' natural history (Martin and Handasyde 1990a; Phillips 1997).

Two species, *Chlamydia pneumoniae* and *C. pecorum,* are involved (Glassick et al. 1996; Sherwin et al., this issue), and the latter is also associated with sheep and cattle, which raises the possibility of cross-species transmission (Jackson et al. 1997). *C. pecorum* is believed to cause reproductive-tract infections in koalas (Jackson et al. 1997) and may limit the reproductive potential of populations (Lee & Martin 1988; Martin & Handasyde 1990a; 1990b). Some researchers have identified reproductive-tract disease as the sole cause of a given population's decline (Gordon et al. 1990). Others argue that human disturbance is the predisposing catalyst for high levels of chlamydial disease (Weigler et al. 1988; Carrick et al. 1996; Phillips 1997). Recent stochastic population modeling has further demonstrated the potential for stable coexistence between *Chlamydia* and koalas over a broad range of test parameters (Augustine 1998).

There is a strong association between the majority of those populations in South Australia and Victoria that suffer from over-browsing or overabundance and the absence of *Chlamydia* (Emmins 1996b; Phillips 1997). This phenomenon can be readily traced to the founder population on French Island, Victoria, which was established in the 1880s from as few as two or three individuals (Houlden et al. 1996) and is *Chlamydia*-negative (McColl et al. 1984; Emmins 1996a). This suggests that *Chlamydia* negativity is a direct consequence of having derived from that population. If so, then the problems of populations founded from French Island stock are not independent of one another but share a common attribute, notably the absence of *Chlamydia.* It has been argued that the absence of *Chlamydia* in these populations means that they are incapable of regulation in response to a limiting food resource (Phillips 1997).

The preceding discussion highlights the extent of differing perspectives on the relationship between koalas, their food resources, and the role of *Chlamydia* in regulating population growth. To find some common ground, the relationship might best be viewed in terms of two contrasting models. The first suggests that there may be koala populations in several areas that conform to an "interactive" herbivore model as described by Krebs (1984), wherein there is potential for irruptive population growth in the absence of other controlling factors. Contrary to Augustine's (1998) assumption of population stability in the absence of disease, the potential for irruptive growth in koala populations can be associated more commonly with *Chlamydia* negativity. Management history of the French Island population (Backhouse & Crouch 1990) and more recent events on Kangaroo Island (Possingham et al. 1996) show that such populations inevitably require considerable management to keep the number of koalas at ecologically sustainable levels. Throughout the greater part of the koala's geographic range, however, a more complex but largely "noninteractive" herbivore model (Krebs 1984) appears more likely. This model proposes a capacity for koala populations to maintain stable levels in the absence of undue disturbance. It is more complex because it incorporates varying levels of chlamydial infection as a stress-dependent population regulator, with a commensurate decrease in fecundity in response to diminishing food resources or other stress factors. Because of the lower reproductive potentials associated with this model, it follows that *Chlamydia*-positive populations will be more sensitive to disturbance. Indeed, failure to appreciate the sensitivity of such populations to disturbance in the first instance is arguably the major factor contributing to declines in many areas.

The Debate about Koala Population Trends^

Contemporary Population Declines^

Knowledge about the reproductive potential of koala populations has come largely from studies in Victoria. Martin and Handasyde (1990a, 1990b) reported rates of increase (r) and population doubling times (PDTs) that varied from 0.06 (11.8-12.2) years for the *Chlamydia*-positive Raymond Island population to 0.19 (3.6 years) and 0.21-0.26 (2.7-3.3 years) for the *Chlamydia*-negative populations of Quail Island and Sandy Point, respectively. Given the history of these three populations (translocated animals, small founder groups, food resource nonlimiting), such results better approximate r_m-the intrinsic rate of increase-in each instance. Not-withstanding the potential of the r estimates to also be maximal in at least two cases (island populations with no opportunities to enact normal dispersal patterns), such results support notions about the potential of some koala populations to increase rapidly. In contrast, there are few quantitative data on the r values of declining populations.

Smith and Smith (1990) attributed the decline over two decades of a koala population on the Barrenjoey peninsula near Sydney, New South Wales, directly to habitat fragmentation and encroaching urban development (Fig. 1). Prior to the onset of decline in the early 1970s, the data suggest the existence of a stable population.

Figure 1. Population trends (expressed as natural logarithms of raw count data) of the Tucki-Tucki, Mt. Macedon, and Barrenjoey koala populations over approximately 45 years. Survey data obtained from Smith and Smith (1990), New South Wales National Parks and Wildlife Service, and the Macedon Range Conservation Society.

The early history and details of the koala population at Tucki in northeastern New South Wales have been described by Gall (1978, 1980). From 1960 to 1977, surveys of the broader area (approx. 100 km^2) provided 11 counts of between 117 and 145 koalas (mean = 122.18, SD = 13.33; Fig. 1). The regression approach of Caughley and Gunn (1996) shows that the finite rate of increase for the population during this period was negligible and did not differ significantly from zero ($r = -0.00019$, $t_{10} = 0.107$, $p > 0.05$). Assuming that food resources were limiting, this result, coupled with that for the Barrenjoey population for 1955-1972 ($r = -0.006$, $t_2 = 1.789$, $p > 0.05$), suggests a capacity for koala populations to maintain stable levels in the absence of undue disturbance. In 1976, however, about 30 animals of various demographic cohorts were translocated some 100 km away (Gall 1978). From 1977 to 1990 the finite rate of increase for the Tucki population was r = -0.094, a value that differed significantly from zero ($t_6 = 7.629$, $p < 0.001$) and suggested a population halving time of 4.56-19.25 years (based on use of 95% confidence limits for r and 0.6931/r; Caughley 1978). Given that the Tucki area has been the focus of intense community interest and ongoing habitat regeneration projects since the 1950s (Gall 1978, 1980; New South Wales National Parks and Wildlife Service, unpublished data), habitat loss and fire can be effectively ruled out as reasons for the decline. Management of the area subsequent to Gall's work has included additional tree plantings and the ad hoc introduction of koalas from surrounding areas (New South Wales National Parks and Wildlife Service, unpublished data).

Unlike that of the Tucki population, the history of koalas at Mt. Macedon, Victoria, is less well known. There are records of introductions dating from 1923 as part of the Victorian government's translocation program, including 41 animals from French Island in 1987 and 27 animals from Sandy Point in 1991 (Emmins 1996a). Despite these introductions, the finite rate of increase for the Mt. Macedon population from 1970 to 1997 is r = -0.063. Like the Tucki decline, the rate of increase for Mt. Macedon also differs significantly from zero ($t_6 = 6.564$, $p < 0.001$) and suggests a population halving time of 8.77-14.75 years.

Data from these case studies were derived from three independent populations. Whereas different survey methods were likely used in each, the methods were consistent within each study, which allows the rates of decline to be compared statistically. Although use of the Barrenjoey data is precluded by the small sample size, an analysis of covariance confirms that, despite significant differences in the size of the Mt. Macedon and Tucki populations ($F = 5.478$; $p < 0.05$), differences between the regression slopes associated with the two population declines are not statistically significant ($F = 3.236$; $p > 0.05$, common slope = -0.067).

Given that population size appears to be independent of the rate of decline, the result might also describe the nature of declines in other koala populations. A specific cause for the Mt. Macedon decline remains to be identified; thus it is difficult not to credit the translocation event for the downward trend at Tucki. The Tucki data also illustrate that downward trends cannot always be linked to obvious issues such as habitat destruction; and in both cases declines continued despite the introduction of additional animals. This suggests that the population dynamics of free-ranging koala populations are more complex than might be perceived.

Koala Population Estimates^

Some estimates of koala population size have been obtained by extrapolating from localized studies and assuming that habitat quality, disturbance, and other factors are uniform across broad geographic areas. This method of population estimation has been used in the Strathbogie Ranges and the National Koala Survey. Discrepancies within each illustrate the uncertainty associated with estimating koala population size over large areas-an issue that is rarely acknowledged in public debate.

THE STRATHBOGIE RANGES^

Estimates of the number of koalas in the Strathbogie Ranges (200 km northeast of Melbourne, Victoria) have featured prominently in submissions against upgrading the species' national conservation status. The koala population of the Strathbogies (an area of about 50,000 ha) was initially estimated at more than 50,000 (R.W. Martin, communication to U.S. Fish and Wildlife Service [USFWS], 28 March 1995) but was later increased to more than 180,000 (R.W. Martin, communication to Endangered Species Scientific Subcommittee, 1995). Although justification for revising the original estimate was not detailed, the initial submission cited work that was subsequently reported by Downes et al. (1997). These authors derived mean densities (±SE) of 8.62 (0.25)-8.85 (0.25) koalas/ha from a small number of forest remnants. But the study sites, rather than being random and stratified, were relatively close to one another on the Strathbogie Plateau. Density estimates from these sites are therefore of limited value in extrapolating over a larger area. Additional surveys in the area have shown densities of one to eight koalas per hectare (K. Handasyde, personal communication). Although confidence levels of these estimates of sampling procedures are unavailable, the use of lower-order density estimates, when applied to the total area of forest cover, will yield population estimates in the order of that proposed to the USFWS.

An alternative method of estimating the koala population of the Strathbogies is to model population growth from the known history of koala introductions and an expected "intrinsic" rate of increase (r_m). The endemic population was either extinct or very small by the 1940s (R. W. Martin, communication to USFWS, 28 March 1995). From 1941 to 1945, 341 koalas were released into the area under the auspices of the Victorian Government's translocation program: 273 animals from Phillip Island and 68 animals from Quail Island (Emmins 1996a). Phillip Island stock were derived from a population with a long history of chlamydial infection (Martin 1981), whereas those from Quail Island were not. Therefore, 80% of founding koalas in the Strathbogies were probably *Chlamydia*-positive, and one can assume an intrinsic rate of increase similar to that determined for the Raymond Island population by Martin and Handasyde (1990a; 1990b). The r_m may be somewhat less given the potential contribution of *Chlamydia*-negative animals over the short term. For growth curves associated with a range of r_m values from 0.09 to 0.04 (corresponding [population doubling times] 8-16 years), each based on the founding population size, none of the projected population estimates for 1995 (Fig. 2a) approach that proposed to the USFWS and ESSS. These results (Fig. 2a) should be interpreted with caution. The potential for growth is contingent upon meeting several assumptions, not the least of which are habitat homogeneity and the presence of a nonlimiting food resource. Among translocated koalas, furthermore, Lee et al. (1990b) reported mortality rates of 12-20%, a lack of social cohesion, and wide-ranging dispersal patterns, which diminish the size of potential founder groups. Finally, realizing full growth potential also requires immunity from stochastic events, but in 1990 an intense wildfire burned between 30,000 and 40,000 ha of farmland and forest on the Strathbogie Ranges in 1990 (A. Harrison, personal communication). Thus, an alternative 1995 population estimate for the Strathbogies of between 2,000 and 18,000 koalas (Fig. 2b) could also be argued theoretically.

Figure 2. A model of population growth curves for the koala population of the Strathbogie Ranges, Victoria, that result from a consideration of intrinsic rates of increase (r_m) of between 0.04 to 0.09 (corresponding population doubling times of 16 to 8 years, respectively). Modeling is based on a founding population of 341 koalas in 1945 and (a) assumes no limiting factors and (b) assumes no limiting factors until 1990, when an estimated 60% reduction in population size over half the area occurred as a result of wildfire.

NATIONAL KOALA SURVEY^

In discussing the results of the National Koala Survey (NKS), Phillips (1990) cautioned against using the data to estimate population size, citing variation in survey technique, observer effort, and habitat accessibility. G. Gordon (submission to USFWS, 31 March 1995), however, urged the USFWS to reject the nomination to list koalas as threatened, asserting that NKS data could be used to "gain a crude estimate of population size" on the premise that it conservatively represented 1% of the likely number of koalas in Australia. The disparities between the 1% approach (Table 1) and data from unpublished studies suggest that far more than 1% of koalas have been sighted in surveys, at least for these particular populations. Therefore, the 1% assumption-or any other percentage-is arbitrary and likely to lead to flawed predictions of koala population size. Nevertheless, koala encounters are memorable events in Australian society (Phillips 1990; Reed et al. 1990; Lunney et al. 1996b; 1997; 1998). It is thus realistic to assume that the distribution of NKS records provides a reasonably accurate portrayal of the locations of remaining koala populations. Although the extent to which such records can be used to assess population size is clearly limited, when properly interpreted they can indicate longer-term trends, as they have for declining koala populations in New South Wales and Queensland (Reed et al. 1990; Patterson 1996; Lunney et al. 1997).

Table 1. Koala population estimates for several areas based on National Koala Survey (NKS) records conservatively representing 1% of likely population size[a] compared with arguably more reliable estimates proposed for the same areas by other studies.

GENERATION TIME^

Another matter relevant to population declines is the concept of a koala generation. The IUCN (1994:10) specifies that a generation (for any species) "may be measured as the average age of parents in the population. This is greater than the age at first breeding, except in taxa where individuals breed only once."

Based on data from a free-ranging, *Chlamydia*-positive population in northeastern New South Wales (Australian Koala Foundation, unpublished data), my colleagues and I have derived an estimated generation time of 6.02 years (n = 28, range 3-9, SD = 1.93). This estimate was determined by taking the mean of the midpoint values of age classes determined for individual animals by the tooth wear criteria of Gordon (1991) and by excluding midpoint values of <4 years in the case of male koalas, and

<2 years in the case of females. A lower estimate of 5.6 years (*n* = 17, range 2-8, SD = 1.9) can be obtained from this same population by determining the mean age of adult female koalas only, whereas a generation time of 7.8 years results from a consideration of the "age class-frequency of breeding females" approach of Caughley and Gunn (1996). Based on the work of Martin and Handasyde (1990b), a longer generation time would be conceivable for *Chlamydia*-negative populations, given the greater longevity and fecundity of females.

Assessing the Conservation Status of Koalas^

Criteria developed by Millsap et al. (1990) have frequently been applied to resolving issues of conservation status. In Australia the approach was initially employed to determine the conservation status of vertebrates in New South Wales (Lunney et al. 1996a). Nationally it has also been used to assess the status of reptiles (Cogger et al. 1993), marsupials, and monotremes (Maxwell et al. 1996).

The extent to which population size has influenced assessments of the koala's conservation status is enigmatic. In accord with the approach of Maxwell et al. (1996), a national population size >50,000 koalas had a biological score of zero. Conversely, the estimated New South Wales population size of 10,000-100,000 animals contributed 9 points toward the median biological score of 63 reported by Lunney et al. (1996a). Such differences reflect the extent to which the original Millsap approach has been modified. Lunney and his colleagues used a relatively complex process with statistical analyses of responses to 10 biological criteria, whereas Maxwell et al. (1996) used four broad criteria, the deliberations of a group of workshop participants, and several independent assessors.

The issue of population size has also influenced regional determinations of conservation status. In rejecting a nomination to list the southeastern New South Wales koala population as endangered, and despite evidence of a chronic decline historically (Lunney et al. 1997), the New South Wales Scientific Committee (NSWSC) cited contentious population estimates (varying from 50 to 1000) as one of three issues that influenced its decision (NSWSC, communication to South East Forests Conservation Council, 4 June 1998). The NSWSC recently listed the Barrenjoey koalas as an endangered population, based on data suggesting that fewer than 6 animals may still be alive (NSWSC 1998). In the absence of an aggressive recovery program, the listing will perhaps serve as a fitting epitaph for this beleaguered population, the history of which exemplifies the failure of political, legal, and social processes to effectively protect koalas.

Current thinking (Maxwell et al. 1996) suggests an imminent move away from the Millsap approach to one that better embraces IUCN (1994:19) criteria, which place a greater and clearly independent emphasis on population trends and fluctuations, as in this description of the vulnerable category:

1. An observed, estimated, inferred or suspected reduction of at least 20% over the last ten years or three generations, whichever is the longer, based on (and specifying) any of the following: (a) direct observation, (b) an index of abundance appropriate for the taxon, (c) a decline in the area of occupancy, extent of occurrence and/or quality of habitat, (d) actual or potential levels of exploitation, (e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2. A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

The three major conservation categories currently recognized by the IUCN (World Conservation Union Species Survival Commission 1994) are critically endangered (population size <250, reduction trend of 80%), endangered (population size <2500, reduction trend of 50%), and vulnerable (population size <10000, reduction trend of 20%).

Application of IUCN Criteria^

There was unanimous agreement among biologists contributing to the most recent assessment of the status of koalas (Maxwell et al. 1996) that the area historically occupied by the species had declined by 25-74%, a figure that appears to satisfy IUCN criterion 1(c) for vulnerable, albeit over a greater time period. Although workshop participants believed that this conclusion supported a classification of koalas as lower risk (near threatened), it assumes the population is stable (World Conservation Union Species Survival Commission 1994). Application of IUCN criteria to the population trends described above, coupled with those detailed below, suggest a measure of population instability across the species' range. The selection of an appropriate generation time for koalas is now relevant, and from the estimates of 6-8 years presented above, the lower estimate has been used. In addition to representing a more conservative approach, a 6-year generation interval also adheres most closely to the IUCN definition, thereby providing a meaningful measure by which to gauge the significance of contemporary declines. In the case of Mt. Macedon, the data indicate a decline in population size of 68% over the three-generation period 1972-1990 (Fig. 1). The Tucki data show a 73% decline from 1977-1990. Although less robust, the Barrenjoey data suggest a decline of 93% over the period 1972 to 1988.

Declines of this magnitude are not uniform throughout the remaining range of the koala, but they are wide-spread. Lunney et al. (1993) reported localized extinctions over 16-20 years in the Coffs Harbour area of New South Wales. The population at Oakey, Queensland, reported by Gordon et al. (1990) decreased 54% over the 12-year period of their study, and counts on Phillip Island, by Backhouse and Crouch (1990) indicate a decline of nearly 90% from 1973 to 1988. Declines have also been documented for Kuringai Chase, New South Wales (Smith & Smith 1990), southeastern New South Wales (Lunney et al. 1997), and the Grampians, Victoria (Martin & Handasyde 1990a). The distribution and extent of these declines suggest widespread population instability which, on average, not only exceeds IUCN criteria for vulnerable listing but also implies uncertainty about the current and long-term conservation status of koalas. The issue of uncertainty has been addressed by the IUCN (1994:6): "Given that data are rarely available for the whole range or population of a taxon, it may often be appropriate to use the information that is available to make intelligent inferences about the overall status of the taxon in question. In cases where a wide variation in estimates is found, it is legitimate to apply the precautionary principle and use the estimate (providing it is credible) that leads to listing in the category of highest risk."

Conservation Implications and Recommendations^

Legislators and policymakers at all levels of government must secure a future for koalas. This task is not easy, and will not be achieved by using the standards of assessment and management currently afforded the koala. The National Koala Conservation Strategy (Australian and New Zealand Environment and Conservation Council 1998:3) states that with respect to Queensland, "In areas where leasehold land predominates (mainly in inland regions), clearing of koala habitat is controlled mainly by provisions of the Land Act 1962." Although such a statement may be reassuring, its efficacy can be gauged in the light of a 1994 survey by the Australian Bureau of Agricultural and Resource Economics, which asked farmers how much forest and woodland they intended to clear in the next 5 years. At the national level, the response was about 3.28 million ha between 1994-1995 and 1998-1999 (about 6500 km^2 a year), most of which was expected to occur in Queensland (State of the Environment Advisory Council 1996). Because koalas potentially occur throughout these forests and woodlands, the effects of clearing on the long-term viability of koala populations needs to be considered.

One possible reason that applications for national listing have been unsuccessful is that a number of koala populations in Victoria and South Australia have increased recently, and some scientists believe that declines elsewhere do not yet threaten the species overall. Indeed, it is difficult to determine conservation status objectively when spectres of overabundance, exponential growth, and 180,000 koalas in a single area are proposed. Unfortunately, scientists who contribute to the listing process are rarely required to identify the assumptions and data on which their opinions are based. In terms of the requirements for a robust decision-making process (Stratford et al., this issue), this lack of attention to detail represents a serious lapse of standards which, when combined with uncertainty about contemporary population trends, must be addressed in future conservation assessments, legislation, and policies regarding koalas.

Likely moves away from overreliance on population estimates toward a greater emphasis on population trends are reassuring. From a regional, intrastate perspective, however, consideration of population size has some application. Although guidelines in this regard are still being developed (World Conservation Union Species Survival Commission 1994), the prudent application of IUCN population estimate criteria (subject to assessments of population stability) could be a useful interim measure for resolving regional or localized issues of conservation status. Both arguments demand greater rigor and standards for monitoring population trends. Without these, koala conservation will continue to remain a circular argument.

By applying standards to information and using caution in addressing disagreement and uncertainty about population trends a conservative conclusion that the category of highest risk applicable to the koala throughout most of its remaining range is that of vulnerable (in accordance with IUCN criteria) must be considered. Given the rate of habitat loss and fragmentation in eastern Australia and the time periods of contemporary population declines, a pessimistic forecaster might suggest that there is a real risk of koalas becoming endangered in the next 10-15 years. The next and most important steps are (1) to acknowledge the legitimacy of different opinions while critically assessing the assumptions and data on which they are based and (2) to accept and work with the uncertainty in a precautionary way as recommended by the IUCN.

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