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RADIOCARBON DATING THE END OF MOA-HUNTING IN NEW ZEALAND PREHISTORY

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Introduction

For over 150 years, New Zealand scientists and prehistorians have investigated and debated when the last moa (Aves: *Dinornithiformes*) was hunted and killed by humans (see Anderson 1989). Prior to the introduction of radiocarbon dating into New Zealand archaeology in the mid-1950s, theories on when moa predation ended were based on Maori oral tradition, dubious eye witness accounts, moa bones found on the surface of the ground and arbitrary archaeological excavations of large culling sites. Radiocarbon dating provided an absolute chronological tool for determining when the remains of moa found in prehistoric contexts were deposited, meaning the activity of moa-hunting could be more easily attributed to a particular period in New Zealand prehistory. This dating method together with a systematic approach towards the archaeological investigation of moa-hunting since the late 1960s (Anderson 1989: 189), has now seen 80 'moa-hunting' sites radiocarbon dated, constituting 304 radiocarbon ages[1]. Although the number of radiocarbon dates from moa-hunting sites is thus extensive, only three studies have undertaken an analysis of a sweep of radiocarbon ages from these sites to determine when moa-hunting possibly ceased in New Zealand prehistory.

The first of these studies was by Anderson (1989: 171-178) who focused on the charcoal radiocarbon chronology, as the reliability of various marine shell species, moa egg shell, moa bone or rat bone for radiocarbon dating New Zealand prehistory were not known at this time. He concluded from his analysis

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[1] Data obtained from the New Zealand Radiocarbon Dating Database (*www.waikato.ac.nz/cgi-bin/nzcd/search.pl*).

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that moa-hunting had possibly ceased by *ca.* 1550 AD (Anderson 1989:178). However, Anderson (1989) did not undertake a detailed critique of the charcoal radiocarbon record, and so many of the charcoal ages in his sample may still have been affected by inbuilt age[2]. Some ten years later, Petchey's (1999) study looked specifically at the reliability of radiocarbon dating New Zealand archaeological bone. Using a 'discard protocol' developed for bone ^{14}C dates, she isolated seven archaeological sites where the moa bone radiocarbon ages were believed to be reliable. The latest moa bone age came from the Tumbledown Bay site (N37/12) in the South Island, where the calibrated radiocarbon age at 1σ showed that moa-hunting was still possibly being practised at this site as late as the 17^{th} century AD.

Holdaway and Jacomb's (2000) recent investigation on the human induced extinction of the moa, proposed that within 100 years of Polynesian colonisation of New Zealand *ca.* 1250 AD, moa-hunting had ceased. This proposition was based on a Leslie matrix population model which considered factors such as the size of New Zealand's first colonising Polynesian population, 'cropping rates' of moa by human predation, and the estimated breeding rates of extinct *Dinornithiformes*. Holdaway and Jacomb (2000) argued that their model was supported by the charcoal, moa egg shell and marine shell radiocarbon chronologies from five moa-hunting sites dated to the mid-13^{th} to early-15^{th} centuries AD (such as Wairau Bar and Shag Mouth, see below), and one site with no moa remains radiocarbon dated to the late 14^{th} century AD (Monck's Cave). Their analysis, however, did not provide a list of the radiocarbon dates derived from the moa-hunting sites mentioned, and so the integrity of the ^{14}C ages used to their support their model could not be evaluated.

It can be seen from the three studies presented above, that of the various sample types used to radiocarbon date moa-hunting sites, only the moa-bone radiocarbon chronology has been satisfactorily scrutinised to determine when moa-hunting possibly ceased. It is apparent, therefore, that to determine when the last moa was hunted in prehistoric New Zealand, a critique of the current marine shell, charcoal and moa egg shell radiocarbon chronology is required. The aim of this study is to undertake such an analysis by applying a 'discard protocol' to marine shell,

[2] Inbuilt age may be defined as "the difference in age between the death of the sample and the archaeological event dated. For wood, it is the combination of growth age (the age of old wood in a tree) and storage age (the time the tree was lying around before it was used)." (McFadgen, Knox and Cole 1994:223).

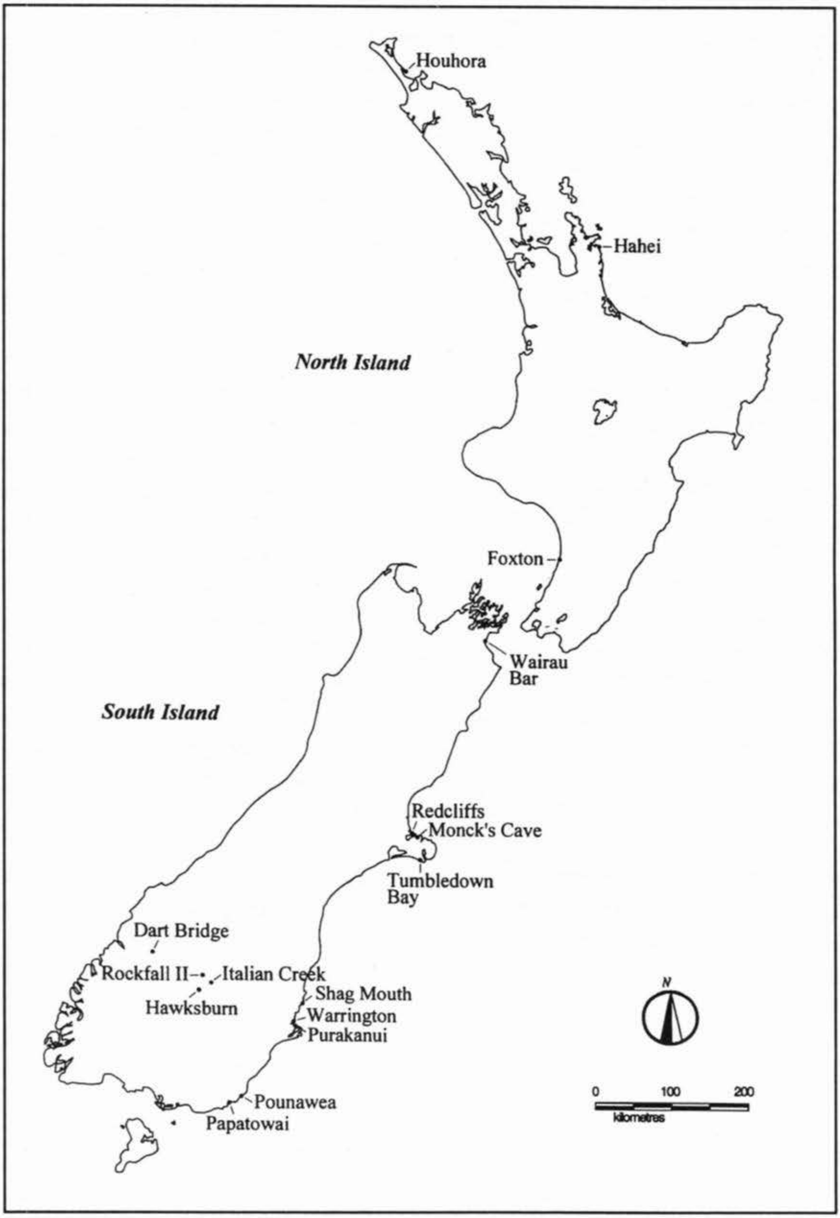

Figure 1. Locations of moa-hunting sites mentioned in the text.

charcoal and moa egg shell radiocarbon ages from moa-hunting sites which post-date the large culling sites of Wairau Bar and Shag Mouth (see below).

Radiocarbon dates on these three sample types have been chosen for examination, as particular species of marine shellfish, twig charcoal from short-lived tree and shrub species, and moa egg shell are now widely considered to reliably radiocarbon date New Zealand archaeological contexts (see Higham 1993; Higham and Hogg 1995; Schmidt 1996a, 2000b). The reliability of rat bone (*Rattus exulans*) for radiocarbon dating appears problematic at present, and so ages on this sample type are not considered (see Anderson 1996; Smith and Anderson 1998). In light of this analysis, observations are made on the current state of the moa-hunting radiocarbon record and what the present chronology can actually tell us about moa-hunting in prehistoric New Zealand on both a national and regional level.

Refining the Moa-hunting Radiocarbon Chronology

The archaeological sites of Wairau Bar and Shag Mouth in the South Island of New Zealand, are prime examples of the importance of moa-hunting to the prehistoric Maori (Figure 1) (Anderson, Smith and Higham 1996; Higham, Anderson and Jacomb 1999). It has been estimated from the extensive archaeological investigations at these sites, that during their brief occupation of possibly less than 100 years, 8733 moa may have been butchered at Wairau Bar, and about 6000 moa at Shag Mouth (Anderson 1989: 124, 135). Both archaeological sites have been comprehensively radiocarbon dated with samples in direct association with evidence of moa-hunting, and which are reliable for radiocarbon dating New Zealand prehistory (Anderson, Smith and Higham 1996; Higham, Anderson and Jacomb 1999)[3]. A total of 18 marine shell, 16 charcoal and 14 moa egg shell conventional ^{14}C ages have been determined for Wairau Bar and Shag Mouth combined, and, because of this ^{14}C chronology, these locations have been used to illustrate both the peak of moa-hunting activity in prehistoric New Zealand (Anderson, Smith and Higham 1996; Higham, Anderson and Jacomb 1999) and its climax (Holdaway and Jacomb 2000). The calibrated radiocarbon ages from Wairau Bar indicate moa-hunting was well underway during the late 13th century AD (see Higham, Anderson and Jacomb 1999). At Shag Mouth,

[3] Radiocarbon ages from these sites were derived from the shellfish species *Paphies australis* and *Austrovenus stutchburyi*, as well as moa egg shell and, for the Shag Mouth site, charcoal from twigs of short-lived tree and shrub species (see Higham 1993, 1994; Schmidt 1996b, 2000b).

calibrated ^{14}C dates show moa-hunting activity during the late 14th to early 15th centuries AD (see Anderson, Smith and Higham 1996).

In investigating the end of moa-hunting in New Zealand prehistory, selecting archaeological sites with conventional radiocarbon ages (CRA) that 'dove-tail' or are younger than the radiocarbon dates from Wairau Bar and Shag Mouth, will indicate what locations in prehistoric New Zealand were involved in hunting moa during or after the occupation of these sites. The lists of marine shell CRA from Wairau Bar and Shag Mouth provided by Anderson, Smith and Higham (1996) and Higham, Anderson and Jacomb (1999), show that the youngest reliable marine shell CRA derived from these sites is 950 ± 45 years BP (Wk-2857). The terrestrial (charcoal and moa egg shell) CRAs from Wairau Bar and Shag Mouth overlap at 650 years BP (see Anderson, Smith and Higham 1996; Higham, Anderson and Jacomb 1999). Other moa-hunting sites with marine shell CRA ≤ 950 years BP, and charcoal or moa egg shell CRA ≤ 650 years BP, would therefore have been occupied during or after Wairau Bar and Shag Mouth, and so sites with these radiocarbon dates were considered in this analysis.

One important consideration for this study was the association of radiocarbon ages from the sites with evidence of moa-hunting. The importance of specific event and association of the dated sample has been discussed in previous studies which have used discard protocols (see Anderson 1991; Schmidt 1996b, 2000b; Higham and Hogg 1997). In these studies, the interpretation of what the date represented first considered the interpretation of the researcher who dated the site, as seen in his/her associated publications or sample details recorded at the laboratory where the sample was dated, and secondly the authors own assessment of that interpretation. This method of determining the significance of a date and its cultural association was also used for this analysis of ^{14}C ages from moa-hunting sites.

For a radiocarbon age to date human predation of a moa in this study, the researcher must have clearly described the provenance of the dated sample in relation to the moa remains, and demonstrated that the death of the moa was due to human action. Indicators of human predation would be, for example, burnt/cooked moa-bone found in hangi (ovens), or a predominance of leg remains in a site associated with butchering/hunting artefacts (such as silcrete blades and flake tools) and sometimes moa eggshell. Large moa-hunting sites often provide clear evidence of moa killed by human hands, but smaller sites with scant remains can make it difficult to distinguish the origins of the moa bone, and thus must be viewed with caution. At the sites of Timpenden (M33/11), Awamoa (J41/3) and Waihao Mouth (J40/32) (see Anderson 1989:172), for example, moa remains have been identified as possibly being sub-fossil in origin and were imported into the site for industrial purposes. This analysis found that the majority of researchers who radiocarbon dated 'moa-hunting contexts' did date samples that were in direct association of culled moa remains.

'Chronometric hygiene', discard protocols and moa-hunting radiocarbon dates

This study uses a 'chronometric hygiene' approach to refine the sample of radiocarbon dates under analysis. This methodology applies a 'discard protocol' to sets of radiocarbon dates where unreliable ages are rejected based on both archaeological and radiocarbon dating considerations. New Zealand's short prehistory (*ca.* 700 years) makes the removal of unreliable archaeological ^{14}C ages particularly important, as factors such as inbuilt age of charcoal samples or dating the wrong species of shellfish, can dramatically affect the chronological placement of an archaeological site within this brief time period (Anderson 1991; Schmidt 1996a; Higham and Hogg 1997). New Zealand studies which have employed the chronometric hygiene approach are those by Anderson (1991), Schmidt (1996a, 2000b) and Higham and Hogg (1997) to determine the beginning of prehistoric colonisation of New Zealand, Schmidt (1996b) to ascertain the commencement of *pa* (fortification) construction, and Petchey (1999) for the radiocarbon dating of New Zealand archaeological bone.

To investigate when moa-hunting possibly ceased, the New Zealand Radiocarbon Dating Database (*www.waikato.ac.nz/cgi-bin/nzcd/search.pl*) and lists of ^{14}C dates from moa-hunting sites provided by Anderson (1982, 1989, 1991), Caughley (1988), Anderson and McGovern-Wilson (1990), Anderson, Smith and Higham (1996), Higham and Hogg (1997), and Higham, Anderson and Jacomb (1999) were searched for marine shell conventional radiocarbon dates ≤ 950 years BP, and charcoal and moa egg shell conventional radiocarbon ages ≤ 650 years BP, that were noted in these records as coming from 'moa-hunting' contexts. The number of radiocarbon ages obtained from this search was extensive, and so they have been placed on the New Zealand Archaeological Association Internet Homepage at ***http://c14.sci.waikato.ac.nz/nzaa/schmidtmoa.html*** as Tables 1 to 3 (Schmidt 2000a). Tables 1 to 3 list 38 marine shell conventional radiocarbon ages ≤ 950 years BP, and 75 charcoal and 6 moa egg shell conventional radiocarbon dates ≤ 650 years BP from 45 moa-hunting sites. These tables also show for each radiocarbon age: the laboratory number from whence the age was derived; name of the archaeological site dated as well as the New Zealand Archaeological Association Site Record number (old and new); the provenance of the sample as shown in the New Zealand Radiocarbon Dating Database; and the species of shellfish dated, or the tree and shrub species dated for the charcoal samples.

After obtaining the sample of late moa-hunting radiocarbon dates, a discard protocol containing acceptance and rejection criteria for these radiocarbon ages was developed, based on the earlier protocols used by Anderson (1991), Schmidt (1996a, 1996b, 2000b) and Higham and Hogg (1997) (see below). This discard protocol was then applied to the radiocarbon ages in Tables 1 to 3, with the acceptance and rejection criteria being noted in column six of each table.

Discard protocol for late moa-hunting radiocarbon ages

1. Charcoal radiocarbon ages from moa-hunting sites may be rejected for the following reasons:

A. all or part of the charcoal sample has not been identified to twigs of tree or shrub species. Radiocarbon ages on unidentified charcoal retain the risk of high inbuilt age of the sample and so cannot be deemed reliable (see McFadgen, Knox and Cole 1994).

Inbuilt age has more often been a concern for archaeologists when determining the beginning or earliest occurrence of an archaeological event rather than the end, as this factor may push back the time at which the event occurred dramatically (see Anderson 1991; Schmidt 1996a). However, when determining the end of a prehistoric activity, it is still important to reject ^{14}C ages from a site which have possibly been affected by inbuilt age, as we must still be sure the sample dated is actually dating the event in question. An example of this are the radiocarbon dates from the Killermont site (Wk-2782, Wk-2783, Wk-2916, Wk-2991) which were all derived from identified charcoal other than one piece in each sample being unidentified (see Table 2). Though the charcoal radiocarbon ages are consistent for this site and inbuilt age is probably negligible, they are placed to one side for this analysis (though not outrightly rejected) as a precaution as there would still be the possibility that these ages are not showing the latest time for moa-hunting at this location;

B. the identified charcoal dated is still at risk of possessing high inbuilt age. After 1976, charcoal samples from New Zealand archaeological sites were identified to twigs of short-lived tree and shrub species prior to radiocarbon dating to reduce the risk of inbuilt age (see Anderson 1991; Schmidt 1996a, 2000b). However, opinion is divided on the actual longevity of various tree and shrub species used for dating, as well as whether longevity is a relevant consideration for the sample being dated as because the sample constitutes twig charcoal, these constituents represent only a few years of growth (see McFadgen, Knox and Cole 1994; Schmidt 2000b: 29-31). In this discard protocol, any radiocarbon ages derived from twig charcoal that is dominated or co-dominated by long-lived species are rejected as a precaution against inbuilt age (see Tables 2 and 4).

2. Marine shell radiocarbon ages from moa-hunting sites may be excluded where:

C. all or part of the marine shell sample dated has not been identified to shellfish species. A radiocarbon age derived from unidentified shellfish species may contain species which are known not to be reliable for radiocarbon dating New Zealand prehistory (see discard protocols D and E), therefore dates on these samples are rejected;

D. the shellfish species radiocarbon dated has an unknown reliability. At present, nine shellfish species have been identified as being reliable for radiocarbon dating New Zealand prehistory through the comparison of charcoal/marine shell paired radiocarbon ages from archaeological deposits throughout New Zealand (Table 5) (see Schmidt 2000b). Other species of shellfish radiocarbon dated must be deemed unreliable at present until future research confirms them otherwise;

E. the shellfish dates have been derived from the deposit feeding organisms *Amphibola crenata* (mudsnail) or *Macomona liliana*. These species of shellfish have been observed as showing variations in their measurable ^{14}C, and hence are unreliable for dating purposes (see Anderson 1991:768, 1996; Higham 1993; Schmidt 1996b; Hogg, Higham and Dahm 1998).

3. Radiocarbon ages from moa-hunting sites may also be rejected where:

F. Unacceptable materials have been used or where the reliability of the material as a dating medium is at present unknown for New Zealand archaeology. These include peat, kumara, soil, grease and feather (see Anderson 1991, 1996; Schmidt 1996b, 2000b; Higham and Hogg 1997);

G. Dates from archaeological sites where there is evidence or the possibility of post-depositional disturbance are rejected. Here the exact provenance and chronological integrity of the sample is dubious;

H. it is unclear whether the dated sample is in direct association with evidence of moa-hunting. For these radiocarbon ages, establishing the exact provenance of the sample was difficult to ascertain even though they may date moa-hunting at the site, therefore these dates were put to one side;

I. the conventional radiocarbon age is less than 250 years BP. Such dates can only be deemed modern.

4. Acceptance of radiocarbon ages

J. Radiocarbon dates from New Zealand moa-hunting sites are accepted when they pass all the tests above.

Results

After application of the discard protocol, only nine marine shell, 14 charcoal and no moa egg shell ^{14}C ages are available for further analysis. Forty two percent of marine shell ages were rejected because the shell species dated were either unidentified, untested or from unreliable species, with 64% of charcoal ages being discarded due to the sample constituents either being unidentified or dominated by long-lived species. All moa egg shell ^{14}C ages were rejected because both sites dated with this sample type were post-depositionally disturbed.

All acceptable marine shell and charcoal CRA from New Zealand moa-hunting sites were calibrated to years cal AD at 1σ using CALIB 4.0 (see Stuiver and Reimer 1993) (Figures 2 and 3). Marine shell CRAs were calibrated using the modelled marine calibration curves of Stuiver, Reimer and Braziunas (1998) and applying a ΔR value of -25 ± 15 years (Higham and Hogg 1995). Charcoal CRA were calibrated using the Stuiver *et al.* (1998) decadal atmospheric calibration curves with application of the southern hemisphere correction of -27 years BP as recommended by McCormac *et al.* (1998).

Both calibrated marine shell and charcoal radiocarbon ages in figures 2 and 3 indicate that moa-hunting possibly ceased in North and South Islands at *ca.* 1650 AD. However, there appears to be three sites in figure 3 with anomalous radiocarbon dates. The sites of Hahei, Rockfall II and Italian Creek all show large age variations between the youngest and oldest calibrated charcoal ^{14}C dates from the same provenance within each site, causing difficulty when attempting to define when moa-hunting actually occurred at these locations. Even when the charcoal CRA from these sites are calibrated at 2σ (see Table 6), only the calibrated charcoal ages from Italian Creek overlap, but due to the large standard errors associated with the charcoal ages from this site, the calibrated age ranges are spread over 700 years. All the charcoal samples from these sites were identified to twigs of short-lived tree and shrub species prior to radiocarbon dating, and so should retain negligible inbuilt age. Whether the charcoal age differences at these sites is due to the older dates still being affected by inbuilt age, or the younger ages due to contamination of the samples by more modern carbon, is difficult to ascertain. Because of these concerns, the charcoal radiocarbon ages from these sites are put aside from further analysis.

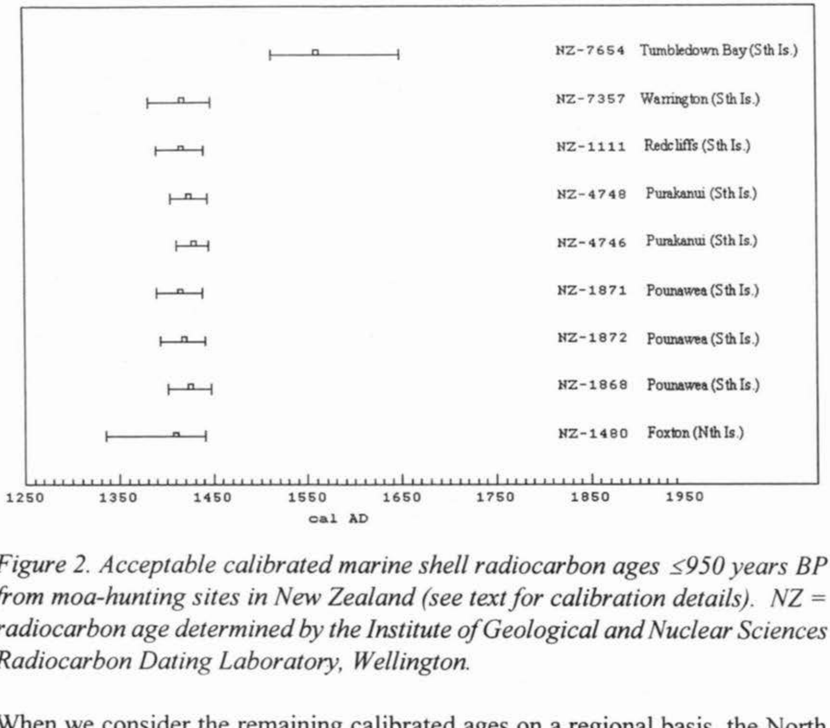

Figure 2. Acceptable calibrated marine shell radiocarbon ages ≤950 years BP from moa-hunting sites in New Zealand (see text for calibration details). NZ = radiocarbon age determined by the Institute of Geological and Nuclear Sciences Radiocarbon Dating Laboratory, Wellington.

When we consider the remaining calibrated ages on a regional basis, the North Island appears to show moa-hunting ceasing at *ca.* 1450 AD, but in the South Island at *ca.* 1650 AD as illustrated by the calibrated marine shell age from Tumbledown Bay (NZ-7654)[4] (Figures 2 and 3). *Pa* (fortification) construction is believed to have begun after moa-hunting ceased in New Zealand prehistory, as evidenced by no moa remains having being found in these site types (Schmidt 1996b). The earliest calibrated radiocarbon ages from *pa* in the North Island indicate commencement of *pa* construction at around 1500 AD, and from the South Island the earliest reliable *pa* calibrated radiocarbon ages show building possibly began *ca.* 1650 AD (Schmidt 1996a:446, 460). This data suggests that both moa-hunting ceased and *pa* construction commenced in the South Island of

[4] The calibrated marine shell radiocarbon age from Tumbledown Bay (NZ-7654) is in agreement with Petchey's (1999) calibrated moa bone collagen radiocarbon date (1487-1670, 1780-1797, 1942-1945 cal AD at 1σ) from the same provenance.

New Zealand some 200 years after these events had taken place in the North Island.

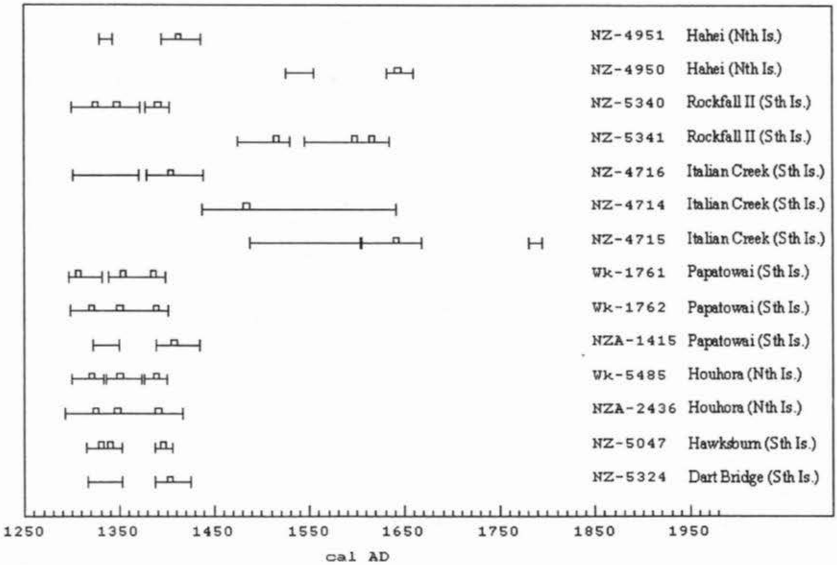

Figure 3. Acceptable calibrated charcoal radiocarbon ages ≤ 650 years BP from moa-hunting sites in New Zealand (see text for calibration details). NZ= radiocarbon age determined by the Institute of Geological and Nuclear Sciences Radiocarbon Dating Laboratory, Wellington. Wk= radiocarbon age determined by the University of Waikato.

Discussion and Conclusions

This analysis of radiocarbon ages from late moa-hunting sites does appear to support Anderson (1989) and Petchey's (1999) respective charcoal and moa bone radiocarbon chronologies which show moa-hunting was still active in New Zealand at least until 1500 AD. Holdaway and Jacomb's (2000:2251) Leslie matrix population model of rapid moa extinction is not supported by the moa-hunting radiocarbon chronology presented in this study.

What the data from this analysis also illustrates, however, is that there is essentially a lack of well dated moa-hunting sites outside of Wairau Bar and Shag Mouth in the South Island, to be able to determine a precise end of this activity in New Zealand prehistory as a whole. The number of reliable early radiocarbon ages from New Zealand *pa* at present totals 60 (Schmidt 1999), whereas in this analysis only 14 reliable ages from late moa-hunting sites have been isolated. Of these 14 dates, only 5 are from North Island sites.

In addition to a lack of well dated moa-hunting sites, another factor which compounds determining the end of moa-hunting, is New Zealand's short prehistoric chronology. With colonisation of New Zealand believed to have occurred *ca.* 1250 AD (Anderson 1991; Higham and Hogg 1997), archaeological sites with single radiocarbon ages from prehistoric contexts can only provide a possible time in which an event occurred relative to initial Polynesian colonisation, changes in artefact and settlement style and form, and Cooks arrival in 1769. This is because New Zealand radiocarbon dating laboratories produce conventional radiocarbon dates with a standard error of ± 40 years at 1σ as the norm, though these errors may be greater (see the New Zealand Radiocarbon Dating Database). When a charcoal or marine shell radiocarbon age with this standard error is calibrated, the calibrated age range may be significantly increased due to either 'wiggles' in the atmospheric calibration curve when calibrating a charcoal age, or a flattening of the modelled marine calibration curve when calibrating marine shell dates. For the period 1500 AD to 1700 AD in which moa-hunting possibly ceased, these atmospheric and modelled marine calibration curve variances are particularly pronounced (see Stuiver *et al* 1998: 1073, 1083; Schmidt 2000b: 88-93), making it difficult to narrow down when a moa-hunting site was abandoned. Only through deriving a sweep of ^{14}C ages from a moa-hunting site, such as at Wairau Bar and Shag Mouth, can these radiocarbon dates then be statistically combined to reduce the standard error, and the pooled age calibrated to produce a more precise time for this event.

The difficulty in verifying whether a site with Archaic artefacts and no moa remains infers that moa were extinct in that region, also complicates determining when moa-hunting ceased. The Monck's Cave archaeological site discussed by Holdaway and Jacomb (2000) does have an extensive radiocarbon record, and its lack of moa remains together with its Archaic to Classic style artefacts, does appear to show moa were not resourced in the area local to the site during the late 14^{th} to early 15^{th} centuries AD. But this site does not demonstrate that all regions in New Zealand during this time were devoid of moa. The young marine shell and moa bone collagen radiocarbon ages from Tumbledown Bay on the opposing side of the peninsula from Monck's Cave, may indicate that sporadic hunting of small populations of moa was still occurring in this region until the mid 17^{th} century AD (Figure 1). This site may illustrate opportunistic hunting as the resource was encountered during movements down the east coast of the South Island.

In conclusion, this study has proposed a chronology for when moa-hunting may have ceased regionally in New Zealand based on acceptable radiocarbon ages, but in doing so it has also demonstrated that one important aspect of New Zealand prehistory essentially still remains unanswered due to a lack of data. Until further sites similar to Monck's cave, Tumbledown Bay, Wairau Bar and Shag Mouth are identified, excavated, and dated extensively, the question of when precisely the last moa was hunted in New Zealand prehistory remains open.

Acknowledgements

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Table 4. McFadgen, Knox and Coles's (1994: 224) table of life expectancy of plant species used for radiocarbon dating in New Zealand. This table is used to reject charcoal radiocarbon ages from moa-hunting sites which have been dated using charcoal samples dominated or co-dominated by long-lived tree or shrub species.

Short (< 100 yr)	Medium (100–300 yr)	Long (> 300 yr)
Aristotelia serrata	*Ackama rosifolia*†	*Agathis australis*
Brachyglottis sp.	*Alectryon excelsus*	*Dacrydium cupressinum*
Carmichaelia sp.	*Beilschmiedia* sp.‡	*Halocarpus kirkii*
Carpodetus serratus‡	*Cordyline australis*	*Lagarostrobus colensoi*†
Cassinia sp.	*Corynocarpus laevigatus*	*Laurelia novaezelandia*†
Coprosma sp.	*Discaria toumatou*	*Libocedrus bidwillii*†
Coriaria sp.	*Dysoxylum spectibile*	*Metrosideros* sp.
Corokia macrocarpa	*Hoheria* sp.†	*Nothofagus* sp.†
Geniostoma rupestre	*Knightia excelsa*	*Phyllocladus* sp.†
Hebe sp.	*Kunzea ericoides*	*Podocarpus totara*
Hedycarya arborea‡	*Myrsine divaricata*†	*Prumnopitys spicatus*
Leptospermum scoparium‡	*Myoporum laetum*	*Vitex lucens*†
Leucopogon fusciculatus	*Nestigis* sp.‡	
Lophomyrtus obcordata‡	*Olearia* sp.	
Macropiper excelsus	*Pseudopanax* sp.†	
Melicytus ramiflorus‡	*Paratropis microphylla*	
Melicytus sp.‡	*Pittosporum eugenoides*	
Myrsine australis‡	*Pittosporum tenuifolium*†	
Myrsine sp.‡	*Plagianthus* sp.	
Olearia rani‡	*Sophora microphylla*	
Pseudopanax arboreus‡	*Sophora* sp.	
Pseudopanax crassifolius‡	*Weinmannia* sp.	
Pseudowintera sp.		
Pteridium esculentum		
Schefflera digitata		
Tree fern		

*Data provided by Dr. Philip Simpson, Botanist, Science and Research Division, Department of Conservation.
†Life span can be much shorter than designated years.
‡Life span can be longer than designated years.

Table 5. Shellfish species found to be reliable for radiocarbon dating New Zealand prehistory (from Schmidt 2000b: 96).

Estuarine	Sandy Shore	Rocky Shore
Austrovenus stutchburyi *Paphies australis* *Venerupis largillierti*	*Paphies subtriangulatum*	*Cominella adspersa* *Cominella virgata* *Crassostrea glomerata* *Lunella smaragda* *Perna canaliculus*

Table 6. Charcoal conventional and calibrated radiocarbon dates from Hahei, Italian Creek and Rockfall II moa-hunting sites (see text for calibration details and Figure 3 for 1 σ calibrated ages from these sites). Charcoal CRAs from the same provenance in these sites vary markedly even though the charcoal samples have been identified to twigs of short-lived tree and shrub species. (CRA = conventional radiocarbon age. NZ = radiocarbon age determined by the Institute of Geological and Nuclear Sciences Radiocarbon Dating Laboratory, Wellington).

Lab No.	Site & Site No.	Provenance	Tree and shrub species identification	CRA years BP	calibrated age range AD at 2σ
NZ-4950	Hahei (T11/326)	Firepit, top layer 4	*Melicytus ramiflorus, Hebe sp. - codominant; Agathis australis - subdominant; Pittosporum sp. - minor*	300 ± 45	1487 – 1604 1606 – 1673 1778 – 1799 1943 – 1945
NZ-4951	Hahei (T11/326)	Firepit, top layer 4	*Pittosporum sp, Melicytus ramiflorus - codominant; Agathis australis - minor; Pseudopanax colensoi/arboreus group - rare*	556 ± 61	1300 – 1373 1377 – 1454
NZ-4715	Italian Creek (G42/183)	Square A2, Layer 1A - hearth.	*Hebe sp. - 50%, Discaria toumatou - 50%*	309 ± 82	1441 – 1694 1726 – 1813 1849 – 1865 1918 – 1949
NZ-4714	Italian Creek (G42/183)	Square A2, Layer 1A - hearth.	*Hebe sp. - 84%, Discaria toumatou - 16%*	399 ± 88	1406 – 1669 1781 – 1796
NZ-4716	Italian Creek (G42/183)	Square A4, Layer 1A – hearth.	*Discaria toumatou - 66%, Hebe sp. - 34%*	579 ± 96	1279 – 1491 1603 – 1609
NZ-5341	Rockfall II (G41/453)	Sample was from an oven excavated into layer 2 [buff silt].	*Discaria toumatou - dominant; Hebe sp. - minor; Sophora sp. [probably S. microphylla], Coprosma sp. - minor*	376 ± 38	1445 – 1644
NZ-5340	Rockfall II (G41/453)	Sample derived from an oven excavated into layer 2 [buff silt].	*Discaria toumatou - dominant; Sophora sp. [probably S. microphylla] - minor; Coprosma sp., Leptospermum ericoides - trace*	632 ± 45	1290 – 1421