Native wildlife on rangelands to minimize methane and produce lower-emission meat: kangaroos versus livestock

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Climate change; emissions trading scheme; greenhouse gases; kangaroo; livestock; methane; rangeland; sustainable use.

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Abstract

Ruminant livestock produce the greenhouse gas methane and so contribute to global warming and biodiversity reduction. Methane from the foregut of cattle and sheep constitutes 11% of Australia's total greenhouse gas emissions (GHG). Kangaroos, on the other hand, are nonruminant forestomach fermenters that produce negligible amounts of methane. We quantified the GHG savings Australia could make if livestock were reduced on the rangelands where kangaroo harvesting occurs and kangaroo numbers increased to 175 million to produce same amount of meat. Removing 7 million cattle and 36 million sheep by 2020 would lower Australia's GHG emissions by 16 megatonnes, or 3% of Australia's annual emissions. However, the change will require large cultural and social adjustments and reinvestment. Trials are underway based on international experiences of managing free-ranging species. They are enabling collaboration between farmers, and if they also show benefits to sustainability, rural productivity, and conservation of biodiversity, they could be expanded to incorporate change on the scale of this article. Farmers have few options to reduce the contribution that livestock make to GHG production. Using kangaroos to produce low-emission meat is an option for the Australian rangelands which would avoid permit fees under Australia's Emissions Trading Scheme, and could even have global application.

Introduction

Methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (NO_2) exist in the atmosphere as a result of natural processes; however, human activities are increasing their concentrations, enhancing the greenhouse effect, causing global warming, and thereby adversely affecting biodiversity. Methane is a principal concern because more than 500 million metric tonnes enter the atmosphere annually, which exceeds the amount that can be naturally removed (Intergovernmental Panel on Climate Change 1992). The dominant sink is oxidation within the atmosphere by chemical reaction with hydroxyl radicals (OH) to produce alkyd radicals (CH_3) and water in the troposphere (IPCC 2001). Methane's warming potential over a 100-year time frame is 21 times higher than that of CO_2 (National Greenhouse Gas Inventory 2005); however, its chemical lifetime in the atmosphere is 8–12 years (Wahlen 1993) compared to 100 years for CO_2 (United States Environmental Protection Agency 2006). Therefore, reducing methane production is an attractive short-term target for mitigating global warming.

Australian agriculture contributes 16% of total national emissions, mainly methane and nitrous oxide (National Greenhouse Gas Inventory 2005). The methane comes from enteric fermentation, which is microbial fermentation during digestion of feed by ruminants, mostly domestic livestock (cattle and sheep). Enteric methane accounts for 67% of the total agricultural emissions and 11% of Australia's total emissions (National Greenhouse Gas Inventory 2005). This means that methane from livestock is equivalent to two-thirds the emissions produced by the Australian transport sector (National Greenhouse Gas Inventory 2005). To reduce greenhouse gas (GHG) emissions, the Australian Government has committed to implementing a "cap and trade" emissions trading scheme (ETS) by 2010 and to consult with the agriculture and forestry sectors on the terms and time frame for their inclusion in the scheme (Wong 2008). When agriculture is covered in the ETS, ruminant livestock owners or downstream service providers such as abattoirs and shipping terminals will have to account for livestock emissions.

Strategies being considered to ameliorate the methane problem include using alternative breeds of livestock (Garnaut 2007). Other strategies are to change livestock diets and replace the methane-producing bacteria in the rumen by inoculating with kangaroo microorganisms (Wolin *et al.* 1997; Ouwerkerk *et al.* 2005; Klieve *et al.* 2007). Modifications to rumen physiology and new feeding regimes may be useful for intensive industries such as dairying and feedlots, but cost-effective self-sustaining options for cattle and sheep on the rangelands are not readily apparent. This raises the prospect of a decline in rangelands livestock industries because they continue to produce large quantities of GHG (Howden & Reyenga 1999). While vegetarians would see this as a satisfactory outcome, it is difficult to conceive how most human consumers would abandon meat in their diets, and there are few rural enterprises for the region other than grazing.

The use of alternative species is another option worthy of consideration. Greater use of kangaroos as production animals on the Australian rangelands has long been proposed to be consistent with conservation objectives (Wilson 1974; Archer 2002), including "sheep replacement therapy" (Grigg 1988). The concept is that the value of native species on private landholdings is more likely to be an incentive for protection of native habitats and so complement protected-area conservation reserves. On the other hand, continuation of agriculture based exclusively on species exotic to Australia limits the potential size of the population of native species. Agricultural landscapes supporting exotic animals are more likely to be monocultures or fragmented natural landscapes. The conservation benefits of fewer livestock and more kangaroos may include reduction in hard-hoofed livestock damage to riparian environments, improved soil conservation, increased capacity of vegetation to respond after drought, improved water quality, and long-term sustainability of vegetation used in production processes. Under a scenario of sustainable wildlife harvest, the primary aim of management remains production which may require continuation of management practices such as provision of artificial water, selective harvesting of males, and possibly predator control because large dingo (*Canis lupus dingo*) populations are associated with fewer kangaroos (Newsome 1990).

This article examines the option of reducing cattle and sheep on the rangelands, which are 30% of the national herd, to lower methane emissions. We construct a simple model that estimates the reduction in GHG emissions associated with a larger kangaroo population while providing an equivalent mass of marketable meat now derived from exotic livestock species. The model proposes a decrease in total grazing pressure that would result in a greater capacity for native species to resist other threats to their conservation (e.g., habitat loss, increasing frequency of drought).

Why kangaroos do not produce methane

Both domestic livestock and kangaroos are forestomach fermenters, but the rumen in sheep and cattle is a "single-stirred tank reactor" and the pregastric stomach in kangaroos is a "multi-stirred tank reactor" with shorter retention times of ingested food (Hume 1999). Both groups have microorganisms in the forestomach, which decompose vegetable matter and produce hydrogen, CO_2 and short-chain fatty acids used for growth (Wolin *et al.* 1997; Joblin 1999). The partial pressure of hydrogen needs to be kept low to enable re-oxidation of NADH for digestion to proceed normally. Cattle and sheep contain microorganisms that reduce hydrogen during this process and produce methane (Stevens & Hume 1998). Kangaroos and wallabies, on the other hand, have different microorganisms in their pre-gastric stomachs and emit little methane (Kempton *et al.* 1976; von Engelhardt *et al.* 1978; Dellow *et al.* 1988; Hume 1999). This is probably because methanogens are slow growing and would be flushed out of the kangaroo's forestomach (Hume 1999) due to the shorter retention time. Instead, reductive acetogens have been identified in kangaroos suggesting that kangaroos use reductive acetogenesis as the dominant hydrogen-utilizing reaction (Ouwerkerk *et al.* 2007). While we see no reason to doubt these results, replication of the experiments that set the rate of production of greenhouse gas equivalents per kangaroo is recommended to confirm the figure we used in our calculations, 0.003 tonnes/individual/year.

Kangaroo populations

Kangaroos are abundant in the temperate Australian rangelands where cattle and sheep are raised, competing with the latter in dry times and being labeled by many livestock producers as pests (e.g., South West NRM Ltd 2003). Kangaroos are not contained and roam from property to property seeking best pastures in response to local rainfall. Under current arrangements, it is rare for

Table 1 Kangaroo populations for commercial harvest areas for 2001–2006 (Department of the Environment 2007)

Year	Red kangaroo (*Macropus rufus*)	Western gray (*Macropus fuliginosus*)	Eastern gray (*Macropus giganteus*)	Wallaroo/Euro (*Macropus robustus*)	Total
2006	7,892,774	2,642,224	10,424,926	2,647,005	23,606,929
2005	7,753,247	2,625,708	10,876,498	3,380,838	24,636,291
2004	7,987,250	3,019,320	11,111,840	3,196,511	25,314,921
2003	8,727,856	2,610,931	13,875,828	2,999,906	28,214,521
2002	13,633,816	3,764,289	23,383,249	3,064,178	43,845,532
2001	17,434,513	3,424,992	29,721,271	6,849,250	57,430,026
Six-year average	10,571,576	3,014,577	16,565,602	3,701,234	33,841,370

landholders to benefit from the kangaroos on their lands or play a role in their management.

Kangaroo harvesting is the shooting of kangaroos for their meat and skins. It is a process regulated under nationally coordinated wildlife trade management plans (EPBC 1999). Kangaroos are shot in the field at night using high-powered spotlights and rifles by certified and licensed shooters. A Code of Practice requires head shots and instantaneous death. Most carcasses are processed to human-consumption standard and kangaroo meat is currently exported and sold in Australia to the food service industry, retail outlets and also as pet food (Kelly 2005). Kangaroo skins are valued for their high strength:weight ratio. Kangaroo harvesters are generally independent, small businesses paid per kilogram for the kangaroo carcasses they supply to processors.

Quotas are set to ensure that harvests are sustainable. They are based on research and rigorous monitoring of population size and breeding patterns (Lindenmayer 2007), and are only set for abundant, nonthreatened species. National parks, where little or no harvesting occurs, within the commercial harvest areas provide an additional refuge for kangaroo populations. Table 1 shows kangaroo population estimates compiled from aerial and ground surveys for the commercial kangaroo harvest areas, species by species (Department of the Environment 2007). Populations remain high in areas where commercial hunting is most intense. The true national population is higher because these figures do not include estimates for areas not surveyed. Endorsement of the management program from professional ecologists and wildlife managers and their associations has been consistent (Australasian Wildlife Management Society 2004; Lindenmayer 2007).

Figure 1 shows population estimates for 25 years from 1981 to 2006 for commercially harvested red kangaroos (*Macropus rufus*), eastern gray kangaroos (*M. giganteus*), western grey kangaroos (*M. fuliginosus*), and euros/wallaroos (*M. robustus*) (Department of the Environment 2007). Populations can grow rapidly in years favorable for breeding and survival, for example, from 1996 to 2001. Droughts can depress populations equally rapidly (Bayliss 1987; Pople & Grigg 1999). Harvest quotas are set at 15% of estimated population size based on recommendations of field investigations (Caughley 1987). Figure 1 also shows that harvests are a small proportion of the population and unrelated to fluctuations. From 2001 to 2006, harvests took 6–13% of the population, or 51–81% of the available quota (Department of the Environment 2007).

We have defined the area of the Australian rangelands in which commercial kangaroo harvesting is concentrated (Figure 2). The area excludes the eastern region of the commercial zones in Queensland and the southwestern region of Western Australia because kangaroo numbers and harvesting are lower there (Department of Conservation and Land Management 2002; Queensland Parks and Wildlife Service 2002) and because land use there is more intensive farming and crop production. We have also excluded Tasmania because the larger species (Table 1) are not harvested there although wallabies are. There is no commercial industry in Victoria, Australian Capital Territory or the Northern Territory.

Fewer cattle and sheep, more kangaroos

To analyze the option of reducing methane while producing an equivalent quantity of meat from the rangelands where kangaroo harvesting currently occurs, we developed a simple spreadsheet model (Microsoft Excel 2007) of the kangaroo harvesting area (Figure 2). The model simulates selling down cattle and sheep populations from 7.5 million cattle and 38.7 million sheep in 2007 (Australian Bureau of Statistics 2001, 2006) to 0.5 million cattle and 2.7 million sheep by 2020. This was an average rate of decrease (r) of -0.205 (where $N_t = N_0 e^{rt}$), or 20% per year. Dry sheep equivalents (DSE) are units used in

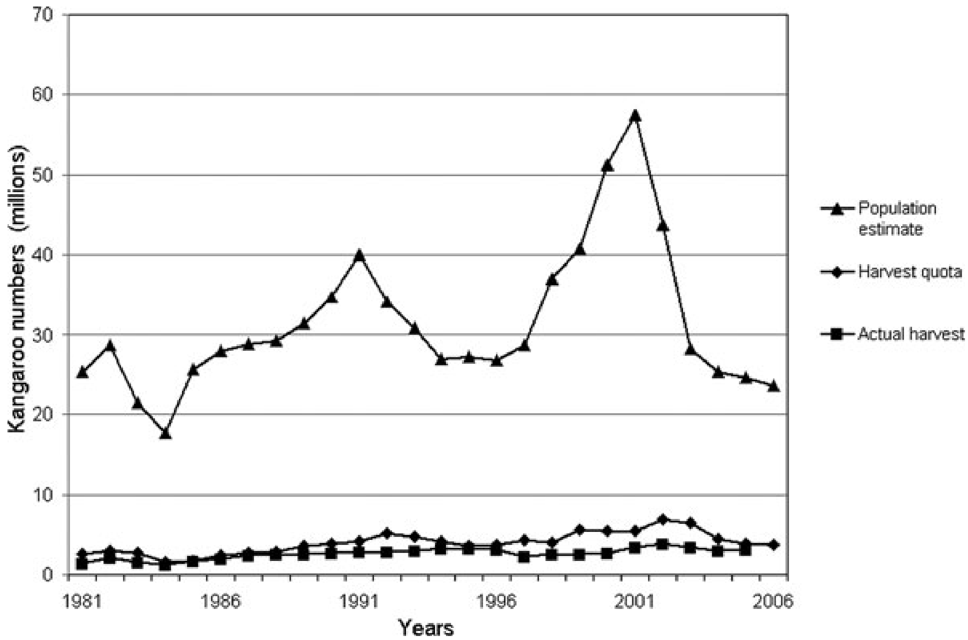

Figure 1 Kangaroo population estimates quotas and harvests for commercial zones 1982 to 2006.

Figure 2 The area of the Australian rangelands in which commercial kangaroo harvesting is practiced.

Australia to compare the number of grazing animals that can be sustained by an amount of pasture. The system enables equivalency comparisons similar to the animal unit months (AUMs) in use in the USA. One 450-kg cow has the DSE of twelve 50-kg sheep (Millear *et al.* 2001), and one kangaroo is roughly half a DSE, although some researchers suggest that the figure is even smaller (Grigg 2002). We used 0.5 DSE to convert the reduction in cattle and sheep numbers to DSE. We calculated that removing cattle and sheep creates the opportunity for an increase in kangaroo numbers by 240 million. Replacability of livestock with kangaroos is supported by independent studies demonstrating that sheep depress kangaroo populations (Caughley 1987) although we note that there can also be positive rather than negative effect of domestic herbivore density on the population-growth rate of kangaroos (Jonzen *et al.* 2005). We chose a lower figure of 175 million as a target population because it can produce the same amount of meat as the current livestock population (see below) and in consideration of the potential for density-dependent effects to constrain the increase in kangaroo populations (McCarthy 1996).

The 2007 kangaroo population at the start of the simulation is assumed to be 34 million (the average of the previous 6 years for the commercial areas, Table 1). An increase from 34 to 175 million over 13 years is equivalent to $r = 0.128$. It is comparable to rates achieved during productive years in the last 25 years in commercial areas with continued harvesting. For example, the harvested population (Figure 1) experienced good seasons between 1996 and 2001 and increased at $r = 0.16$, and between 1984 and 1991, at $r = 0.09$. Field studies show that r for an unharvested population can be much higher, 0.5, and are greater in favorable seasons (Bayliss 1987).

Carbon dioxide equivalents savings

Net carbon savings by 2020 from the simulated population changes are 16 megatonnes of CO_2 equivalents. These savings over 13 years are 3% of Australia's annual carbon accountability of 559 megatonnes (National

Table 2 Kangaroo, cattle, and sheep statistics used in calculations

	Kangaroo	Cattle	Sheep
Average weight (kg)	48 not 19[a]	465[b]	49[b]
Carcass from average weight (%)	66[c]	59[d]	68[e]
Population number (m)	34[f]	7.5[g]	38.7[g]
Harvest/slaughter from population (%)	15[h]	35[i]	22[i]
Amount ($) per kg "at farm gate"	1.00[j]	1.39[k]	1.47[k]
Amount carcass produced (tonnes) in first year	170,000	720,000	140,000
Greenhouse equivalents (tonnes/per head/yr)	0.003 (Kempton *et al.* 1976)	1.67 (National Greenhouse Gas Inventory 2005)	0.14 (National Greenhouse Gas Inventory 2005)

[a]Mean live weight for harvested kangaroo populations in South Australia (Grigg 2002). 48kg average from Dawson 1995, Wilson & Read 2003, Kempton et al 1976

[b]Calculated mean live weight for cattle (not including feedlot cattle or bulls, steers, and cows < 1 year) and mean live weight for sheep and lambs (National Greenhouse Gas Inventory 2005).

[c]Carcass weight/empty body weight (where empty body weights are in weight range groups 20, 30, and 40 kg) (Hopwood *et al.* 1976).

[d]Selected dressing percentage of starved live weight gain for cattle weighing 454–498 kg (Berg & Butterfield 1976).

[e]Calculated from linear regressions for carcass dressed weights on empty body weight (Hopwood *et al.* 1976).

[f]The average number of kangaroos (from 2001 to 2006) in the selected commercial kangaroo harvest area in Figure 2 (Department of the Environment 2007).

[g]The average number of cattle and sheep in the selected commercial kangaroo harvest area in Figure 2 from the 2000–2001 and 2005–2006 livestock census (Australian Bureau of Statistics 2001, 2006).

[h]Harvest quotas are set at 15% of estimated populations following recommendations of field investigations (Caughley 1987).

[i]National slaughter (Australian Bureau of Statistics 2007).

[j]Prices fluctuated in 2007 from 0.80c to $1.50 kg. Tom Garrett, personal communication.

[k]Calculated from Australian Beef and Lamb Reports; "at the farm gate" $/head, (2003–2007 for cattle and 2003–2006 for sheep) (Australian Bureau of Agriculture and Resource Economics 2006).

Greenhouse Gas Inventory 2005), or 28% of agricultural emissions. Estimates are based on an annual production of methane carbon equivalents into our model (Table 2). The model removed 7 million cattle and 36 million sheep, or the equivalent of 120 DSE while allowing the kangaroo population to increase by 141 to 175 million. Kangaroo emissions are not currently counted in the emission inventories, but we have included the small contribution from kangaroos in our calculations.

At €24/tonne (the 2008 price of carbon in the European Union ETS), the CO_2 equivalents saved from 2007 to 2020 would be worth A $655 million (€1 = A $1.45). Assuming landholders are able to sell or obtain credits for changing enterprises to kangaroos, $655 million is not a strong incentive for farmers to replace cattle and sheep with kangaroos. However, if a national ETS requires livestock owners to purchase carbon permits to remain with cattle and sheep, landholders would have a stronger incentive to use kangaroo as low-emission meat.

Cattle, sheep, and kangaroo meat products

So far we have asserted that the number of kangaroos in Australia's rangelands can be increased if cattle and sheep numbers are reduced, that the population changes will promote considerable CO_2 equivalent savings, and that the incentive for livestock owners to do so is low. In this section, we analyze whether the population changes can produce comparable amounts of marketable red meat. We partially test if financial viability is possible by comparing the gross incomes generated from livestock and kangaroos and calculate the cost of emissions permits.

We calculated that by slaughtering 35% of cattle and 22% of sheep per year (Australian Bureau of Statistics 2007), the starting livestock population in 2007 was capable of producing around 720,000 tonnes of cattle and 140,000 tonnes of sheep carcasses/year. Figure 3 shows the meat produced by the simulated livestock and kangaroo population changes. If the assumed kangaroo population in the same area in 2007 was 34 million and harvested to the quota capacity of 15%, the region would produce 170,000 tonnes of kangaroo carcasses. We gradually increased the harvest rate to 22% by 2020 to produce 1.2 million tonnes of kangaroo meat. We believe that the 22% harvest rate could be achieved as pasture becomes available through the increased availability of DSE, if seasonal conditions are favorable (adequate rainfall) and by selectively harvesting males. Kangaroos are promiscuous so that if the proportion of males in the population is reduced by harvesting (up to a threshold),

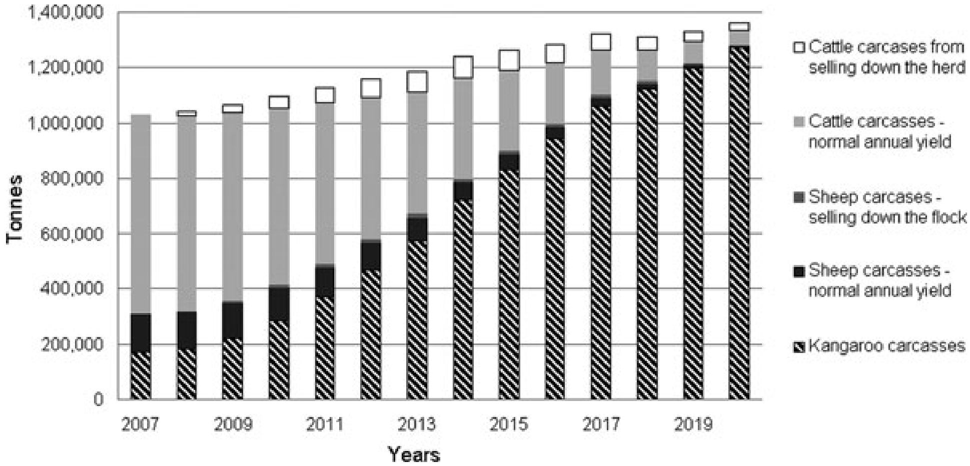

Figure 3 Meat production from cattle, sheep, and kangaroos in simulated population changes.

females will still mate with remaining males (Pople & Grigg 1999).

The strongest incentive for livestock producers to change to low-emission meat would be higher profitability. The initial value of cattle from the area is $1,001 million and sheep meat is $206 million based on the value of product passing out the farm gate in Table 2. Wool sales also bring in $929 million based on $24 per sheep per year. Kangaroos bring only $170 million valued at $1/kg at the farm gate, although the costs of producing a kilogram of kangaroo meat from a free-ranging, minimal-input production system are lower than those for cattle or sheep. For example, there are no costs for fences or yards, internal or external parasite control, shearing, crutching, purchasing new genetic material (e.g., stud rams and bulls), branding, dehorning, or castrating. Assessing the costs of such a change from conventional livestock would require a closer analysis of costs of the two production systems and more information about infrastructure, investment, and social issues, consideration of which are beyond the scope of the current investigation.

Figure 4 shows the gross returns of cattle, sheep, and kangaroos at the farm gate each year to 2020 under the terms of the model. It includes a return for selling down the sheep and cattle herds. The model allows for a rise in the value of kangaroo meat over the period of 3% a year that would enable it to equal cattle at $1.50/kg by 2020. Such an increase could be achieved through landholder involvement in management and attention to product description and reliability of supply. The gross returns from kangaroos nevertheless do not reach the $2200 million from conventional livestock in 2007.

Figure 4 also shows the introduction of the Australian ETS from the year 2010 and the cost of cattle, sheep, and kangaroo carbon permits. With carbon permits at $40 per tonne per year, the gross returns after payment for carbon permits fall to $1,627 million. With the changeover to low-emission kangaroo meat by 2020, gross returns rise to $1,989 million. So the introduction of the ETS makes net income from kangaroos higher than if landholders stayed with livestock production.

A complex cultural and social change

Taking full advantage of the benefits of the digestive processes of kangaroos over ruminants in the Australian rangelands to produce lower-emission meat will require cultural and social changes and new investments. One of the impediments to change is protective legislation and the status of kangaroos as a national icon. Some people are opposed to private ownership and commercial use and value for wildlife for ethical reasons and because they believe it will threaten species (Vegetarians International Voice for Animals 2008). Such opposition need not be insurmountable to the proposal presented here. Wildlife industries are replacing cattle production in southern Africa (Bothma 1996) and game species thrive on private lands integrated with conventional agricultural production in Britain (Deer Commission for Scotland 2008) and North America (Turner 2008). In all three examples, iconic species and national symbols—springbok (*Antidorcas marsupialis*) in South Africa, red deer (*Cervus elaphus*) in Scotland, and bison (*Bison bison*) in the USA are in expanding production systems. In all three areas, landholder involvement in wildlife management has increased populations on private lands and encouraged maintenance of habitats in their natural state.

Notwithstanding that a relatively small kangaroo industry exists, Australia has been slow to follow these

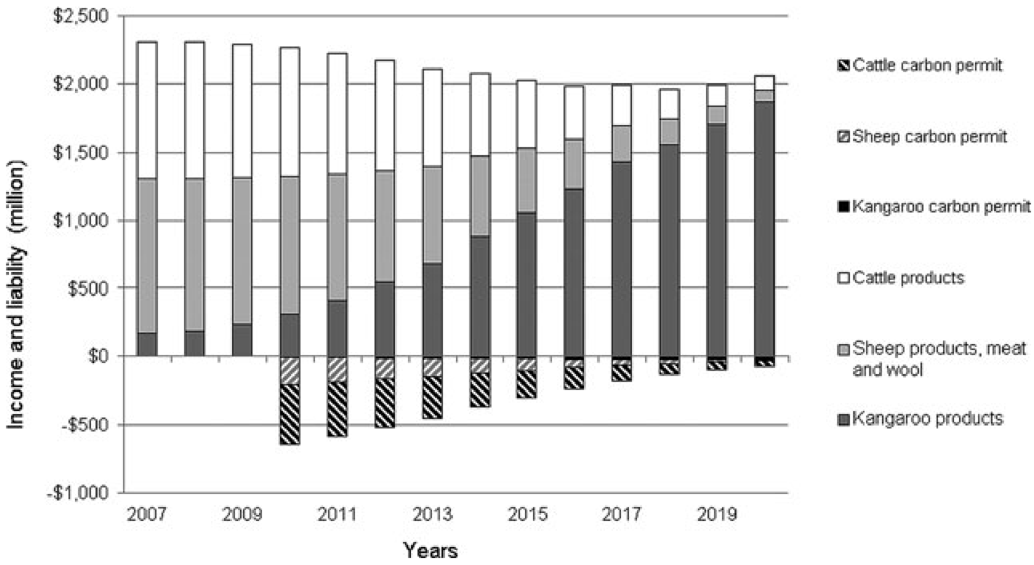

Figure 4 Income from cattle, sheep, and kangaroos and potential liability for carbon permits per year at $40 a tonne of carbon equivalents.

examples, and in particular, to involve landholders. To do so, other issues need to be resolved. Local migration is an important element of kangaroos' adaptation strategy to Australia's erratic rainfall. This means that they move from property to property and claiming ownership or managing them is difficult. Regional collaboration in management has addressed ownership and local movement issues in other countries. The establishment of cooperatives is one solution that brings together independent livestock producers and kangaroo harvesters (Cooney 2008) and assists in marketing products. The attitude of landholders would also need to change. Most landholders currently regard kangaroos as pests that compete with livestock and provide no benefit. Greater landholder involvement in management of kangaroos would follow an increase in the value of kangaroos. It is anticipated that this could be achieved by improved product control and marketing. Many of the initiatives would emulate the product quality and enhanced description practices used in the cattle industry in recent years. Marketing to increase demand could be based on low-emission meat and other environmentally friendly attributes of using kangaroos in the rangelands.

Biodiversity considerations

The Australian rangelands have been subject to considerable modification by livestock. Grazing damage to native ecosystems has contributed to the extinction of at least 20 species of mammals (Lunney 2001) and continues to threaten around one quarter of the plant species listed as endangered (SOE Report 2006). Although we are proposing an increase in kangaroo numbers, the net planned effect is for a lower grazing impact and for maintenance of kangaroo and other wildlife habitat. We believe it is likely that the kangaroos' adaptations to Australia's erratic, variable climate, and recurring droughts will bring a range of biodiversity and conservation benefits. Monitoring the effects on biodiversity would be an essential part of such a transition and would indicate the extent of the side benefits of the change.

In the future, climate change and rising GHG concentrations have the potential to alter vegetation on the rangelands where kangaroos are harvested. If rainfall decreases in southern Australia in winter and spring, cropping and irrigation will be replaced by grazing and animal production (Department of Climate Change 2002). Thus, rangelands will increase in area, although some currently marginal areas could be expected to become unproductive.

To address these scientific and technical issues and social and cultural changes, experimental trials are needed to test a range of economic and management strategies. In 2005, Sustainable Wildlife Enterprises (SWE) trials began with the object of integrating kangaroo production into conventional livestock production processes. (Wilson & Mitchell 2005) The trials seek to bring kangaroo production onto landholder's balance sheets as contributing enterprises. After 3 years, progress is being made but continuing research support is needed, particularly to advise and monitor the establishment of cooperatives and marketing, economic, ecological, and social issues. An expansion of the SWE trials to include low-emission meat production as modeled here would require a larger investment, including a need to monitor kangaroo population size and performance, regional harvesting quotas, and to measure the effects on biodiversity of maintaining high densities in the face of density-dependent feedback that could occur through responses to rainfall, predation, reductions in livestock, or all of the above. It would also be prudent to remeasure greenhouse gas emissions from kangaroos under a range of diets.

Conclusion

Livestock producers throughout the world have few options to reduce the contribution of methane to GHG production other than modifying feed type, reducing livestock numbers, and changing to other species. Studies expected to demonstrate clearly defined, effective abatement technologies to reduce enteric methane emissions from livestock have rarely done so. Our analysis shows that while the incentives for landholders to have fewer cattle and sheep and more kangaroos are not now strong, when GHG emissions from livestock are exposed to their cost and as markets for carbon trading emerge, the avoided cost of having to buy emissions permits will provide additional incentive. The demand for and value of kangaroo meat could also be increased with market development particularly into Asia, attention to product consistency and emphasis on a range of other environmental benefits (Ampt & Owen 2008; Chudleigh *et al.* 2008). Economic benefits could also come by taking advantage of kangaroos' capacity to thrive with minimal management inputs, and adaptations to Australian habitats and highly variable climate and mobility.

Our analysis has focused on the rangelands where kangaroos are harvested. The other 70% of Australia's livestock population, 18 million cattle and 69 million sheep, lie outside this area (Australian Bureau of Statistics 2001, 2006). In southern Australia, cropping and irrigation areas are likely to reduce in size as a result of climate change and be replaced by pastoralism on newly reformed rangelands (Department of Climate Change 2002). Thus, kangaroos could have an even greater role in redu cing methane emissions in these areas of Australia and in northern Australia where the kangaroo industry does not currently operate or perhaps elsewhere in the world.

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