Tūhoe Tuawhenua mātauranga of kererū (*Hemiphaga novaseelandiae novaseelandiae*) in Te Urewera

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Abstract: Indigenous peoples' knowledge on changes in wildlife populations and explanations for these changes can inform current conservation and wildlife management systems. In this study, Tūhoe Tuawhenua interviewees provided *mātauranga* (traditional knowledge) about a repertoire of visual (e.g. decreasing flock size), audible (e.g. less noise from kererū in the forest canopy), and harvest-related (e.g. steep decline in harvests since the 1950) indicators used to assess *kererū* (New Zealand pigeon; *Hemiphaga novaeseelandiae novaeseelandiae*) abundance and condition in Te Urewera, New Zealand over the last 100 years. Metaphorical explanations for the decline in kererū included the loss of *mana* (authority and prestige) by the *iwi* (tribe) over the kererū and forest, and the retraction of the kererū's *mauri* (life force) by *Tāne Mahuta* (God of the Forest). Interviewees reported that predation and interspecific competition with introduced species, variability in food supply, and loss of habitat were the principal biophysical mechanisms to have caused declines in kererū abundance. Long-term qualitative monitoring by Tūhoe Tuawhenua has the potential to guide the restoration of kererū and wider environmental management in Te Urewera. Allowing iwi the self-determination to make management decisions according to their mātauranga (or science, if desired) is likely to lead to greater application of results and altered practices where required for sustainability.

Keywords: competition; Māori; monitoring; predation; restoration; traditional knowledge

Introduction

Relationships between wildlife and indigenous peoples are important for subsistence economies, defining cultural identity, and providing links to history, ancestors, land, art, and environmental philosophy (IIED 1994; Kirikiri & Nugent 1995; Moller et al. 2004). In many instances, harvesting forms the basis for these relationships, with the linkage between the resource and harvester guided by traditional concepts and understanding about the environment. Unlike science-based systems, indigenous peoples' traditional knowledge (in Māori termed *mātauranga*) depict ecosystems not as mechanical, quantitative, and distinct from people and feeling (Berkes 1999), but rather as infused with spirit and life force and based upon reciprocal human–animal relationships (Krupnik & Vakhtin 1997; Tyrrell 2007).

Recording mātauranga holds value in its own right, but also for its potential to assist with designing research and management for a variety of ecological systems (Ohmagari & Berkes 1997). Moller et al. (2004) argued that although traditional monitoring methods may often be imprecise and qualitative, they are nevertheless valuable because observations are diachronic (knowledge developed over a long time-frame and from one locality), incorporate large sample sizes, are inexpensive, invite the participation of harvesters as researchers, and sometimes incorporate subtle multivariate cross-checks for environmental change. Māori recognise that loss of mātauranga has occurred because of the breakdown of transmission related partly to cultural assimilation with European culture over the last 200 years (Tau 2001), and separation from natural resources through government land confiscations and harvest prohibitions. Even so, many *iwi* (tribes) assert that their environmental mātauranga, which is largely based around an ethic of 'resource conservation for future use' (Kirikiri & Nugent 1995; Roberts et al. 1995; Moller 1996), still has the capacity to inform conservation in New Zealand (Lyver 2002). This assertion has been supported and ratified under international agreements such as The Convention on Biological Diversity 1993 (UNEP 2007), to which New Zealand is a signatory.

For Tūhoe, mātauranga forms the basis of their relationship with a culturally significant bird species, the *kererū* (New Zealand pigeon; *Hemiphaga novaeseelandiae novaeseelandiae*). The kererū is a *taonga* (treasure) for Tūhoe from which the iwi draws part of its cultural identity, and it is a highly valued source of food and feathers

(Feldman 2001). The kererū is a large-fruit-eating pigeon (550–850 g in size) that is endemic to New Zealand and inhabits temperate rainforests from 35ºS to 47ºS (Clout 1990). It was historically abundant and also recognised as a food item and game bird by early European settlers (Clout 1988; Atkinson 1993; Coombes 2003). At present, the kererū is listed as 'in gradual decline' by the Department of Conservation (DOC).

This paper describes the change in kererū abundance over the last 100 years in Te Urewera and cultural indicators used by Tūhoe Tuawhenua to monitor population change. We argue that Tūhoe Tuawhenua were not simply optimal foragers, but had ways of proactively sensing and understanding environmental signals and patterns. We identify the agents and mechanisms recognised by Tūhoe Tuawhenua interviewees to be responsible for kererū declines in their region. Finally, we consider the place of mātauranga in informing wildlife management and safeguarding sustainability.

Methodology

Study area and the people

In 2006, the Tūhoe iwi was the ninth largest in New Zealand with its population numbering 32 670 (Statistics New Zealand 2006). Tūhoe have traditionally lived in a region that overlaps the Whakatāne and Wairoa districts, which mostly incorporates the Urewera Ranges, although most (c. 81%) now live outside of their tribal region (Nikora et al. 2004; Statistics New Zealand 2006). The community of Ruatāhuna (Fig. 1) is located in the heart of the Te Urewera Ranges and consists of about 261 people of Tūhoe descent (Statistics New Zealand 2006) clustered around a village centre and 11 *marae* (traditional meeting places). Ruatāhuna is surrounded by podocarp–tawa forest lands vested in the Tūhoe Tuawhenua Trust. These lands are in turn bounded by the Te Urewera National Park. The Tūhoe Tuawhenua lands consist of 8120 ha of native forest

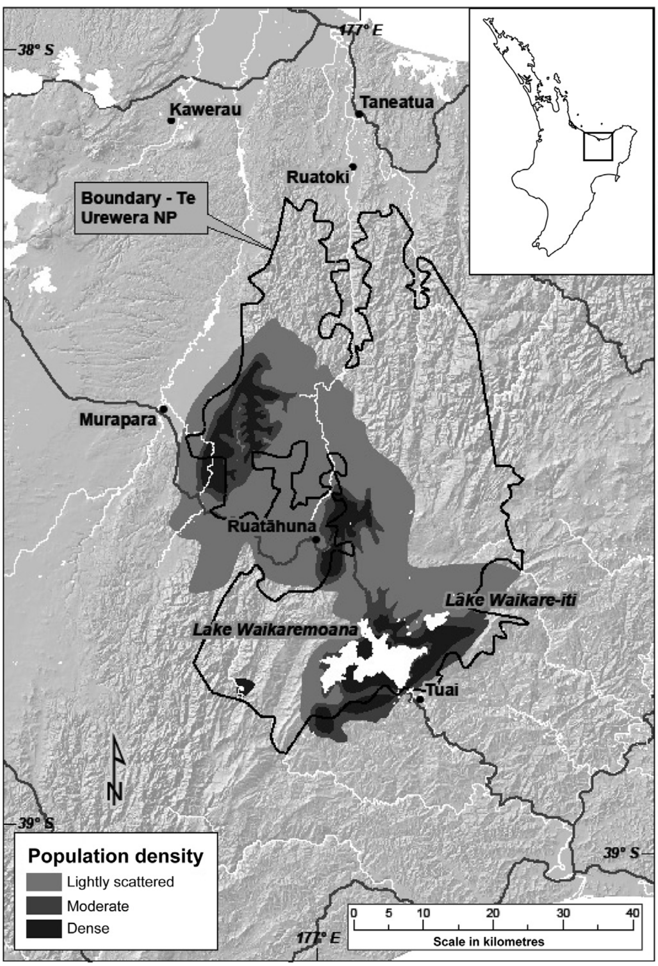

Figure 1. Tūhoe communities Ruatāhuna and Ruatoki, in relation to possum density and distribution in and around Te Urewera National Park in 1955 (from Pracy 1955).

of which a third has been modified by timber extraction. Small-scale cutting of mostly podocarp species began in the 1930s, while intensive timber extraction occurred between 1956 and 1975.

The community of Ruatoki is based around 10 local marae and located approximately 53 km north of Ruatāhuna along the Whakatāne River. Alluvial river flats within the Ruatoki Valley provide approximately 474 people of Tūhoe descent (Statistics New Zealand 2006) with mainly a livestock and cropping based economy. For the communities of both Ruatāhuna and Ruatoki, the rivers and forests of the Te Urewera Ranges provide their people with a valued source of native and introduced flora and fauna for food, medicine, building materials, firewood, and cultural and recreational activities. The name *Tuawhenua* can be translated as 'hinterland', so Tūhoe Tuawhenua refers to Tūhoe people who originate from the interior regions of Te Urewera (J. Doherty pers. comm. 2007).

Interview process

An invitation to conduct the research was extended by the governing Tūhoe Tuawhenua Trust and sanctioned by the community at tribal meetings held at Ruatāhuna and Ruatoki. Selection of interviewees was deliberately non-random. Those individuals that were approached for interviews were recognised by the community to have knowledge and experiences relating to the kererū. Not all individuals were willing to be interviewed and some passed away before they were invited to participate. Therefore, interviews were conducted with 10 of the potential 15 male interviewees identified and their ages ranged from 50 to 84 years. Repeated ideas and patterns of knowledge that emerged over the course of the interviews indicated we had interviewed enough interviewees for the information to be considered reliable. Each of the interviewees had spent their lives in or around the Urewera Ranges and thus had been able to observe the changes in kererū numbers, the forest, and the environment, and talk to younger iwi members who had recently spent time in the forest.

Prior to an interview, an interviewee was contacted and sent a project description, and an oral history agreement governing information use and confidentiality. The content of these documents was discussed with the interviewee before the interview. Semi-structured interviews, in which questions are presented in the context of discussion, were conducted to allow for a more 'natural' conversation to occur and unanticipated insights to emerge (Huntington 2000; Telfer & Garde 2006). At the time of the interview each interviewee was given the list of questions written in both *Te Reo Māori* (Māori language) and English so they could follow the questions as they were asked. Quite often interviewees would provide responses related to a particular topic without being specifically asked about it, so the interviewer would refrain from asking those questions.

Three Tūhoe interviewers were used over the course of the study and all were fluent in English, Te Reo Māori and the Tūhoe vernacular. All the interviewees spoke English but most preferred to be interviewed in Te Reo Māori. Therefore, nine of the interviews were conducted in the Tūhoe vernacular of Te Reo Māori and one in English. The interviews were conducted between April 2004 and May 2007 and ranged from 1.5 to 3 hours in length. All the interviews were conducted on a one-to-one basis, although family members were present at one. Seven of the interviews were recorded on digital video, of which six were translated from Te Reo Māori into English for a transcriber. Three of the interviews were audiotaped and directly transcribed from Te Reo Māori into English by the Tūhoe interviewer. All interviews were transcribed verbatim and vernacular plant names follow Tūhoe Tuawhenua tradition.

Interview questions were developed in conjunction with two Tūhoe Tuawhenua kaumātua who were knowledgeable about kererū. For the purposes of this paper the interview was divided into six sections and addressed key themes of: (1) long-term changes in kererū population; (2) cultural indicators used to gauge kererū abundance; (3) the direct and indirect impacts of introduced mammals and birds on kererū; (4) the types and timing of native fruit and leaves the kererū feed on; (5) the impact of past timber extraction in the region; and (6) observations of changes in climate patterns in the region. Two days were spent in the forest with one interviewee to identify and verify the trees and plants preferred by kererū as food, and a calendar for their consumption.

A workshop, in which both Te Reo Māori and English were spoken, was conducted with seven of the interviewees to verify the narrative and concepts that emerged from the interviews. All three of the co-authors spoke both fluent Māori and English so were able to follow and contribute to the discussion fully at the interviews and workshop. Three *hui* (meetings) were also held with the Tūhoe Tuawhenua Trust and two hui with the Tūhoe Tuawhenua community to review draft research reports and approve the release of knowledge.

Results

Cultural indicators used by Tūhoe Tuawhenua to assess kererū abundance

The interviewees would assess annual kererū abundance when the birds aggregated before (March) and during the fruiting period (April–June) of toromīro (*Prumnopitys ferruginea*; see appendix). A number of the interviewees reported their own grandparents discussing flocks of kererū as numbering in the hundreds, and even thousands at the beginning of the 1900s (Fig. 2). Based on accounts from their kaumātua and parents, the majority of interviewees considered kererū to be abundant in the Ruatāhuna

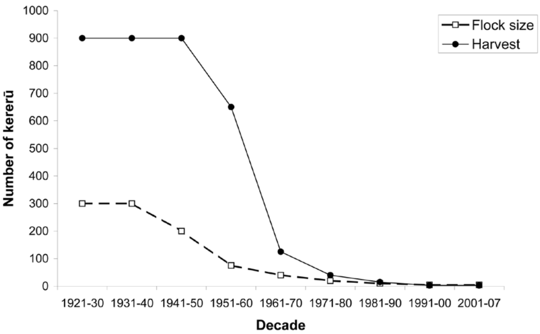

Figure 2. Estimates of kererū flock size and annual kererū harvest per marae in Te Urewera in decades since the 1920s.

and Ruatoki areas up until 1950, although the oldest interviewee reported that early signs of kererū decline were observed in the 1930s. A decline in kererū numbers was most noticeable to this interviewee after he returned from the Second World War in 1945. Some of the younger interviewees reported that their parents spoke about a general decline in kererū occurring after the 1950s, although the birds were still considered to be relatively abundant in the region throughout the 1960s (Fig. 2).

Interviewees used audible cues such as the noise from kererū in the forest canopy to determine when the time was right to initiate harvest, but indicated that with the decline in kererū many of these cues have not been heard for over 35–40 years (Table 1). Before 1970, the numbers of kererū on the toromīro were reported to be so prolific that hunters could often secure a bird by just discharging the firearm (e.g. shotgun) into the tree without taking careful aim. However, after the 1970s, the decline in kererū became increasingly noticeable to the interviewees as harvest levels dropped (Fig. 2) and the indicators used to describe kererū abundance changed (Table 1). Interviewees reported that kererū numbers continued to fall in the 1980s, with the severity of the decline becoming most apparent after 1990. Some acknowledged that with the current rate of decline the local population of kererū could not be maintained in the long term.

Declines in kererū abundance became increasingly noticeable for interviewees as their harvest tallies declined and effort increased (Table 1; Fig. 2). Before 1960, marae hunting parties of 2–3 men could easily harvest 500–1000 kererū over 2–5 days. One interviewee reported 300 kererū being taken by a small hunting party in a day. During this time, it was common for Tūhoe families to harvest 10–15 kerosene tins of *huahua* (kererū preserved in fat) over a season, with each tin holding approximately 50 kererū. After 1970, kererū numbers declined to a point that hunters would return with 10 birds for 3–4 hours effort, and this could only be achieved with the use of firearms and by hunting at optimum times of the day. In some areas it was still possible to achieve reasonable harvests, e.g. one interviewee's grandfather shot 60 kererū during the 1975 season. Based on reports to the interviewees from current kererū hunters in the community, the scale of decline is such that harvesting just 2–3 kererū in a day would be difficult.

Tūhoe explanations for kererū declines in Te Urewera

Loss of stewardship and authority

Interviewees attribute the long-term decline in kererū numbers in the central Te Urewera region to the community failing to uphold traditional customs, protocols and practices regarding kererū and the forest. It was reported that if these traditions had been observed, then the kererū would still be common and readily available for the community for harvest. Traditional rituals conducted by the interviewees' *tūpuna* (ancestors) were a show of respect towards the kererū, to which it would respond by making itself available to the hunters. A decline in ritual observances (e.g. the undertaking of an extensive process of *karakia* (prayer) before the harvest) and traditional practices (e.g. only plucking and processing kererū once back at the marae) caused the *mauri* (life force) of the kererū to be taken from the community by *Tāne Mahuta* (God of the Forest). The interviewees attributed the decline in these traditional practices to the colonialisation process and Crown authorities taking the *mana* (authority) over the kererū from Tūhoe in the first quarter of the 20th century by creating laws and enforcing protection orders that outlawed harvesting of kererū.

Another explanation put forward by two interviewees for the decline in kererū was based on the belief that if a resource is not harvested or utilised by humans, Tāne Mahuta or nature would sense that the resource had become superfluous and would not replenish it. As one interviewee noted:

> The reason why the kererū is actually disappearing is because nature seems to think that it is not worthwhile replenishing because it is not being harvested. That is one of the reasons pikopiko started disappearing years ago because when the Pākehā first came in, they prohibited the picking of pikopiko. Whereas now, I can actually tell you the places the pikopiko is being picked. Every year I go there and get two bags of pikopiko, every year. Nature no longer thinks kererū are required any more, so nature puts a stop to it.

A number of interviewees recounted special occasions where *tohūnga* (traditional expert or priest) used traditional rituals to reclaim the mauri of the kererū from Tāne Mahuta, so that kererū would be available once again for the community to harvest. Once the harvest was complete, the tohūnga returned the mauri of the kererū to the forest through an extensive process of karakia. Many of the interviewees believed the return of authority over the

Table 1. Cultural indicators used by Tūhoe Tuawhenua to monitor kererū abundance in Te Urewera over the last 100 years.

Period	Cultural indicators of kererū abundance
Pre-1950	Small flocks of kererū (20–50 birds) merging into large mega-flocks (100–500 birds) over period of weeks prior to feeding on toromīro Flocks passing overhead would shade the sun Rumbling sound as kererū flock passed overhead Continuous 'rustling' sound in the forest caused by kererū flock in canopy Branches of toromīro would break as flocks of kererū landed to feed Kererū would alight on the hunter if flock landed in vicinity of where he was hidden Feathers and down used for korowai and pillow/mattress filling Kererū harvested on a marae basis A 'hoko' (20 birds) of kererū easy to harvest
1950–60	Large-scale flocking phenomenon before feeding on toromīro no longer observed Continuous rustling sound of flock in canopy Feathers and down used for korowai and pillow/mattress filling Kererū harvested on a marae basis A 'hoko' of kererū (20 birds) easy to harvest in one trip
1960–70	Large flocks of kererū no longer observed Continuous rustling sound of flock in canopy Feathers and down used for korowai and pillow/mattress filling Kererū harvested on a marae basis
1970–80	Large flocks of kererū no longer observed Hunters required to wait for kererū to arrive at toromīro trees Kererū harvested on an individual basis A 'hoko' of kererū (20 birds) difficult to harvest in one trip
1980–90	Hunters required to wait for kererū to arrive at toromīro trees Kererū harvested on an individual basis Impossible to harvest a 'hoko' of kererū (20 birds) in one trip Harvest and eating of kererū limited to special occasions
1990–2007	Kererū not present in toromīro trees for entire fruiting season Few kererū observed in the forest during the year Kererū harvested on an individual basis Impossible to harvest a 'hoko' of kererū (20 birds) in one trip Harvest and eating of kererū limited to special occasions

kererū, land and forest to Tūhoe by the Crown would assist in the recovery of the kererū. They felt that if autonomy were given back to Tūhoe, greater effort would be made to ensure the survival and restoration of the kererū.

Impact of introduced species

Interviewees identified competition and predation by rats (*Rattus* spp.), stoats (*Mustela erminea*), brushtail possums (*Trichosurus vulpecula*), and feral cats (*Felis cattus*) as having the largest cumulative impact on kererū in the region. Some reported that their parents and grandparents first observed possums appearing in the region during the 1920s, becoming common by the late 1940s and early 1950s, and increasing significantly in numbers after 1960. They attributed the expanding range and growth of the possum population to the decline in kererū abundance (Fig. 2) through competition for preferred food species, e.g. toromīro, hinaū (*Elaeocarpus dentatus*) and tawā (*Beilschmiedia tawa*). Interviewees noted that their elders observed an increasing amount of damage to these tree species during the 1940s and 1950s, and a reduction in fruit production caused by possums browsing flowers, new shoots, and the fruit itself. A survey of possums in the central Te Urewera region in the 1950s indicated expanding ranges and densities potentially approaching carrying capacity in some areas around Te Urewera (Fig. 1; from Pracy 1955). Only through recent research conducted on kererū breeding success had some of the interviewees become aware of the predation impact possums also have on the kererū.

Possum hunters had indicated to some interviewees that rat numbers had increased substantially over the last 5–10 years as incidences of rats in their traps increased. Interviewees attributed this increase as contributing to the ongoing suppression of kererū numbers. Also, interviewees considered that the aggressive territorial behaviour exhibited by magpies (*Gymnorhina tibicen*) and spur-winged plovers (*Lobibyx novaehollandiae*) and predation by harrier hawks (*Circus approximans*) had, in part, contributed to the decline in kererū populations around the forest margins. Magpie numbers were reported to have increased sharply between 1975 and 1985 and changed the *āhua* (essence) of the area. Interviewees regularly observed them feeding on toromīro fruit, and harassing kererū attempting to do the same. Red deer (*Cervus elaphus scoticus*) and wild pigs (*Sus scrofa*) were also considered to compete indirectly with kererū for food by hindering forest regeneration through the browsing of seedlings and fallen fruit (e.g. toromīro, hinaū). Three interviewees reported a lack of seedling regeneration throughout the forest, especially of podocarp species.

Changes in food availability and abundance

Seven interviewees acknowledged that the body condition of kererū could vary on an annual basis, depending on the food available to them, especially the quantity and quality of toromīro fruit. It was also reported that kererū fatten on hinaū, tawā, and piritā (*Ripogonum scandens*) fruit, but not quite to the same extent as when feeding on toromīro. Interviewees had witnessed kererū being so excessively fat in some years of heavy toromīro fruiting that they would burst when they hit the ground after being shot. Birds in this condition were referred to as '*whaturua*' (plump birds). However, one interviewee noted that since the 1980s instances of seasonal obesity in kererū have become less frequent, although a complete failure in a toromīro fruiting had never been observed. Interviewees also noted that kererū feed extensively on fruits from the makōmakō (*Aristotelia serrata*), kahikātea (*Dacrycarpus dacrydioides*), rimū (*Dacrydium cupressinum*), and tōtara (*Podocarpus hallii*; Table 2), but never fatten from eating these species.

Interviewees recognised that crop size and fruit development regulates when kererū switch from feeding on fruit to leaves (Table 2). When kererū were observed feeding on kōwhai leaves or secondary fruit sources such as piritā and patatē (*Schefflera digitata*), hunters knew that the toromīro fruit had fallen for the year (Table 2). They emphasised that kererū never fatten on leaves and these secondary fruit species, because they are subsistence

Table 2. Calendar of native food preferences by kererū in the Tūhoe region of Te Urewera (see Appendix for species list).

January:	Karāmurāmu fruit	Houhi/Houwhi leaves Kōwhai/Kōhai leaves Makōmakō leaves		
February:	Black mairē fruit Parāparā fruit Tutu fruit Tātārāmoa fruit (narrow-leafed)	Mahoē fruit Makōmakō fruit Kotukūtukū fruit	Tawā fruit	
March:	Kaikōmako fruit Mataī fruit Tōtara fruit Tātārāmoa fruit (broad-leafed) Puriri fruit (lowlands)	Kaiwēta fruit Rimū fruit Rōhutu fruit		Hinaū fruit Toromīro fruit
April:	Horopitō fruit Kahikātea fruit Pāpāumu fruit		Piritā fruit	
May	Ti kouka fruit (lowlands)		Patatē fruit	
June:				
July:		Katōkatō leaves		Kōwhai/Kōhai leaves
August:	Hanēhanē leaves		Houhi/Houwhi leaves Makōmakō leaves	
September:	Nikaū fruit (lowlands)			
October	Kōwhai/Kōhai flowers			
November:		Porokaiwhīrī fruit		
December:	Kotukūtukū leaves			

food sources. In the past, July was the recognised month for kererū to replace fruit with leaves in their diet (Table 2). However, they indicated in years when fruit ripened and fell early, or when the crop was light, kererū would switch to leaves earlier than normal.

It was acknowledged that extensive extraction of podocarp species (e.g. toromīro, kahikātea, rimū) between 1956 and 1975 in Tuawhenua forests removed crucial feeding, nesting, and roosting habitat to kererū and had contributed substantially to the decline in local kererū populations. All the interviewees noted that small-scale flocking of kererū during the toromīro fruiting still occurs, but that the scarcity of birds meant they have become difficult to observe in the forest once they disperse. Before timber extraction in the region, the kererū were reported never to move far because all the necessary foods were locally available (Table 2). However, without abundant local food sources the kererū must now forage over a much larger area and can no longer feed for long periods in one locality, a factor that has been detrimental to the bird's condition and breeding. For this reason, interviewees attributed the comparatively greater numbers of kererū in the Waikaremoana and Whirinaki regions partly to the larger intact tracts of podocarp forest there. Five interviewees considered the replacement of native forest with large tracts of pine plantation (*Pinus* spp.) on the boundaries of Te Urewera, especially around Ruatoki and west of Ruatāhuna, to be an additional factor suppressing local kererū numbers.

One interviewee reported that the only time kererū are seen now is when they are hungry and come around people's homes in early spring (September–October) to feed on the willow (*Salix* spp.) or cherry (*Prunus* spp.) flowers or new shoots. This was supported by another interviewee who had observed greater numbers of kererū feeding on flowers, leaves and fruit from introduced tree species in the region over the last 5–10 years.

Increasing climate variability

Seven interviewees identified increasingly changeable weather and a general warming trend over the past 10–15 years as factors that have affected the food supply of the kererū. They attributed these changes to trees flowering earlier, fruit crops declining, and the timing of fruiting becoming more variable. A number reported that in some years when they expected the fruit to be ripe on the trees, it had all gone, while in other years the fruit did not ripen until much later in the season. Kererū were observed feeding on ripe toromīro fruit in September and October, some 3–4 months later than normal (Table 2). In 2004, one interviewee noted that the kahikātea fruit were just beginning to ripen in mid-April, when normally the trees should have finished fruiting by February (Table 2).

Interviewees recognised that frosts or cold clear weather during fruit development were essential for setting and ripening the fruit. Two reported that before the mid-1980s, the first frosts had usually occurred by April, but now often did not occur until June or July. Years with frosts in April signalled good years for kererū, while a mild autumn period indicated fruit crops would be lighter, and the fruit would not last as long on the trees. Interviewees also noted that increasing wind strength and frequency in the region during the fruit development period is causing fruit to drop prematurely. A number of the interviewees felt the greater variability in weather required the kererū to continually readjust its feeding habits and breeding cycle, forcing them to eat fruit before it fully ripens. As one interviewee stated:

> Not only are humans confused by it [changing climate] all, but also the trees and plants as well. Some trees like the houhi are so confused that they are flowering twice in one season. The toromīro is a very important tree to Tūhoe because of its importance in the kererū seasonal cycle. In the old days fruit ripened by end of March, and was all gone end of June, but nowadays some trees are fruiting through until mid-October.

Impact of harvest on kererū populations

Interviewees generally did not accept that harvest was a factor in the decline of kererū rather that harvest prohibition was a contributing factor to the population's decline. In support of this, interviewees reported that Tūhoe were very conscious of declines in many other native bird species within Te Urewera, including those that were not traditionally harvested (e.g. tirairaka, pied fantail, *Rhipidura fuliginosa*; rearea, bush robin, *Petroica australis longipes*). One interviewee reported that each marae had a sense of how many kererū could be taken out of their particular region of forest. He stated that the lower harvest tallies reflected the decline in kererū abundance, but also a conscious decision by the people to take fewer birds. He also noted that firearms were generally only used to increase efficiency of the harvest as kererū numbers declined, not to increase the number of birds harvested. Even so, interviewees acknowledged that over the last 50–60 years fewer kererū were harvested for other reasons, such as iwi members moving away from their marae to the cities as part of the rural-to-urban Māori migration, and the threat of prosecution and fines by the policing authorities. Interviewees reported that Government officials were more stringent in enforcement of the prohibition of kererū harvest in those Tūhoe communities that bordered Te Urewera. As a consequence the harvest practice was continued in a greater capacity by those marae and individuals located in the interior regions of Te Urewera.

Discussion

Role of mātauranga in assessing population trends

An important component of mātauranga is an understanding of population baselines, past and current use of the environment, and, in particular, an understanding of trends in harvest rates and prey abundance (Usher 2000; Lyver 2002). Even using coarse inter-decadal estimates of abundance (Fig. 2) our interviewees were aware of the large-scale and increasing decline in kererū numbers throughout their region over the last half-century. The decline in maximum flock size was one of the first indicators used by interviewees to sense that the kererū population was under pressure. This observation, supported by other qualitative visual, audial, and behavioural cues (Table 1) gave interviewees a clear understanding of kererū abundance and trends. Maximum flock size has also been used recently in research to obtain bird count data before the eradication of pest mammals on Maungatautari (Innes et al. 2003, unpubl. report). The technique has potential advantages because it is likely to be efficient to measure and quite robust with regard to differences between observers; non-scientific people can readily relate to it; and it appears to fit the biology of many native birds that anecdotally flock in high numbers where predators are scarce or absent (J. Innes, pers comm. 2007).

A decrease in catch per unit effort (CPUE) was a secondary indicator used by interviewees to track the kererū abundance. However, it was not until the early 1970s that interviewees became growingly concerned about the significant decrease in kererū catch per unit effort, as it became increasingly difficult to harvest the traditional *hoko* (catch of 20 birds) in a single hunting trip (Table 1). This scenario typifies the potential curvilinear relationship that may exist between CPUE and population abundance as described by Moller et al. (2004) when a hunter is faced with a declining resource. By using technological advances, or harvesting at times of aggregated prey, or at places of high prey density hunters can buffer the decline in their catch per unit effort, even when the population is declining at a greater rate. The 10-year lag between observed declines in flock size and harvests (Fig. 2) indicates that interviewees initially compensated for a reduction in kererū abundance by increasing effort, using firearms, and only targeting kererū at times of high density. Based on this curvilinear relationship, if interviewees had only used CPUE as an indicator of kererū abundance, their awareness of the decline would have been delayed, and they most likely would have underestimated the scale of population decline.

The diachronic attributes (knowledge developed over a long time-frame and generally from one locality) of their mātauranga allowed interviewees to effectively track the decline in the kererū population through the intergenerational passing of knowledge. This style of resource assessment is used by many indigenous cultures to track and monitor changes in wildlife abundance, condition and distribution (Berkes 1999; Kofinas et al. 2003). For wildlife managers, the monitoring of population trends is a critical first component of sustainable management of customary harvests of wildlife. However, estimates of abundance using scientifically based methodologies can often be expensive and time-consuming, frequently lack replication and have observer bias, often run for less than a single generation of the species concerned, and are often only 'relative indices' or are accompanied by large confidence intervals, if any at all (Moller 1996). Kererū can be difficult to census especially in steep, rugged and heavily forested terrain like Te Urewera where the canopy can be 30–40 m in height. When considering mātauranga indicators, therefore, the question might be: are they adequate measures of resource abundance over time? Detailed mātauranga from Rakiura muttonbirders about weather, harvest tallies, and harvest effort, as well as changes to the local environment and notes of unusual events such as large storms have given reliable insights into tītī (sooty shearwater, *Puffinus griseus*) population changes over 50 years, and has helped prioritise research and formulate more powerful scientific hypotheses (Newman & Moller 2005). Mātauranga can potentially, therefore, provide equally reliable information as science about baselines and trends in wildlife populations. Qualitative monitoring may not always be considered 'good science' but supported by a modest amount of systematic assessment it has the potential to understand changes in populations and lead or help in resource recovery or sustainability (Moller et al. 2004).

Building mātauranga interpretations into wildlife management

Two of the most common explanations provided by interviewees for the decline in kererū in Te Urewera were rooted in cultural ideology, i.e. the removal of Tūhoe's mana over kererū by Crown authorities implementing prohibition; and Tāne Mahuta reclaiming the mauri of the kererū because of the declining harvest and diminishing respect for the bird by the people. It is common for those who base their actions on traditional knowledge to attribute events or changes in populations and environment to ideological or spiritually based mechanisms. This creates a departure from the science-based system that perceives reality in terms of cause–effect relationships determined entirely by biophysical mechanisms (Moller et al. 2004). Few examples exist in countries with colonial histories where decisions regarding resource use or conservation have been based solely on an indigenous culture's ideological beliefs or metaphysical explanations for changes in populations. The spiritual dimension of mātauranga is unlikely to be fully embraced by ecologists and managers (Berkes et al. 1998), but understanding its role in the way indigenous communities perceive the environment and how it shapes decision making must be important for the collaborative management of ecosystems.

Although monitoring population abundance is an important component for determining sustainability, it is often insufficient in itself for making management decisions (Moller et al. 2004). For example, James Bay Cree trappers continually monitor beaver populations and health of the beaver–vegetation system by observing vegetation changes around beaver ponds, age composition of beaver lodges based on tooth marks on cut wood, and evidence of overcrowding such as fighting among beaver (Berkes 1999). Consequently, government resource management agencies in these regions have recognised the value of these observations and have established systems for including this information into resource management decision-making. Comparable benefits could be realised if greater efforts are made to include Tūhoe monitoring capabilities into the kererū conservation effort. Interviewees recognised that a range of biophysical factors have cumulatively affected the abundance, availability, and quality of the kererū food supply. They emphasised that monitoring the signals related to these parameters was important for understanding the decline in the kererū population. The decline in kererū numbers and body condition reported over the last 30 years suggests the kererū population could be partly food limited during the build-up to winter. A reduction in fruit and delays in toromīro fruiting over the last decade may have created a nutritional bottleneck meaning that an energy-rich food source was unavailable to kererū at the optimal time before breeding.

Cultural indicators of kererū abundance show a dramatic decline occurring after the 1950s. This population trend ties closely with the potential growing predation pressure from the increasing densities and expanding ranges of introduced mammals such as possums, ship rats and mustelids (Pracy 1955; Coombes 2003). Indices of possum densities in the early 1950s showed populations approaching carrying capacity around the community of Ruatāhuna and other regions of Te Urewera (Pracy 1955; see Fig. 1). Unfortunately, it was impossible for interviewees to separate the effects of food limitation from predation by introduced species on the kererū population.

Tūhoe continued to go to great lengths to harvest kererū after the practice was outlawed in 1921 because of the bird's immense cultural significance and value. Kererū have a key role within Tūhoe tradition and it is considered *whakama* (shameful) to receive a visitor of importance and not serve them huahua. This practice is fundamental in defining the iwi and/or individual as a *kaitiaki* (guardian). Tītī have similar cultural significance for Rakiura in the south of New Zealand. The re-establishment of native bird harvests is seen by some Māori as the right to express their identity – a desire driven as much (if not more) by the cultural, social, and spiritual significance of the practices associated with the harvests as by the actual need for food (King 1994; Kirikiri & Nugent 1995). However, this value/belief system is perceived by some conservation organisations as a direct threat to the resource, rather than as a pathway to restoration. Even so, more ardent attempts to self-regulate harvesting might occur if iwi were given decision-making rights over forest management because poaching would more clearly be seen to interfere with traditional customs and success of legitimate sustainable customary use (Kirikiri & Nugent 1995). For Tūhoe, this would be realised with the reinstatement of authority over Te Urewera and return of the kererū's mauri to the iwi.

Place for mātauranga in conservation management

A number of international conventions and national strategies exist that mandate the inclusion of traditional knowledge in biodiversity management (UNEP 1993; Posey 1996; Usher 2000; Manseau et al. 2005). However, in many cases issues remain about who sets policy, who determines the state of a resource, and who ultimately decides the appropriate management action? Current wildlife management systems in countries with colonial histories (e.g. New Zealand, Australia, and Canada) are largely based on Eurocentric scientific principles. The basis of these principles makes it difficult for ecologists and resource managers to accept and include spiritually based explanations for patterns observed in wildlife populations without hypothesis testing or repeatable ecological reasoning. In many well-meaning instances the common practice has been for scientists or environmental resource managers to select what aspects of this knowledge fit with scientific concepts and data requirements and procedures (Ellis 2005; Stevenson 2006). What this practice often fails to account for is that mātauranga is commonly embedded within a broader articulated system of knowledge, which includes ecological and non-ecological components, and its removal from this context is in effect 'dumbing-down' the knowledge (Stevenson 2006). The authors acknowledge that some mātauranga analysed in this paper has been selected and removed from its cultural context for presentation in a scientific medium. For wildlife management to effectively integrate all elements of mātauranga, the initiative and the guidance for its implementation needs to come directly from the knowledge holders.

For some Tūhoe, the fundamental requirements before the integration of mātauranga in conservation management is considered are the return of traditional lands under the Treaty of Waitangi 1840 claims legislation and the autonomy to self-govern and manage the natural resources on those lands (Coombes & Hill 2005). Potential benefits from this course of action were in part demonstrated at Morere Scenic Reserve (east coast of the North Island) where devolvement of political authority to the local iwi made a more significant contribution to kiekie (*Freycinetia baueriana*) management than just mātauranga integration alone (Coombes 2007). Similarly, providing Tūhoe with political self-determination would give the iwi responsibility for problem definition, decision making, knowledge use, and identification of solutions to promote the restoration of species like the kererū.

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Appendix. Tūhoe Tuawhenua plant names and corresponding species of kererū food sources in Te Urewera (note Tūhoe dialect may differ from standard Māori)

Hanēhanē	*Geniostoma ligustrifolium*
Hinaū	*Elaeocarpus dentatus*
Horopitō	*Pseudowintera* spp.
Houhi/Houwhi	*Hoheria* spp.
Kahikātea	*Dacrycarpus dacrydioides*
Kaikōmako	*Pennantia corymbosa*
Kaiwēta	*Carpodetus serratus*
Karāmurāmu	*Coprosma robusta*
Katōkatō	*Parsonsia heterophylla*
Kotukūtukū	*Fuchsia excorticata*
Kōwhai/Kōhai	*Sophora* spp.
Mahoē	*Melicytus ramiflorus*
Mairē	*Nestegis cunninghamii*
Makōmakō	*Aristotelia serrata*
Mataī	*Prumnopitys taxifolia*
Nikaū (lowland)	*Rhopalostylis sapida*
Pāpāumu	*Griselinia littoralis*
Parāparā	*Pseudopanax arboreus*
Patatē	*Schefflera digitata*
Piritā	*Ripogonum scandens*
Porokaiwhīrī	*Hedycarya arborea*
Puriri (lowland)	*Vitex lucens*
Raurēkaū	*Coprosma grandifolia*
Rimū	*Dacrydium cupressinum*
Rōhutu	*Lophomyrtus obcordata*
Tātārāmoa	*Rubus cissoides, R. australis*
Tawā	*Beilschmiedia tawa*
Ti kouka (lowland)	*Cordyline australis*
Toromīro	*Prumnopitys ferruginea*
Tōtara	*Podocarpus hallii, P. totara*
Tutu	*Coriaria arborea*