

Animal Health Board possum control operations on public conservation lands: habitats treated and resulting possum abundance

Ben Reddiex, Wayne Fraser, Steve Ferriss and John Parkes

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ABSTRACT

Possums (*Trichosurus vulpecula*) are the main agents of transmission of bovine Tb to domestic stock in New Zealand. In 2004/05, the Animal Health Board (AHB) undertook possum control on over 5 million ha of land, some of which was on public conservation lands administered by the Department of Conservation (DOC). It is important that we determine the benefits of the AHB's possum control to conservation before this control is reduced or ceased once Tb has been eradicated from wild animal populations. In this study, we quantify and map the location, type and frequency of AHB-funded possum control on public conservation lands for eight management areas (Manawatu-Wanganui, Wellington, Tasman, Marlborough, Canterbury, West Coast, Otago and Southland regions) during 2000/01–2003/04. Data on 1600 possum control operations were collected and analysed. In total, c. 170 000–360 000 ha/year of woody vegetation (forest and scrub) on public conservation lands received AHB-funded possum control, with much of this area receiving regular maintenance control. Although it is likely that maintaining possums at low densities would result in some conservation benefit, we did not measure this directly. Furthermore, there was a general lack of institutional memory of the details of possum control operations in several of the regions surveyed. The lack of measurement of conservation benefits and of consistent and quality data on possum control makes it difficult for DOC or regional councils to plan optimal responses to any reduction or cessation of the AHB's possum control.

Keywords: brushtail possum, *Trichosurus vulpecula*, pest control, Animal Health Board, public conservation lands, control frequency, residual trap catch, conservation benefit, geographic information system (GIS), Land Cover Database

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1. Introduction

The Animal Health Board (AHB) undertakes control of the introduced brushtail possum (*Trichosurus vulpecula*) on public conservation lands managed by the Department of Conservation (DOC) as part of its vector (i.e. transmission agent) management strategy to eradicate bovine tuberculosis (Tb) from domestic livestock. DOC and AHB want to know what benefits to conservation might accrue from AHB's possum control so that they can identify and understand the consequences for conservation once the AHB reduces or ceases control after eradicating Tb from wild animal populations in defined areas of public conservation land.

The initial aim of this project was to undertake a field experiment to assess the conservation benefits of AHB-funded possum control (Reddix & Parkes 2003). The experiment aimed to compare forest canopy condition and relative bird abundance on sites receiving intensive AHB-funded possum control (i.e. annual for at least 3-5 years) with those in comparable, nearby areas of forest that had not received any possum control. Following considerable discussion with AHB staff from several Tb vector management areas on the availability of suitable study sites, five paired sites on public conservation lands were identified. One paired site was sampled in Southland (see Appendix 1). However, when the information supplied for several of the other recommended study sites was found to be inaccurate, the field component of this study was halted. It became apparent that a major limiting factor in undertaking experimental work on the benefits of possum control was the lack of detailed information on the exact location, type and frequency of AHB-funded possum control on public conservation lands at both a conservancy and national level.

As a first step in identifying the benefits to conservation from this possum control, DOC and the AHB commissioned Landcare Research to quantify the location, type and frequency of AHB-funded possum control on public conservation lands. The work was carried out from March 2004 to August 2005.

2. Background

Large-scale control of possums in New Zealand is carried out mostly because they are vectors of Tb to domestic cattle and deer (Coleman & Caley 2000) or to protect indigenous biota (DOC 1994). The total area of New Zealand receiving possum control increased markedly through the 1990s in response to large increases in expenditure both by the AHB and DOC, reflecting the development of the National Pest Management Strategy for Tb (AHB 2004) and a National Possum Control Plan (DOC 1994). DOC controls possums on c. 1 million ha of public conservation lands where its priorities are

highest (Parkes & Murphy 2003), while the AHB has controlled possums on 4.5 million ha, of which c. 13% has been estimated as being on public conservation lands (2001/02 data collected for Fraser et al. 2004).

The AHB's possum control might result in substantial conservation benefits, especially in areas where a strategy of frequent control keeps possum densities very low. Presumably, fewer conservation benefits accrue at sites where the control is less frequent (see Choquenot & Parkes 2000). However, the conservation benefits of the AHB investment have never been measured.

Information on planned AHB control operations is held by individual DOC conservancies, but the nature and quality of this information varies widely. DOC receives information on AHB control operations via the Assessment of Environmental Effects application process. In most cases, locations of control areas are supplied as paper maps, while post-control monitoring results and information on the habitat types targeted by control are often not sent to conservancies at all. These key vector control data are held in unique systems by each vector manager (i.e. each manager of one of the 14 AHB-defined regions that undertake vector control, which is the range of activities directed towards identification and control of wildlife sources of Tb). DOC has a national database system (called 'Pestlink') for recording possum control data from operations undertaken by the Department, but this system is currently not GIS capable. Hence, there is no national system for recording and collating all key possum control information.

3. Objectives

- To compile data on historical and ongoing AHB-funded possum control on public conservation lands.
- To map the area of public conservation lands in each region where the AHB has conducted possum control for at least the period 2000/01–2003/04.
- To quantify the area of public conservation lands in each vector management region (by landcover type) undergoing different types and frequencies of possum control, and to summarise residual-trap-catch index (RTCI) data (where available) for at least the period 2000/01–2003/04 as an indicator of the likely benefit to biodiversity of the possum control carried out.

4. Methods

4.1 SURVEY PROCESS

All vector managers were requested to provide data on historical and current possum control operations to Landcare Research in a standard format (Appendix 2). Two vector managers (Environment Waikato and Hawke's Bay Regional Council) declined to do this because of time and cost constraints. The project budget did not allow us to fund their time. Following a brief review of the number of possum control operations in each region for which we had obtained data, the years that data were available, and the budget for this project, we then focused on collecting all available data for eight vector management regions (Manawatu-Wanganui, Wellington, Tasman, Marlborough, West Coast, Canterbury, Otago, and Southland; Fig. 1). These regions comprise over 18 million ha, of which c. 6.4 million ha are public conservation lands (Table 1). Of the vector management regions where control information was not collected (i.e. Northland, Auckland, Waikato, Bay of Plenty, Hawke's Bay and Taranaki) only the Waikato and Hawke's Bay regions have substantial areas of vector control.

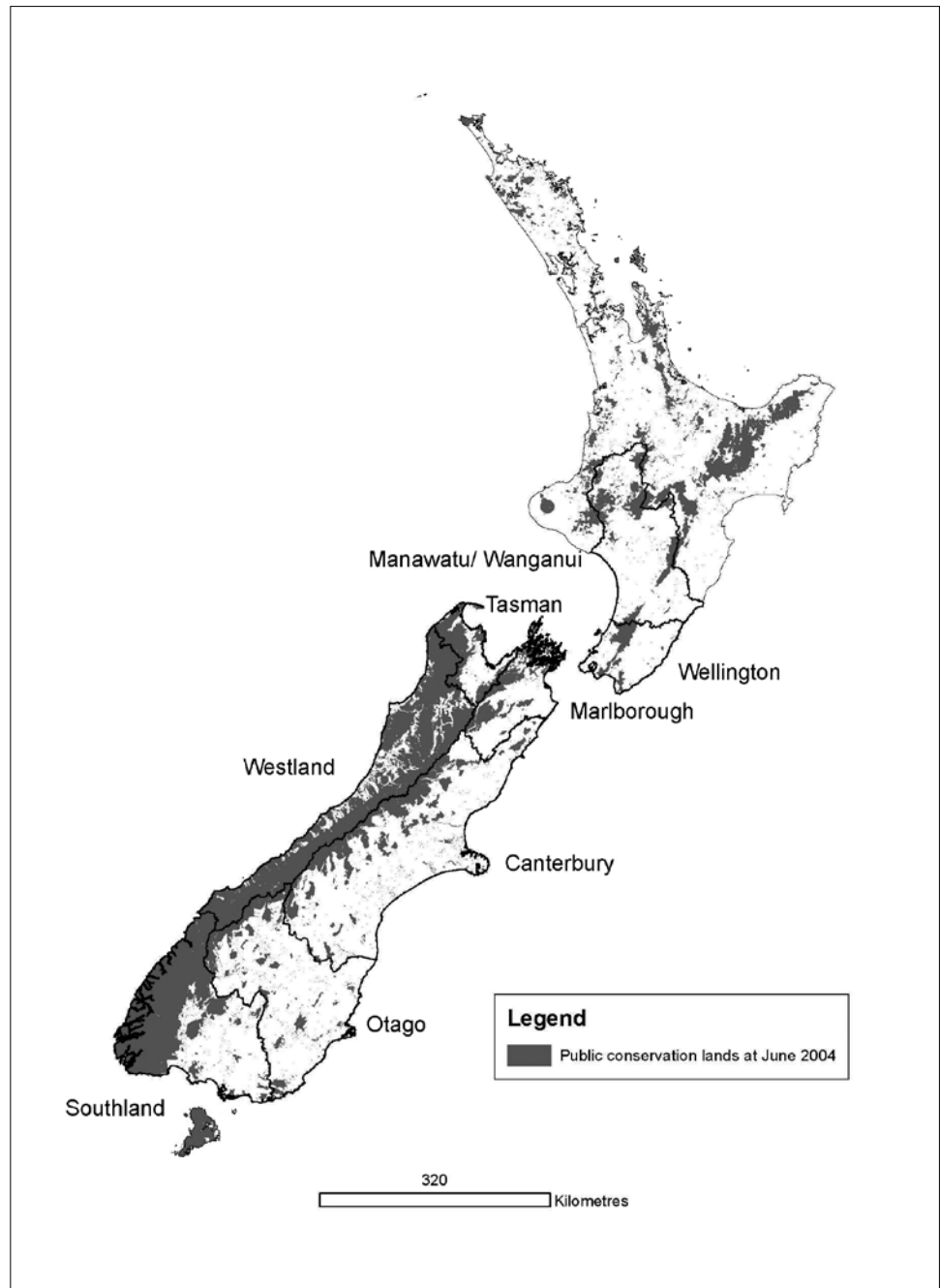
For all regions, data were initially collected at meetings rather than by correspondence. This avoided potential misinterpretation of the survey form and a low response rate, both of which are common problems in mail surveys (Dillman 1978). For most regions, the required information could not be obtained from a single meeting. Where possible, the remaining information was obtained from operational reports that included monitoring data, PestCalc outputs (computer software that analyses pest control monitoring data), electronic spreadsheets and databases from vector managers. Difficulties relating to data collection included discrepancies between

TABLE 1. TOTAL LAND AREA WITHIN VECTOR MANAGEMENT REGIONS FROM WHICH POSSUM CONTROL INFORMATION WAS COLLECTED, AND THE AREA OF PUBLIC CONSERVATION LANDS WITHIN EACH REGION.

REGION	TOTAL AREA (ha)	PUBLIC CONSERVATION LAND AREA* (ha)
Manawatu-Wanganui	2 216 882	396 091
Wellington	813 561	142 298
Tasman	632 843	326 392
Marlborough	1 048 612	320 992
West Coast	2 709 299	2 258 288
Canterbury	4 516 731	829 017
Otago	3 190 754	484 886
Southland	2 998 406	1 685 574
Total	18 127 088	6 443 538

* The areas of public conservation lands do not include c. 96 000 ha (over the eight regions) that were classified as vested reserves, or have other forms of protected status.

Figure 1. Vector management areas where Animal Health Board-funded possum control information was collected and public conservation lands (shading) in New Zealand.



polygons/shapefiles provided and the total area under control operations listed in the vector managers' operational reports, and changes in the control operation names over time. Surveys were completed between May 2004 and April 2005.

4.2 SURVEY AND DATABASE STRUCTURE

Data for each possum control operation (including monitoring information) were stored in a Microsoft Access database, which was linked to spatial information in a GIS (which contained one or more polygons that describe the spatial extent of control). We attempted to coordinate our data collection

with the formats planned for use in the AHB's Vector Management Information System (VMIS) to enable our data to be easily uploaded into that system (note: the VMIS is currently being developed, and limited historical data will be captured by the system). For each region, we included all control operations in each financial year for as many years as possible (as a minimum, the financial period 2000/01-2003/04 was surveyed in each region).

4.3 DATA COLLECTED

Summary information on the general characteristics of control operations is presented in Appendix 3. Detailed information on control operations or control in given locations can be obtained from the Microsoft Access database and associated GIS shapefiles held at Landcare Research, Lincoln.

All spatial and temporal analyses were undertaken by combining the Microsoft Access 2000 database of vector managers' control information with shapefiles constructed in ArcGIS™ GIS software. In the few instances where control boundaries were not available, those operations were omitted from all analyses. The processes of combining data from a range of sources to complete the database (i.e. combining population monitoring with control operation data) and relating the correct control polygons to the control operation information were the difficult and time-consuming parts of this project. Difficulties arose from the fact that data were collected from at least eight different sources, each with different data-organisation styles and data formats. Linking control operation data often involved checking control operational area names, spatial locations and dates. Sometimes, extensive follow-up by phone, email or revisiting the vector manager was required. Despite this, some control operation data had to be abandoned. For all year-based analyses, control was deemed to have been undertaken in a given financial year (1 July-30 June) if control commenced in that year (i.e. where possum control crossed two financial years it was recorded only for the year in which it began). The extent of public conservation lands in June 2004 was supplied as a shapefile by DOC.

The areas where possums were actually controlled in any year sometimes encompassed only part of the operational area (i.e. in some years possum control was undertaken in only parts of some control polygons supplied). This was especially so when an initial control operation (the first time an area is treated) might cover an entire forest and its surrounds (i.e. the whole polygon) but subsequent maintenance control (follow-up control of an initial operation) was conducted only along the forest-pasture margin, but the same polygon as was used in the initial operation was supplied. Therefore, to classify the actual area treated we collected data on the type of habitat (e.g. forest, forest-pasture margin, farmland; Appendix 4) in the public conservation lands under possum control in each operational area. To allow consistent analysis we used the following rules:

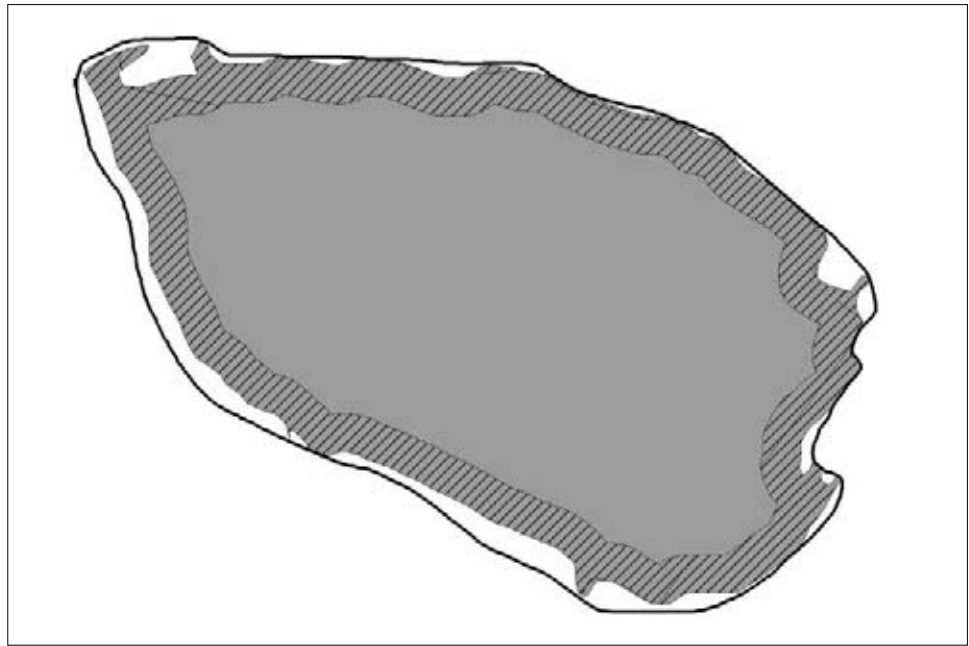
- If the operational area boundaries were known but the part treated in any year was unknown, we assumed all of the public conservation lands within the operational areas were treated. This would overestimate the area of land treated.
- If the actual area treated each year was provided, then the area of public conservation lands within the treated area was included in the analyses.
- We used the Land Cover Database Version 2 (LCDB2) from the Ministry for the Environment to calculate the areas of different habitat (Appendix 4) within public conservation lands treated for possum control. In this report we present data for only 'forest' and 'scrub' habitats, and pool indigenous and exotic categories—exotic vegetation formed a very low proportion of the vegetation on public conservation lands. The full list of LCDB2 habitat classes is in the Access database.
- If either 'farmland' or 'forest-pasture' categories were identified in the survey form (Appendix 2), then all forest and scrub within a 200-m range of 'pasture/other' was deemed to have been treated. The 200-m range was based on Cowan & Clout's (2000) review of possum movement in response to bait stations and poison lines, which found that the distance possums are likely to move to these control devices over a 1-2-week period was limited to 200-400 m.

Because there were two types of treatments, entire forest blocks and buffer strips (i.e. forest buffer of a nominated width or forest-pasture margin with a 200-m width), the data were analysed using two different methods. The ArcMap model builder was used extensively to facilitate repeated overlays of similar data in the GIS. All regions' GIS polygons were given a unique identifier to enable them to be synchronised with the databases of vector managers' control data. Each treatment area polygon was overlaid with the DOC shapefile of public conservation lands and intersected with the LCDB2 vegetation classes. To assess the area of forest receiving possum control for the forest block habitat type, the intersect was dissolved and area of forest (in ha) was calculated from the shapefile area (Appendix 5). In some regions, multiple overlays were necessary to calculate areas where different years had different control polygon boundaries. To assess the area of buffer strips receiving control, arcs from LCDB2 vegetation classes were used to define the forest-pasture boundary, and a 200-m buffer applied to those arcs. These buffers were then intersected with the composite treatment area, public conservation lands and LCDB2 output (Appendix 5). The resultant shapefile represented those areas of forest within 200 m of a forest-pasture margin that are public conservation lands and had received possum control. Figure 2 provides an example of the area of forest treated when forest-pasture margins were classified as being treated.

The total area of possum control per region by year was categorised as receiving initial, maintenance or unknown control, and the type of control as being ground, aerial, a combination of ground and aerial, or unknown.

The number of times that a given area had received possum control was determined by overlaying area polygons for successive years' treatment in the GIS. Areas were based on the total area of control operations only (i.e. not the areas assessed as being treated by incorporating information

Figure 2. Example of a possum control operation where the boundary for the initial control (solid line) might include all of the forest block and its surrounding farmland (shading), but where subsequent maintenance control operations were only along the forest-pasture boundary (hatching). When the forest was the boundary of the public conservation land, only the hatched area—a 200-m strip of forest (or other LCDB2 habitats therein if appropriate)—was included in the analyses for the maintenance control operation.



on habitat types), and therefore overestimate the actual area treated. Results are presented for forest and scrub habitat on public conservation lands only. The number of years of control operations obviously restricted the number of times control was possible. Interpretation of the frequency of possum control operation on public conservation lands is constrained by:

- Changes in control operation boundaries over time that occurred in four of the eight regions
- The frequency of control within an operational area that changed (e.g. the frequency of treatment changed from every 3 years to annually)
- The number of years of control operation information, which varied from 4 to 11 between regions
- The recent commencement of some control operations.

In the absence of measured conservation benefits, residual-trap-catch indices (RTCIs) have been used as an indicator of the likely benefit to biodiversity. The limitation of this approach is that the possum abundance that will provide protection to a range of vegetation species and communities will vary markedly, depending on the vulnerability of those species and communities involved (see Discussion for further comment on this issue). The total area of possum control per region by year as calculated above was presented for each of four RTCI categories for the years 2002/03 and 2003/04 only (i.e. the only years where RTCIs were available for all regions).

4.4 REGIONAL DETAILS

Manawatu-Wanganui: Details of all control operations in the region were supplied by Horizons Regional Council (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of control operations were provided electronically (as GIS polygons)

for each year in the period 1999/2000–2003/04. In most cases, control boundaries of given maintenance control operations varied between years. In the absence of specific details, we have assumed that the existence of a polygon is confirmation that a control operation was undertaken in that area in that year. Information on specific control characteristics were obtained from post-operational reports that include monitoring data, and PestCalc outputs. Missing information was requested and supplied by the Council to enable completion of a separate project (Warburton et al. 2005). Warburton et al. (2005) were not able to locate any information on the biodiversity benefits of AHB-funded possum control in the Manawatu-Wanganui region in their investigation. No information was provided on the specific habitats controlled in each control operation, which prevented analyses on the habitat types treated in this region (see section 4.3).

Wellington: The locations of control operations were supplied electronically (as GIS polygons) for each year in the period 1993/94–2003/04 by Greater Wellington Regional Council (Vector Manager). Control boundaries (i.e. polygons) of given operations did not vary between years. Information on specific control characteristics was obtained from electronic and paper-based reports.

Tasman: Details of all control operations in the Tasman region were supplied by Southern Pest Management (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of control operations were provided electronically (as GIS polygons) for each year in the period 2000/01–2003/04. Control boundaries (i.e. polygons) of given operations did not vary between years. Details of specific control operations were obtained from post-operational reports.

Marlborough: Details of all control operations in the region were supplied by Marlborough District Council (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of control operations were provided electronically (as GIS polygons) for each year in the period 1997/98–2003/04. In most cases, control boundaries (i.e. polygons) of given operations varied between years.

West Coast: Details of all control operations in the region were supplied by West Coast Regional Council (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of all ground-based control operations were provided electronically (as GIS polygons) for each year in the period 1993/94–2003/04. However, details of 44 of the 48 aerial-based control operations were supplied as paper maps only and were subsequently digitised. Control boundaries (i.e. polygons) of ground-based control operations did not vary between years of control. However, nearly all aerial maintenance control operations had unique control polygons. Details of specific control operations were obtained from electronic spreadsheet files, but this information was largely unavailable for the years prior to 2002/03.

Canterbury: Details of all control operations in the region were supplied by Environment Canterbury (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of control operations were provided electronically (as GIS polygons) for each year in the

period 1996/97–2003/04. In most cases, control boundaries (i.e. polygons) of given operations varied between years. Details of specific control operations were obtained from post-operational reports.

Otago: Only information about control operations in the region that contained public conservation lands was supplied by Southern Pest Management (Vector Manager). The locations of control operations were provided electronically (as GIS polygons) for the period 1996/97–2003/04. Control boundaries (i.e. polygons) of given operations did not vary between years. Details of specific control operations were obtained from electronic files for the period 1999/00–2003/04, while earlier paper-based reports were photocopied, selection of the relevant reports being based on operation names provided by Southern Pest Management.

Southland: Details of all control operations in the region were supplied by Environment Southland (Vector Manager), irrespective of whether they contained information on public conservation lands. The locations of control operations were provided electronically (as GIS polygons) for each year in the period 1988/89–2003/04. However, control operation details were available only for 1997/98–2003/04. In most cases, control boundaries (i.e. polygons) of operations varied between years. In the absence of specific control operation details we have assumed that the existence of a polygon is confirmation that a control operation was undertaken in that area in that year. Details of specific control operations were obtained from spreadsheet files, or collated by Environment Southland staff and supplied at a later date. However, there was a considerable amount of missing information on control operations in the period 1997/98–1999/2000, and some disparity in RTCI results between information sources.

5. Results

5.1 EXTENT OF THE ANIMAL HEALTH BOARD'S POSSUM CONTROL ON PUBLIC CONSERVATION LANDS

Information on a total of 1600 possum control operations was collected, although the amount and quality of control operation information varied markedly between regions. The majority of the data relate to operations undertaken in Southland ($n = 420$), Manawatu-Wanganui ($n = 277$) and Otago ($n = 260$). The number of operations per year ranged from four in 1993/94 to 322 in 2001/02, but most of the data (73%) relate to the period 2000/01–2003/04 (Fig. 3). This does not reflect the actual amount of control operation activities undertaken during the period as several regions indicated that varying (sometimes considerable) amounts of additional data existed that they did not have the resources to locate and extract.

The AHB possum control operations in the eight regions combined covered c. 2.5 million ha in 2000/01 and c. 3.5 million ha in 2003/04 (Table 2). The observed increase in the area receiving control over the period 2000/01–2003/04 is largely a result of an increase in the number of control operations for which data were collected over this period. The AHB's expenditure on vector control increased from approximately \$30 million to \$54 million per year over the time period 2000/01–2003/04 which supports a real increase in the actual number of operations; however, a higher proportion of operations may have been reported in the latter years as well.

The combined total annual area of public conservation lands within AHB control operation boundaries in the eight regions over the period 2000/01–2003/04 ranged from c. 250 000 to c. 460 000 ha (Table 2).

Figure 3. Total number of possum control operations per year from all eight vector management regions for which information was collected.

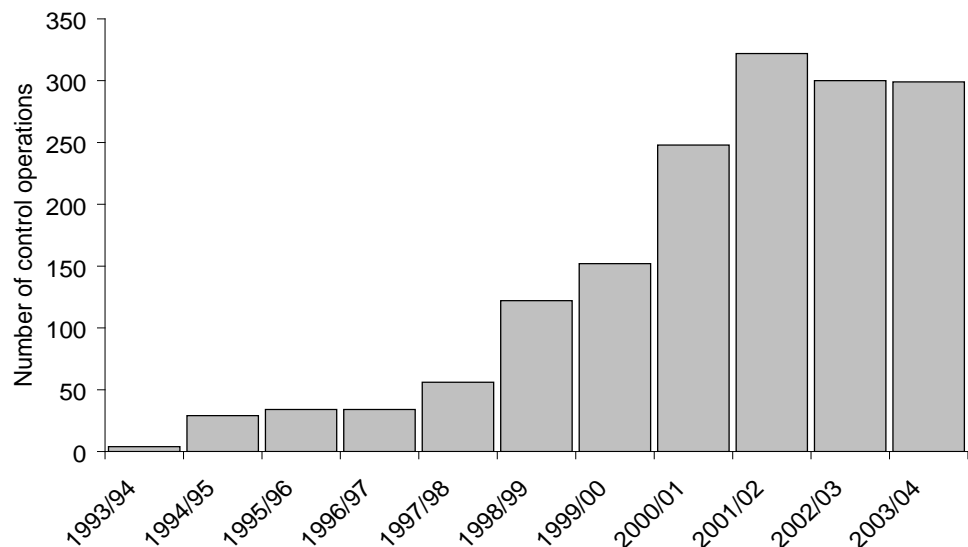


TABLE 2. TOTAL, KNOWN, AND COMBINED KNOWN AND POTENTIAL AREA (ha) OF POSSUM CONTROL OPERATIONS FOR ALL EIGHT SURVEYED AHB REGIONS IN PUBLIC CONSERVATION LANDS (PCL). KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY.

YEAR	TOTAL AREA OF CONTROL OPERATIONS	TOTAL AREA OF PCL IN CONTROL OPERATIONS	KNOWN AREA [*] OF PCL CONTROLLED		POTENTIAL AREA [†] OF PCL CONTROLLED		COMBINED KNOWN AND POTENTIAL AREA OF PCL CONTROLLED	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
2000/01	2 479 307	249 543	122 878	10 865	33 554	3022	156 432	13 887
2001/02	3 141 834	345 997	149 602	24 521	77 848	4320	227 450	28 841
2002/03	3 667 063	462 510	223 843	37 099	90 648	8372	314 491	45 471
2003/04	3 481 312	455 652	193 703	30 244	109 830	13 030	303 533	43 274

* Possum control operations where habitat types were known.

† Possum control operations where habitat types were not provided.

5.2 ANIMAL HEALTH BOARD'S POSSUM CONTROL IN FOREST AND SCRUB HABITATS

The majority of control operations (95%) included public conservation lands within the control boundaries (Table 3). These ranged from small reserves (<1 ha) to the entire control area (>c.10 000 ha). Forest-pasture margins and farmland were the most frequent habitat types targeted for control in Canterbury and on the West Coast, while forest, forest-pasture margins and farmland were all frequently targeted for control in Marlborough, Otago, Southland and Tasman. Forest was the most frequently targeted habitat type in Wellington, partially reflecting the fact that public conservation lands received control for that region.

The total known and potential area of forest habitat receiving possum control per year ranged from c.156 000 ha to c.314 000 ha, and of scrub habitat ranged from c.14 000 ha to c.45 000 ha (Table 2). There were significant differences in the amount of forest habitat receiving control between regions (see Appendix 6, Tables A6.1-A6.8 for the areas of control for each region by year).

The maximum area of forest and scrub on public conservation lands that received one or more years of AHB-funded possum control operation over the eight regions is c.800 000 ha (Table 4). It is important to note that this area will be overestimated, as the area was estimated from total control operation areas (see section 4.4), not on specific habitat types treated (i.e. would include all farmland habitat within the control area).

TABLE 3. NUMBER OF POSSUM CONTROL OPERATIONS FOR WHICH INFORMATION WAS COLLECTED, THE PERCENTAGE OF OPERATIONS THAT CONTAINED AT LEAST SOME PUBLIC CONSERVATION LANDS (PCL) AND THE PERCENTAGE OF CONTROL OPERATIONS THAT TARGETED DIFFERENT HABITAT TYPES, BY REGION. NOTE: HABITAT TYPE MAY EXCEED 100% IN SOME YEARS AS MULTIPLE HABITAT TYPES MAY HAVE RECEIVED POSSUM CONTROL IN INDIVIDUAL CONTROL OPERATIONS.

REGION	YEAR	NUMBER OF CONTROL OPERATIONS	PERCENTAGE OF OPERATIONS CONTAINING PCL (%)	HABITAT TYPE				
				FOREST (%)	FOREST BUFFER (%)	FOREST -PASTURE (%)	FARM-LAND (%)	UNKNOWN (%)
Manawatu-Wanganui								
	1999/00	14	79					100
	2000/01	37	87					100
	2001/02	77	83	18		18	18	79
	2002/03	74	84	8		5	4	93
	2003/04	75	84					100
Wellington								
	1993/94	3	100	100				
	1994/95	8	100	100				
	1995/96	5	80	100				
	1996/97	5	80	80		20		
	1997/98	9	100	89		11	11	
	1998/99	7	100	86		14	14	
	1999/00	4	100	75	25			
	2000/01	9	89	89		22	11	11
	2001/02	8	88	100				
	2002/03	6	100	100			17	
	2003/04	12	92	92			8	8
Tasman								
	2000/01	6	100	67		67	83	
	2001/02	8	100	88		88	88	13
	2002/03	17	100	100		94	94	
	2003/04	20	100	95		85	85	5
Marlborough								
	1997/98	1	100	100				
	1998/99	5	100	60		80	100	
	1999/00	6	100	100		100	100	
	2000/01	9	100	89		100	100	
	2001/02	12	100	83		92	92	8
	2002/03	14	100	86		93	93	7
	2003/04	14	100	79		93	93	7
West Coast								
	1993/94	1	100	100				
	1994/95	21	100	29		71	71	
	1995/96	29	100	31		69	69	
	1996/97	24	100	8		92	92	
	1997/98	24	100	8		92	92	
	1998/99	25	100	12		88	88	
	1999/00	29	100	14		86	86	
	2000/01	30	100	17		83	83	
	2001/02	30	100	17		83	83	
	2002/03	31	100	19		81	81	
	2003/04	30	100	17		83	83	

Continued on next page

Table 3—continued

REGION	YEAR	NUMBER OF CONTROL OPERATIONS	PERCENTAGE OF OPERATIONS CONTAINING PCL (%)	HABITAT TYPE				
				FOREST (%)	FOREST BUFFER (%)	FOREST -PASTURE (%)	FARM-LAND (%)	UNKNOWN (%)
Canterbury								
	1996/97	2	100				50	50
	1997/98	8	100	38		50	88	
	1998/99	10	100	10		50	70	30
	1999/00	19	100	11		21	79	21
	2000/01	34	94	12		21	74	21
	2001/02	31	97	10		13	87	6
	2002/03	45	91	13		18	9	11
	2003/04	32	94	13		19	59	34
Otago								
	1996/97	3	100			33		67
	1997/98	3	100			33	67	33
	1998/99	18	100	33		11	83	6
	1999/00	34	100	35		47	91	
	2000/01	39	100	13		59	97	3
	2001/02	45	100	42		36	93	2
	2002/03	62	100	45		30	94	2
	2003/04	56	100	39		27	98	
Southland								
	1997/98	11	100					100
	1998/99	57	98					100
	1999/00	46	98					100
	2000/01	84	100	89		89	96	4
	2001/02	111	96	86	2	83	96	1
	2002/03	51	98	55	4	63	65	29
	2003/04	60	92	62	2	70	68	27
All regions								
	2000/01	248	97	44		58	74	20
	2001/02	322	94	50	1	52	72	21
	2002/03	300	94	36	1	39	63	30
	2003/04	299	93	36	1	39	57	35

* Presented only for those years in which control operation data were available for all regions.

5.3 TYPE OF ANIMAL HEALTH BOARD-FUNDED CONTROL

The proportion of the total area in which initial or maintenance possum control has been undertaken in forest and/or scrub habitats on public conservation lands varied between the eight regions (Fig. 4). For most regions, a large proportion of the area controlled is under regular maintenance control. The limited area of initial control operations in most regions suggests that data

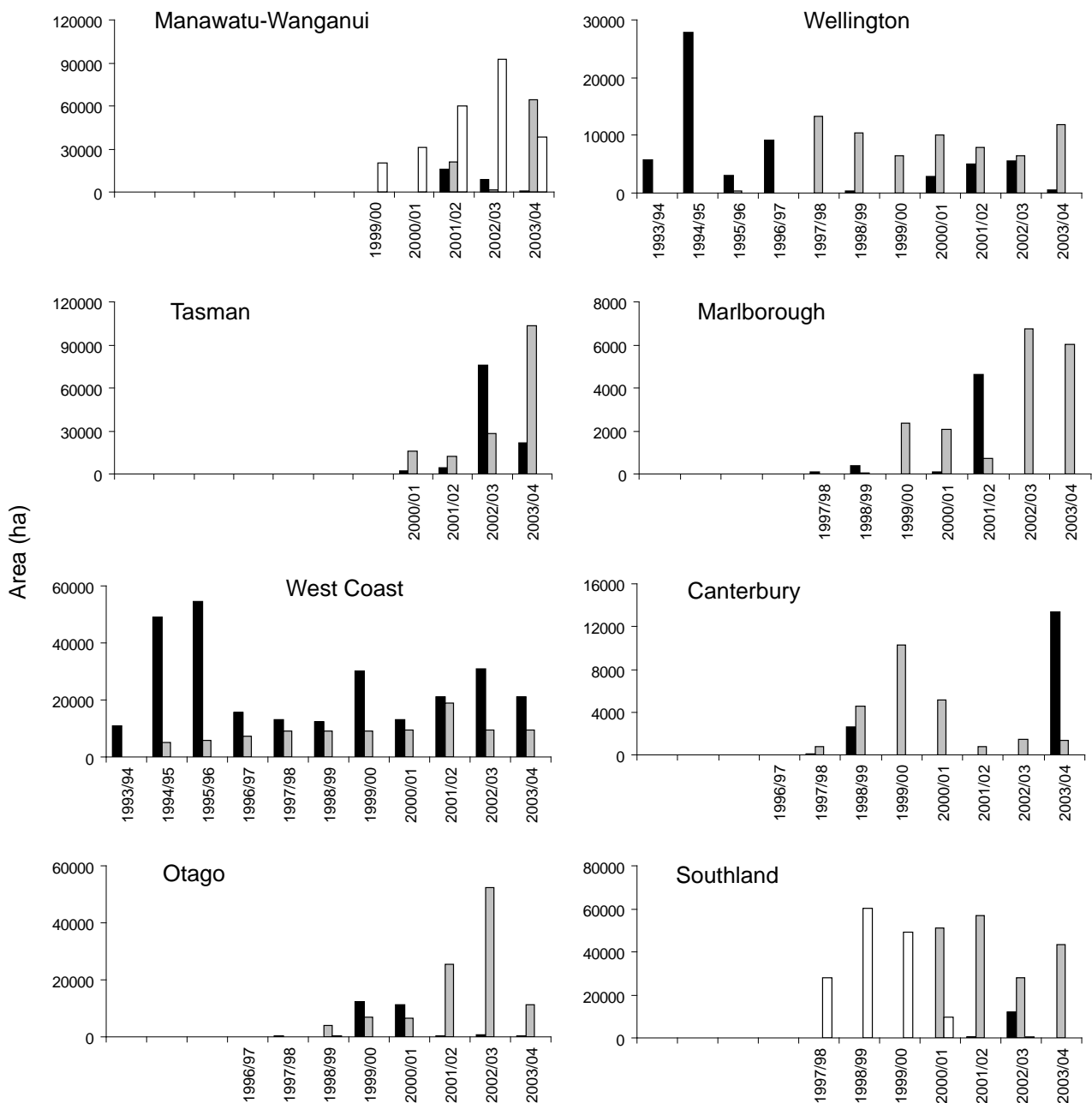


Figure 4. Total area of forest and scrub habitat (combined) on public conservation lands receiving initial (black), maintenance (grey) or unknown (white) types of control per year for the eight regions studied.

collection did not capture many of the initial operations, and that in recent years there has been limited expansion in the area of public conservation lands receiving AHB-funded possum control (but see Canterbury in 2003/04 and Tasman in 2002/03). In both the Wellington and West Coast Regions, where 11 years of control information was collected, peaks of initial control in the area occurred prior to 1996/97, although initial operations continue annually in the West Coast.

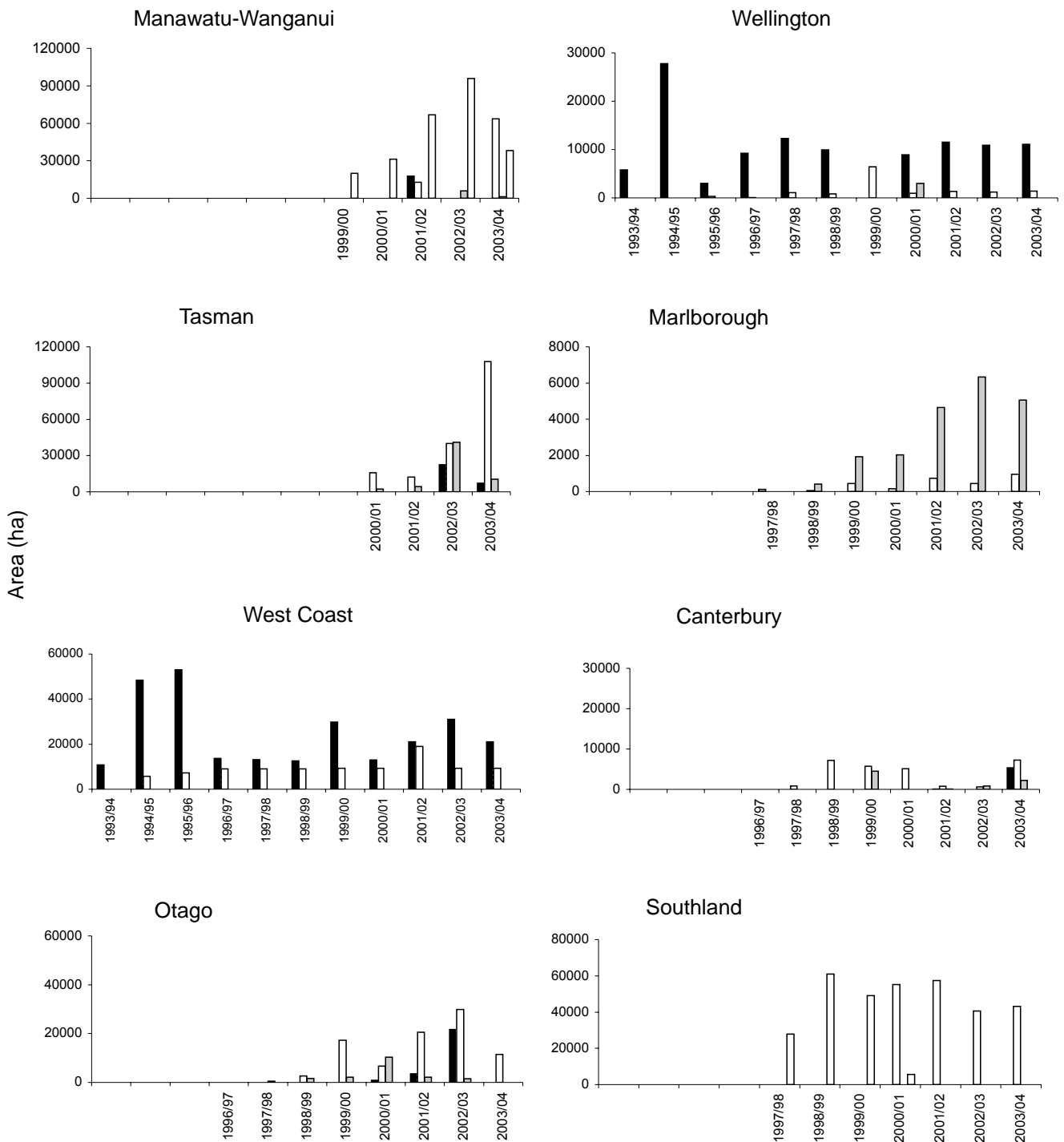


Figure 5. Total area of forest and/or scrub habitat (combined) on public conservation lands receiving aerial (black), ground (hatched), a combination of aerial and ground (grey), or unknown (white) types of control over time for the eight regions studied.

The area of public conservation lands receiving aerial, ground or a combination of aerial and ground control varied between regions, but remained relatively constant within regions (Fig. 5). Ground control has been the dominant method (in terms of area treated) of controlling possums in Canterbury, Otago, Tasman and (at least in recent years) in Southland. By contrast, in

both Wellington and the West Coast, aerial control has been the dominant technique, with the combination of aerial and ground control being the dominant method in Marlborough. Control types in the Manawatu-Wanganui region could not be determined owing to the limited information supplied.

5.4 FREQUENCY OF ANIMAL HEALTH BOARD-FUNDED CONTROL

Over all of the regions studied, it was found that where public conservation lands received control, the majority received ≤ 3 years of control over the 4-11-year period that data were collected (Table 4; Figs 6A, 7A, 8A, 9A, 10A, 11A, 12A & 13A).

For the four regions where the treatment boundaries remained the same over all years for which data were collected, possum control was undertaken annually in over 66% of operations in three of the regions (Marlborough, Otago and Tasman). In contrast, the number of years between control operations was greater in Wellington, probably because aerial control was the predominant treatment method on public conservation land in this region (see Fig. 14).

In general, AHB-funded possum control operations appear to be carried out more frequently than DOC-funded operations. Parkes et al. (unpubl. data) found that for more than 65% of DOC control operations in the 1990s in the West Coast, Nelson-Marlborough, Otago, Wanganui, Southland and Wellington conservancies, the frequency of control was ≥ 3 years apart. This probably reflects differences in management aims, and subsequently the target possum densities between DOC (e.g. biodiversity protection) and the AHB (e.g. removal of Tb from wildlife).

TABLE 4. TOTAL AREAS OF FOREST AND SCRUB HABITAT (COMBINED) (ha) ON PUBLIC CONSERVATION LANDS THAT HAVE RECEIVED ONE OR MORE YEARS OF POSSUM CONTROL. AREAS ARE BASED ON CONTROL OPERATION TOTAL AREAS ONLY.

REGION	NO. OF YEARS YEARS CONTROL INFORMATION	NUMBER OF YEARS OF CONTROL					
		1	2	3	4	5	> 5
Manawatu-Wanganui	5	34 392	36 552	40 720	32 131	255	
Wellington	11	549	10 342	22 803	288	7601	1727
Tasman	4	21 564	72 339	38 927	530		
Marlborough	7	3088	157	7046	102	20	549
West Coast	11	106 566	63 152	7238		696	9616
Canterbury	8	22 883	7601	15 560	11 894	3102	4
Otago	8	25 446	23 641	17 635	4438	6893	7074
Southland	7	51 345	14 532	11 192	14 315	20 549	24 998
Total		265 833	228 316	161 121	63 698	39 116	43 968

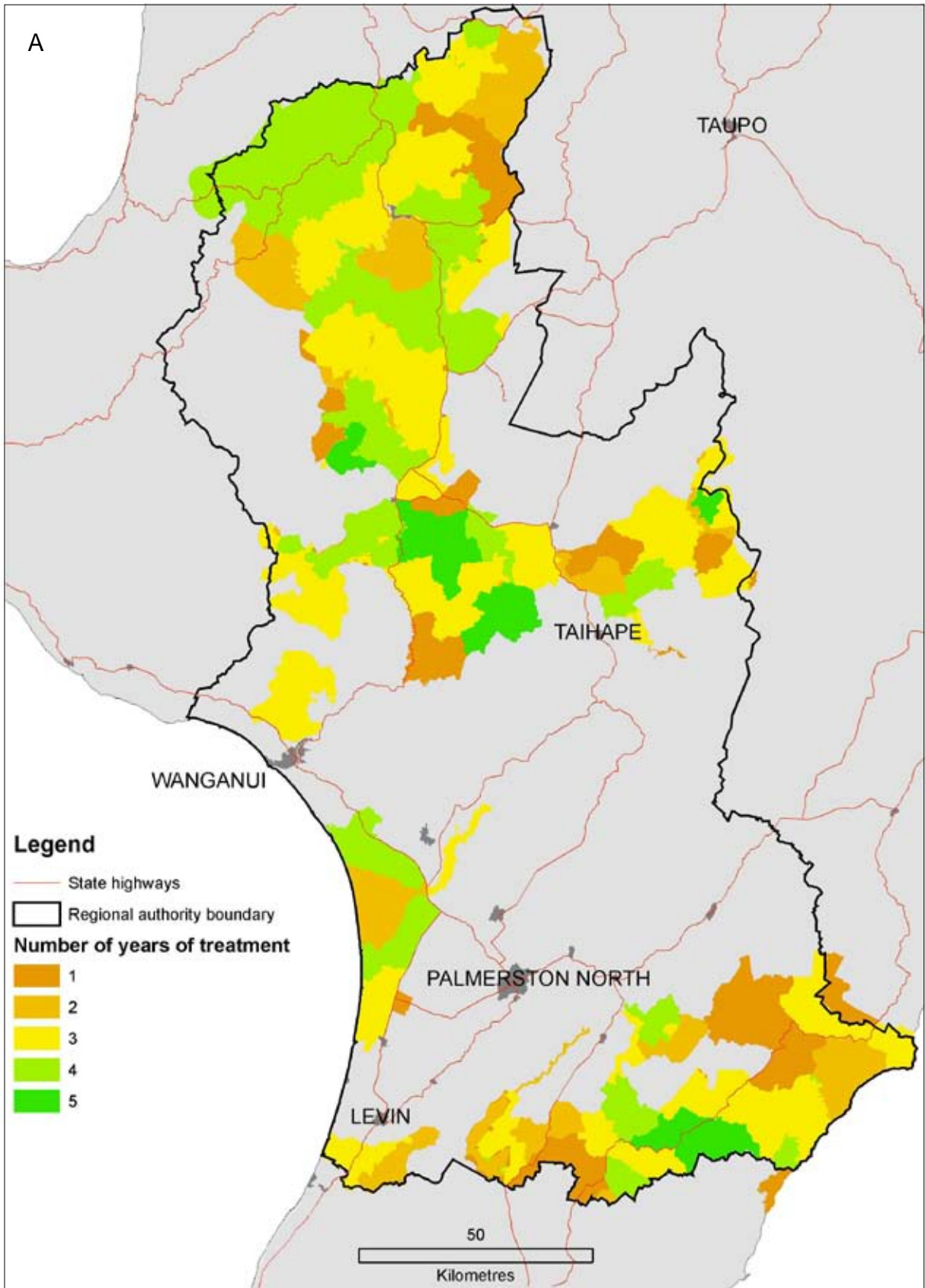
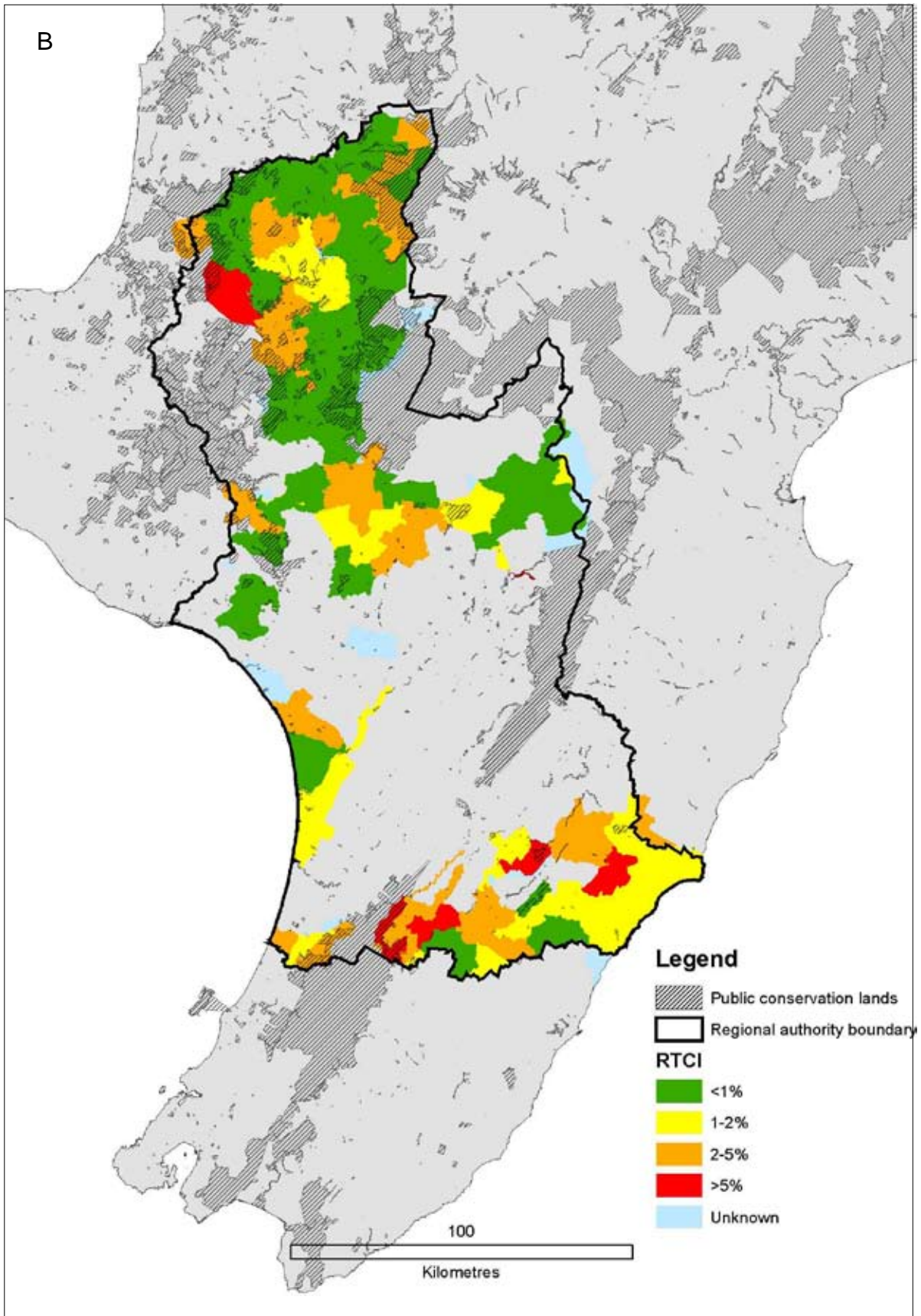


Figure 6. Manawatu-Wanganui Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1999/2000 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



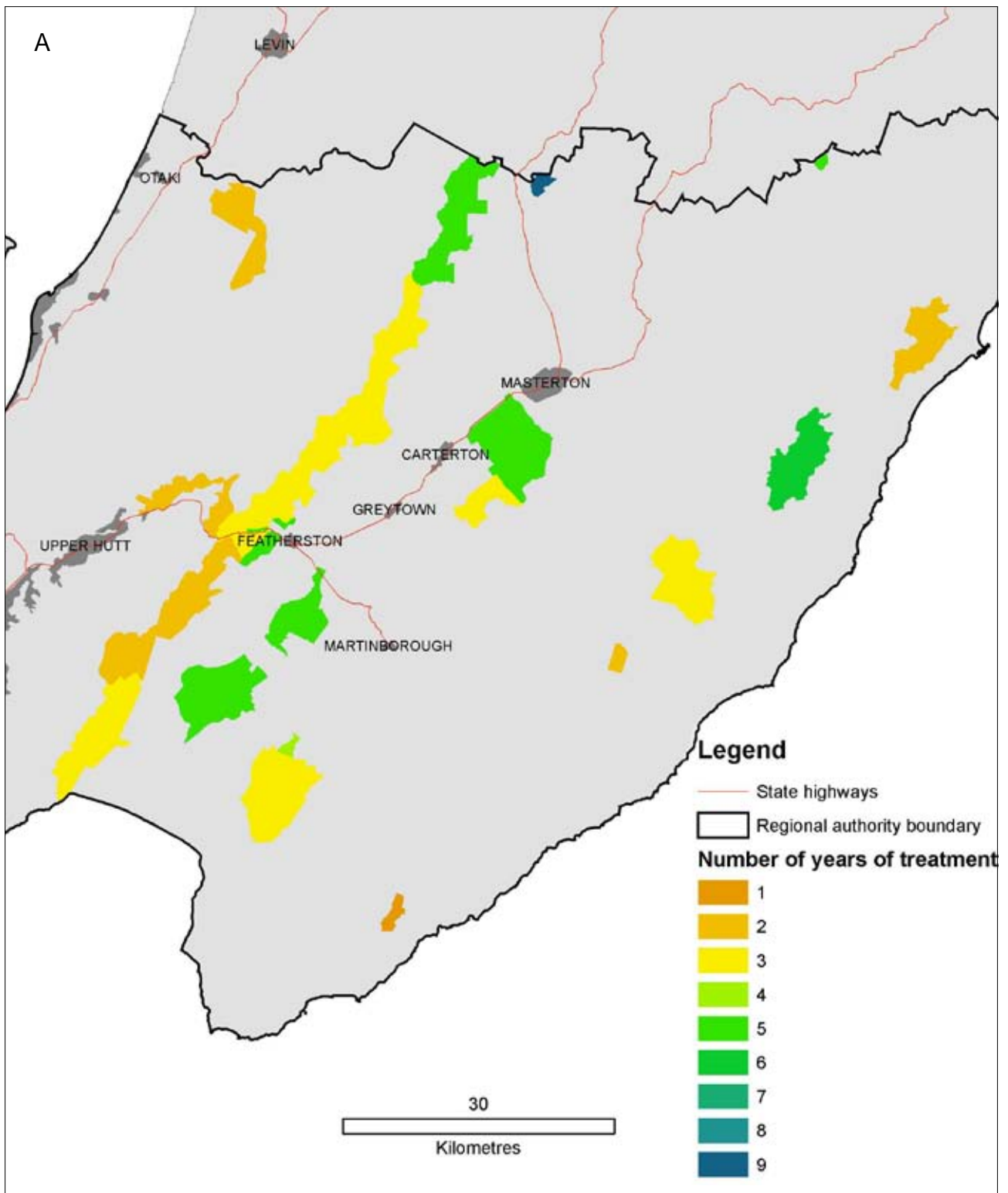
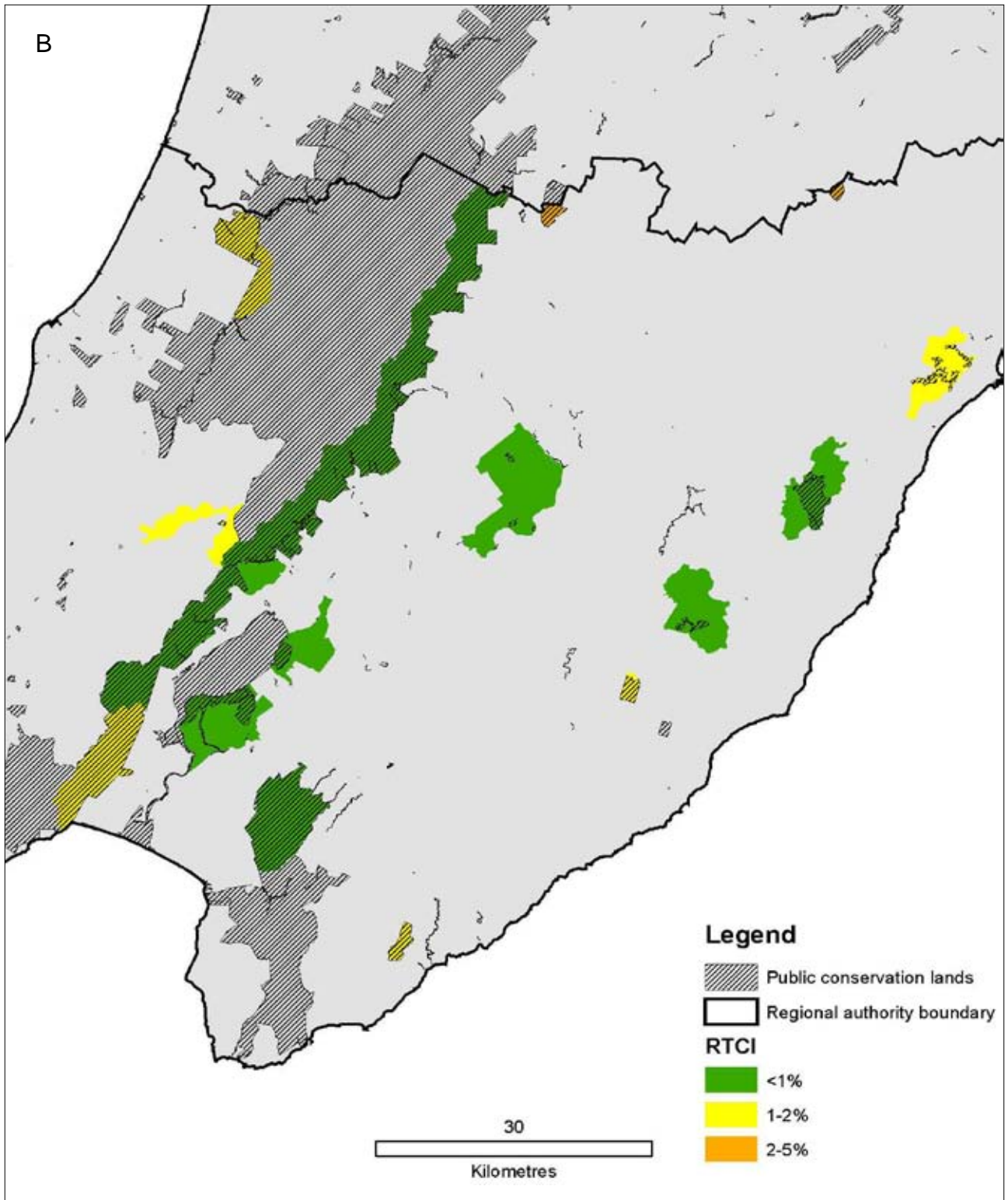


Figure 7. Wellington Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1993/94 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



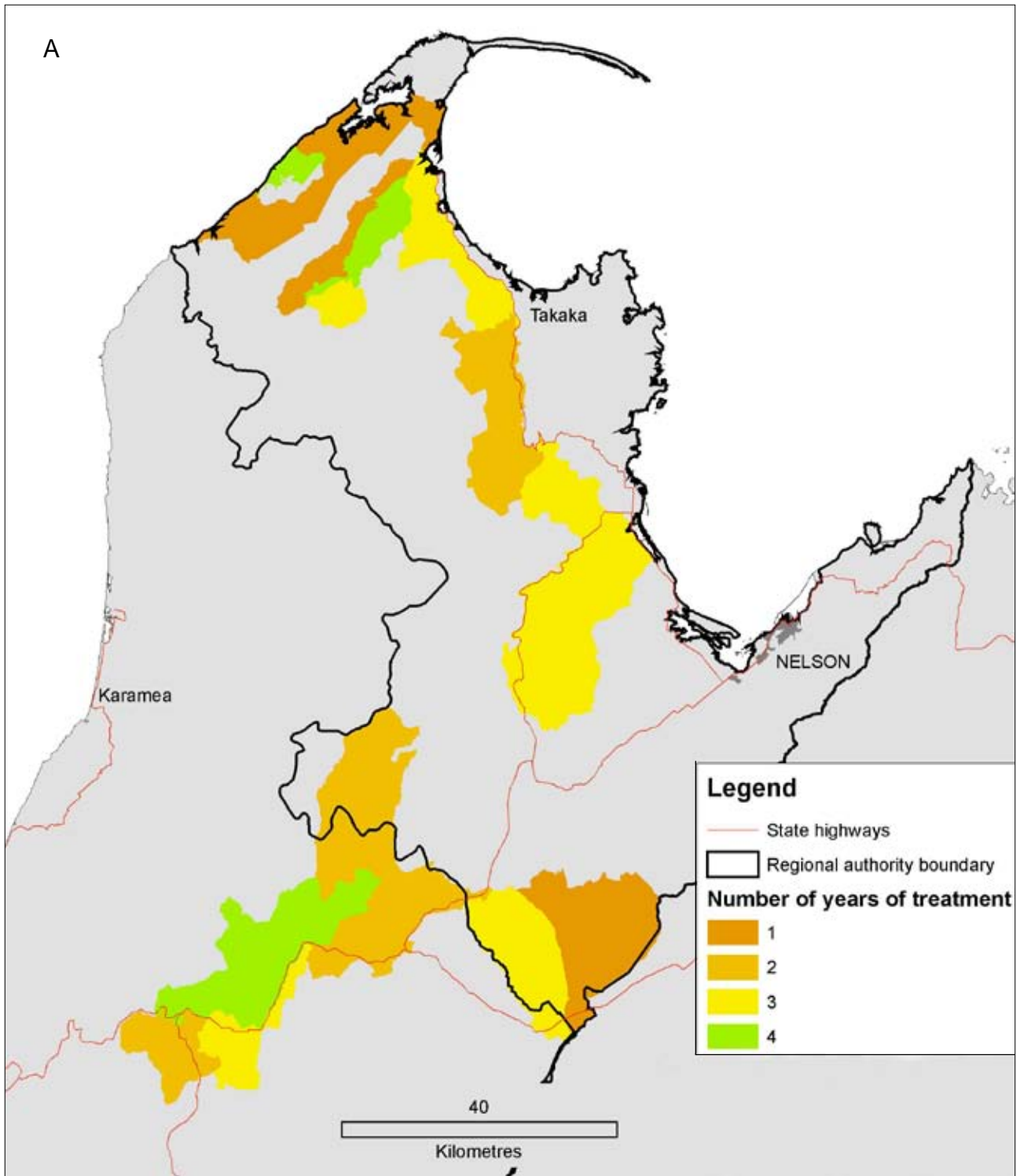
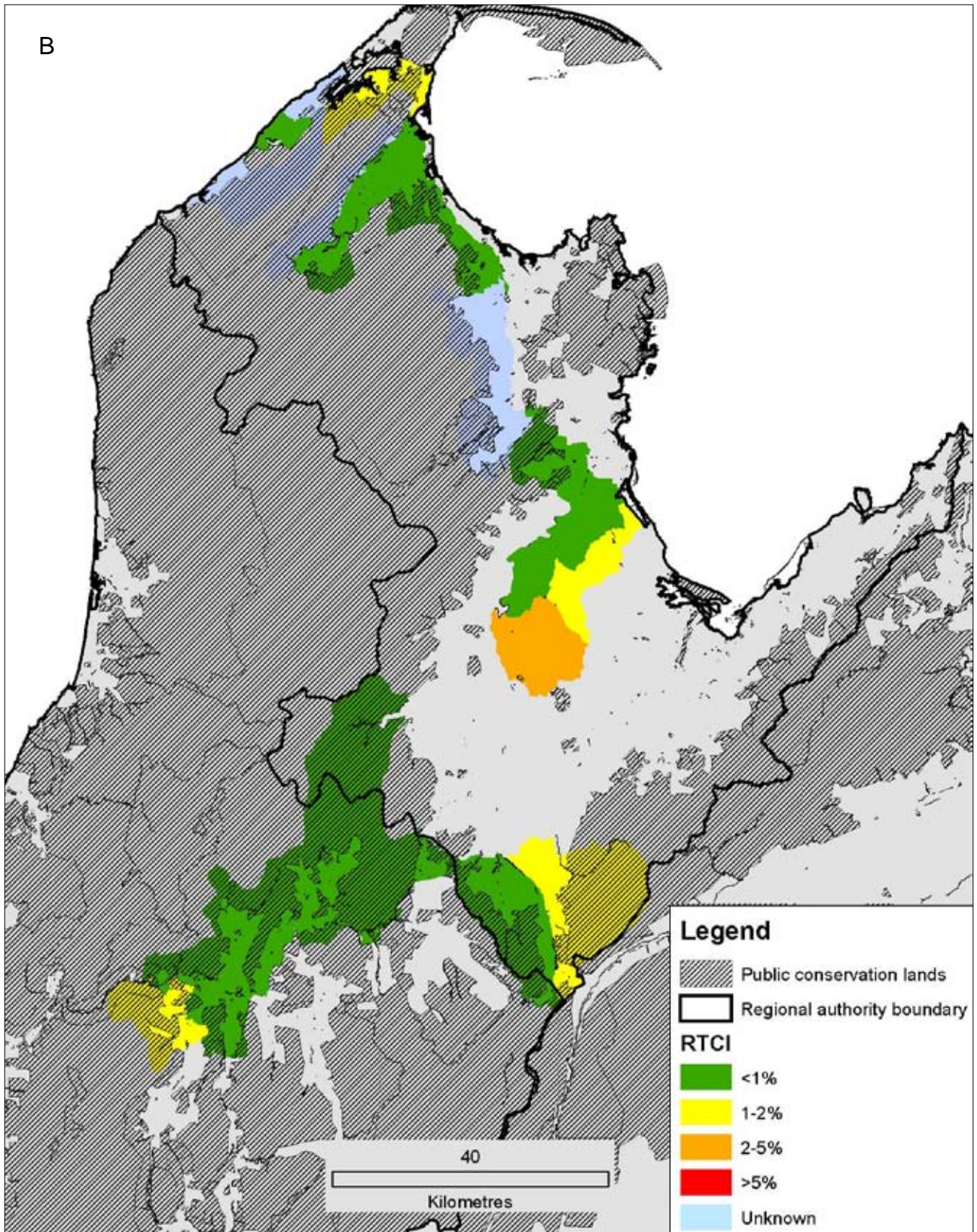


Figure 8. Tasman Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 2000/01 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



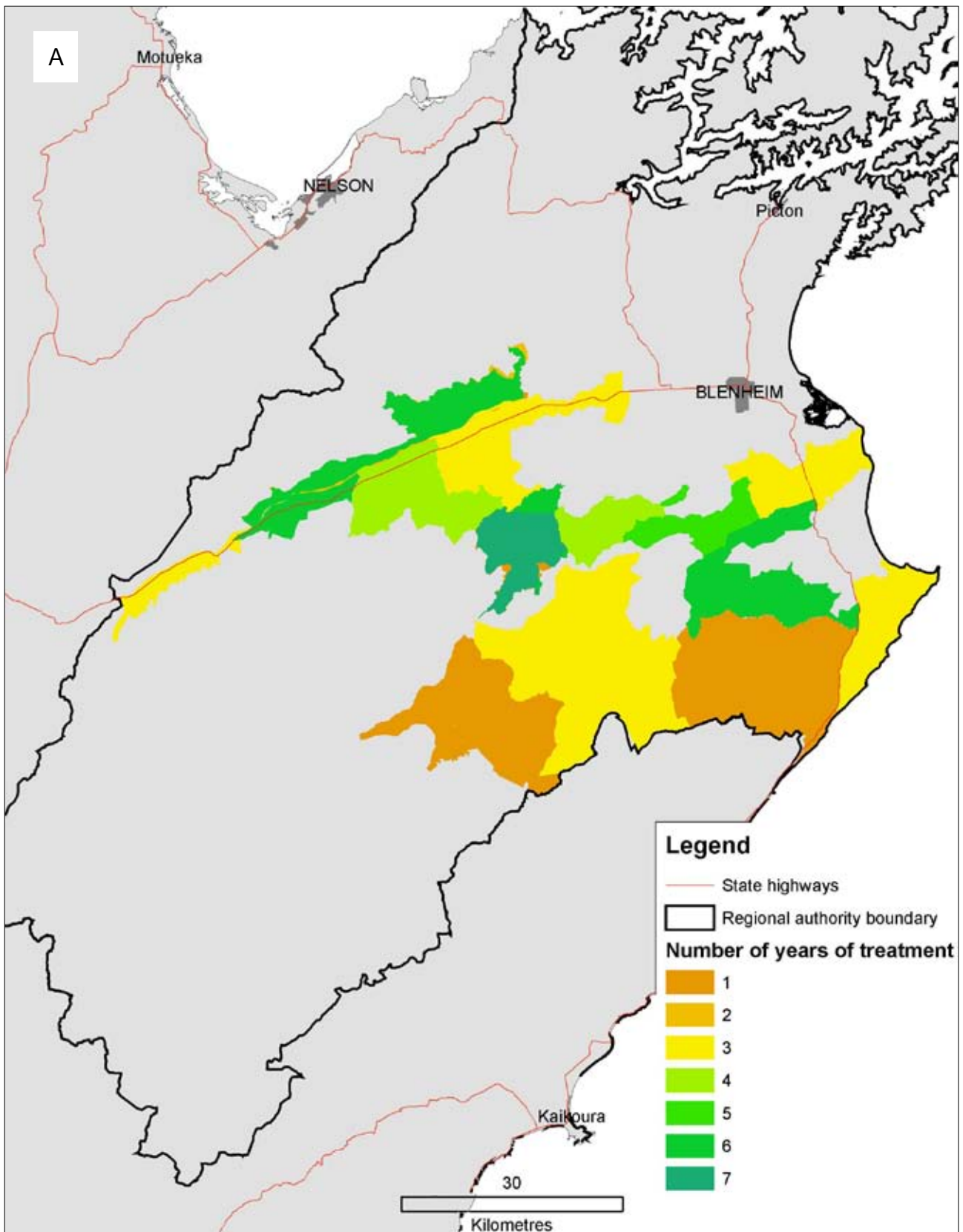
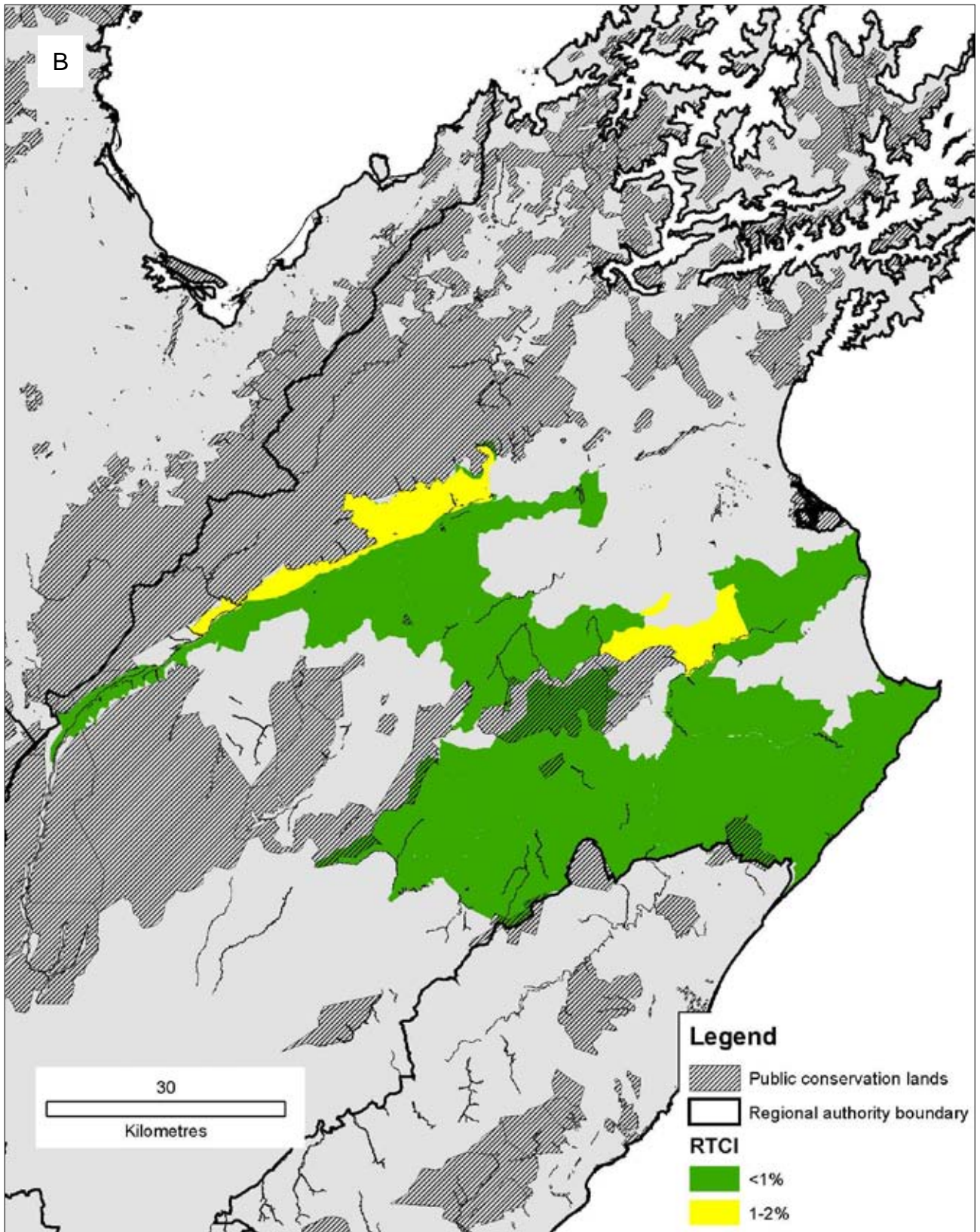


Figure 9. Marlborough Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1997/98 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area)



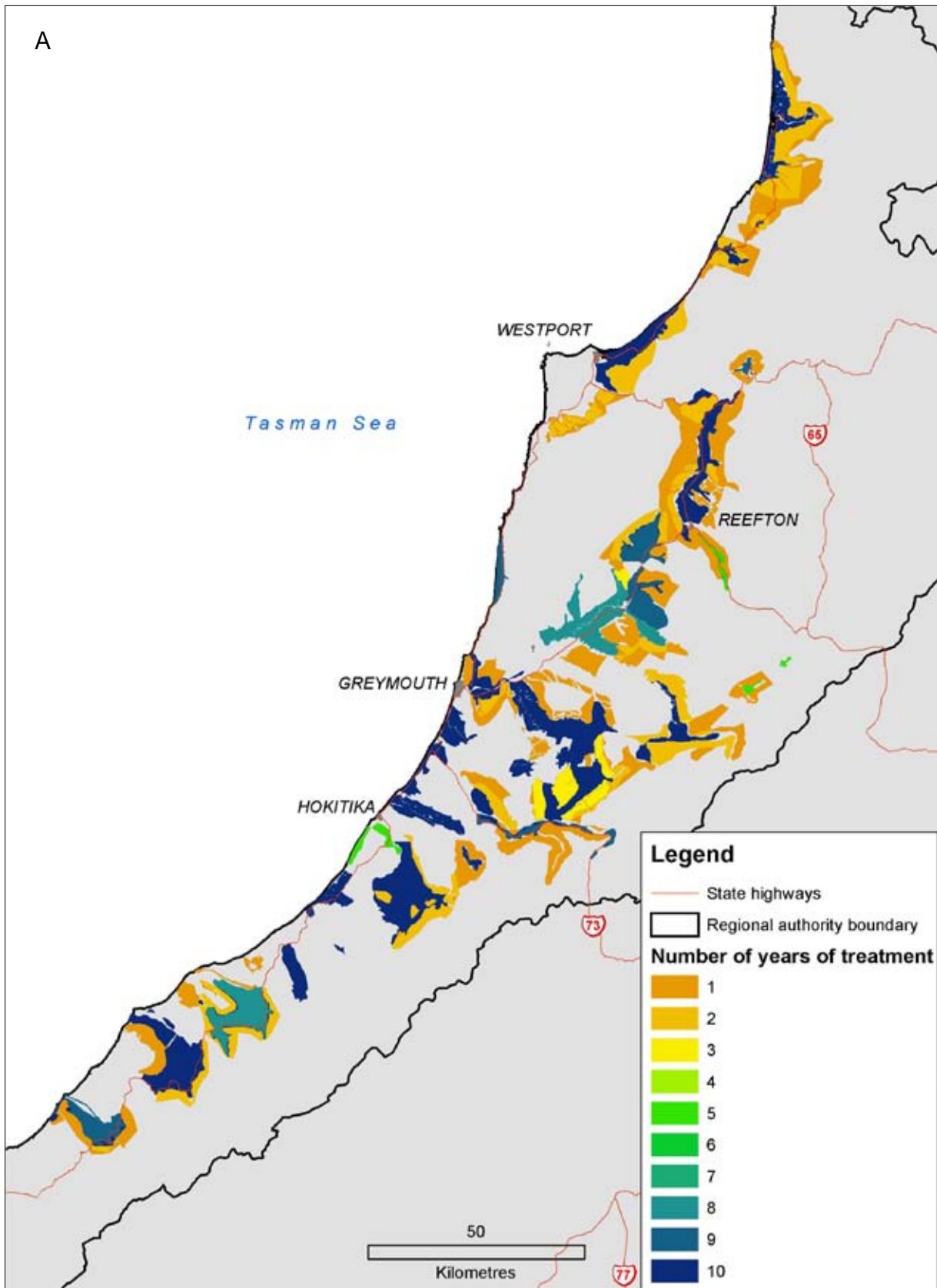
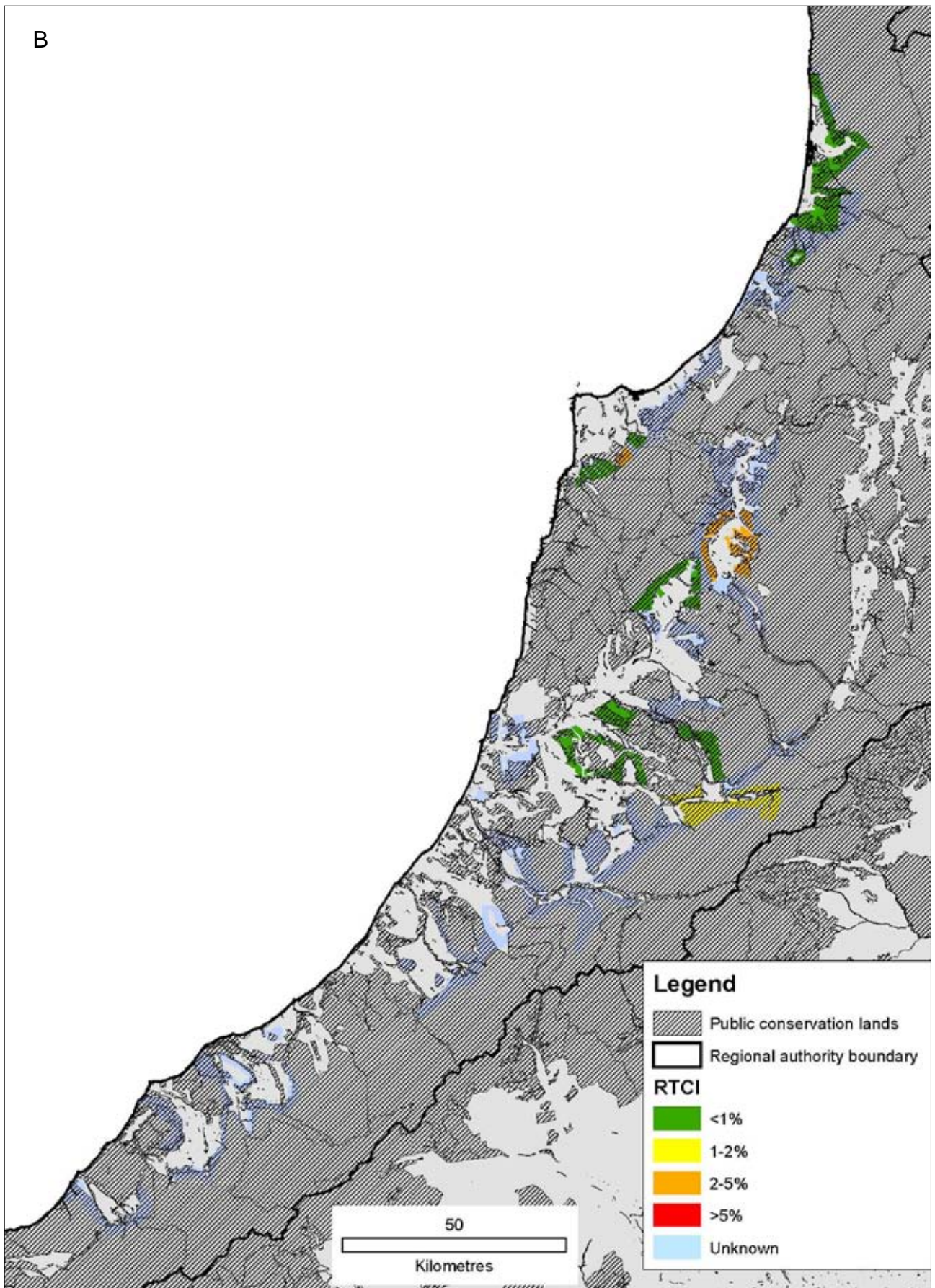


Figure 10. West Coast Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1993/94 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).

B



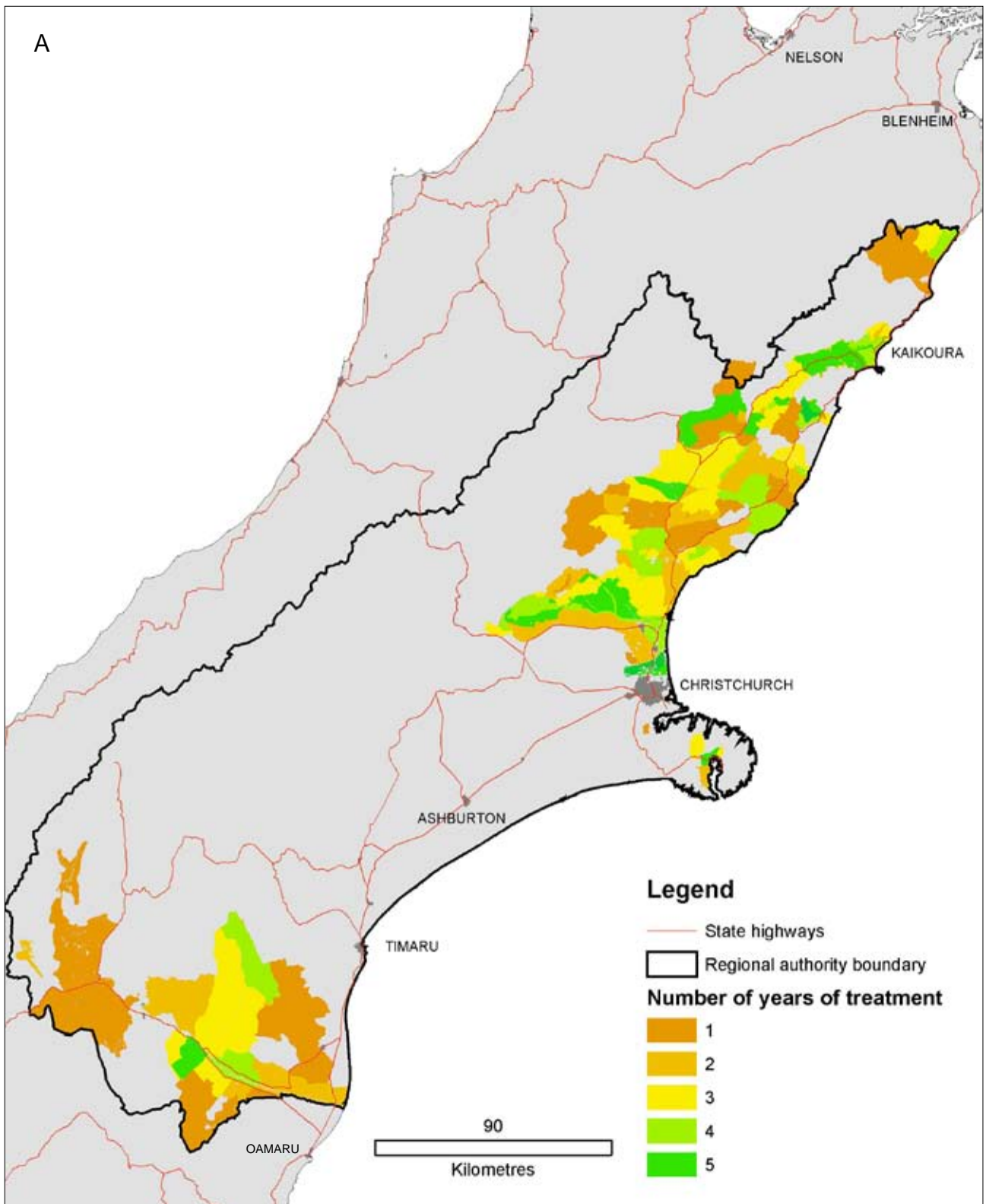
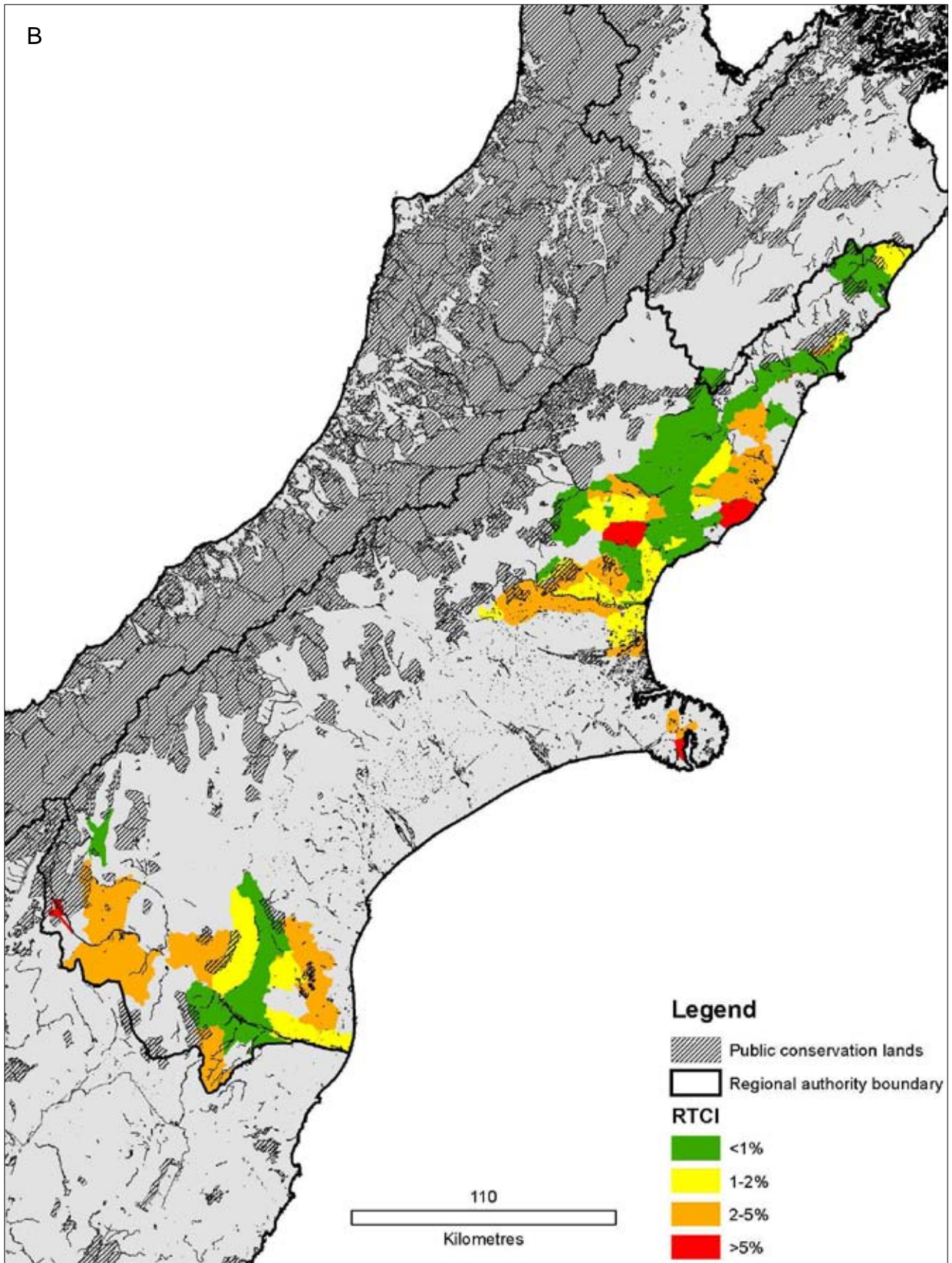


Figure 11. Canterbury Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1996/97 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



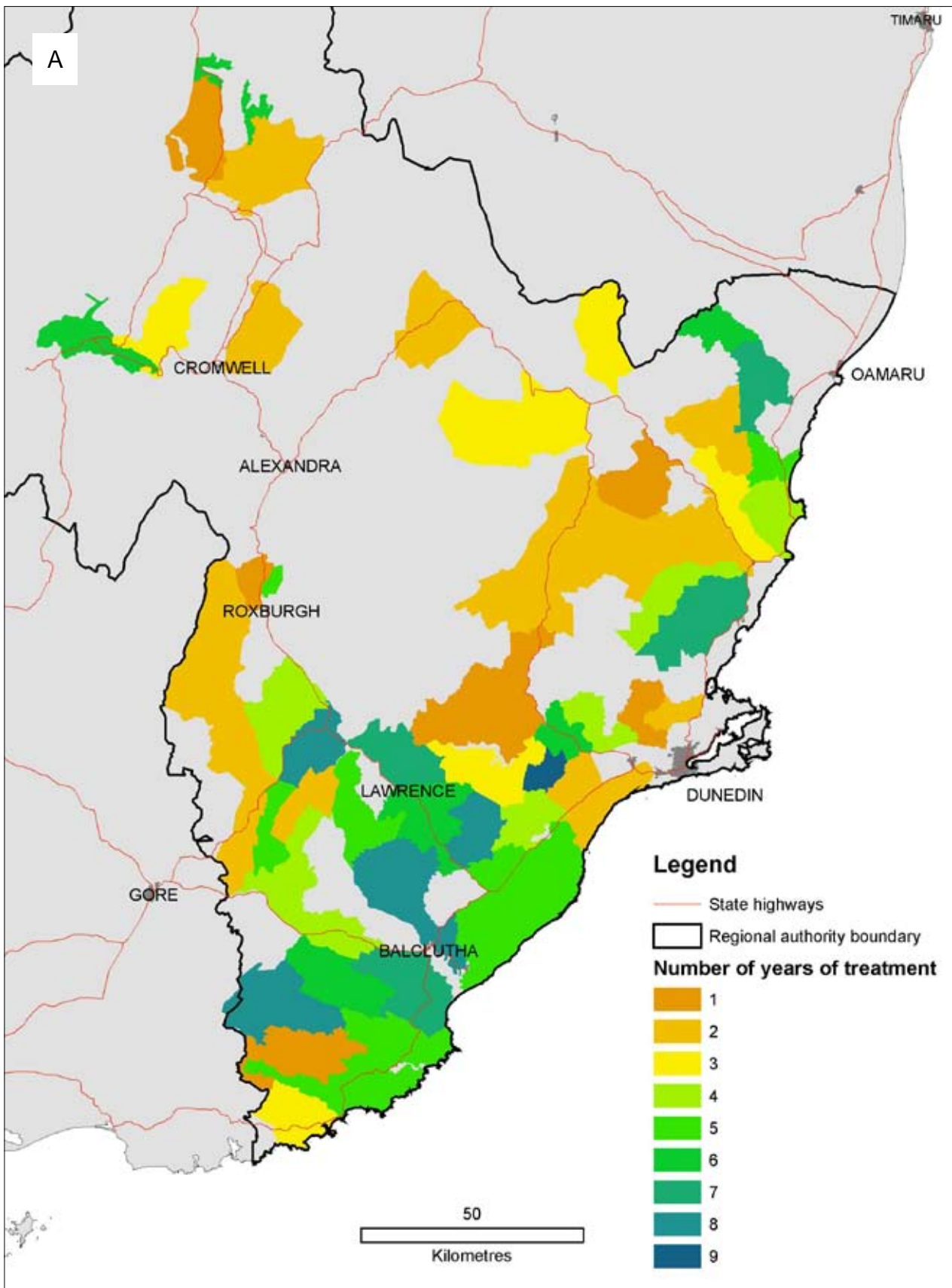
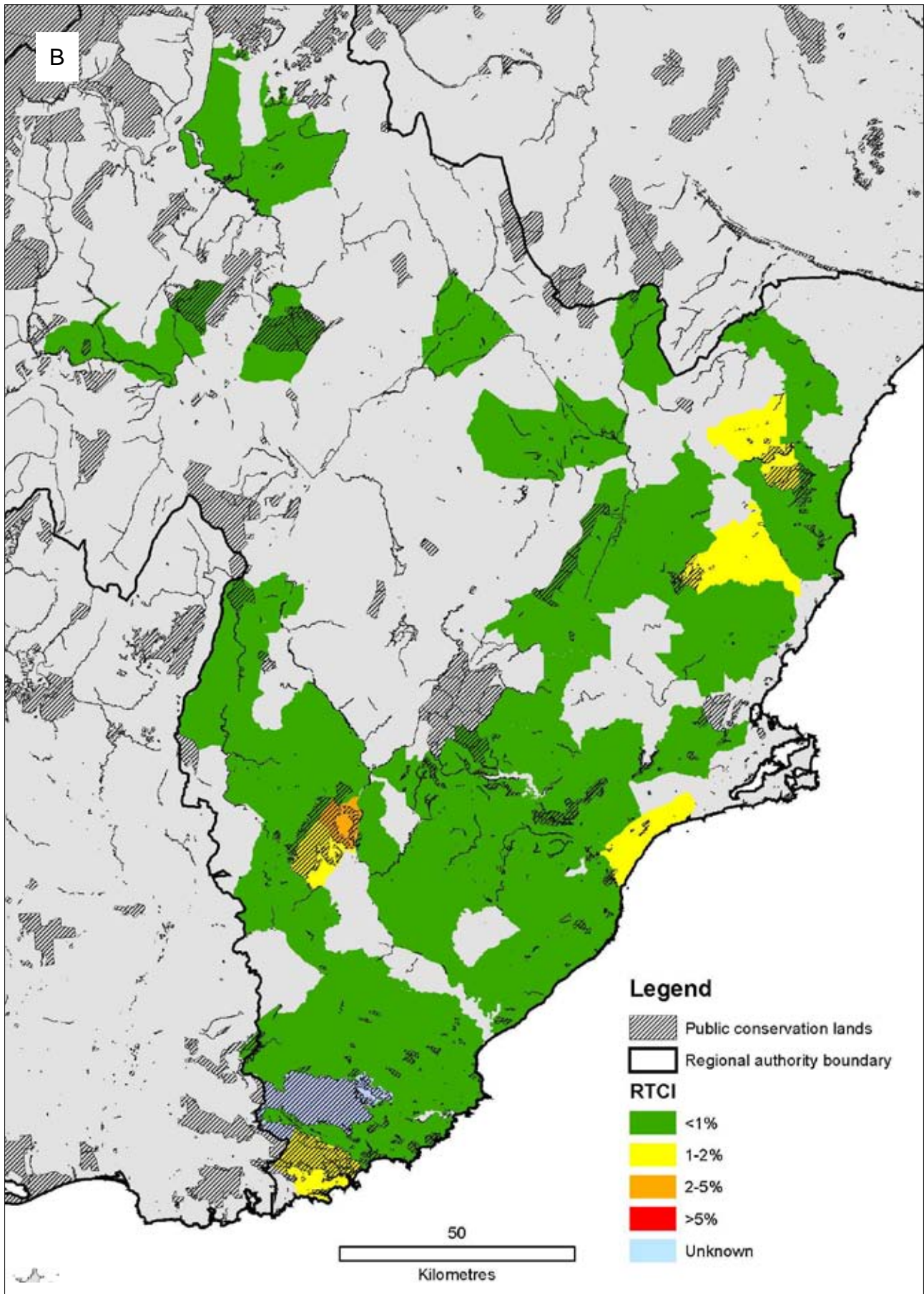


Figure 12. Otago Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1996/97 to 2003/04). B: The most recent residual trap-catch-index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



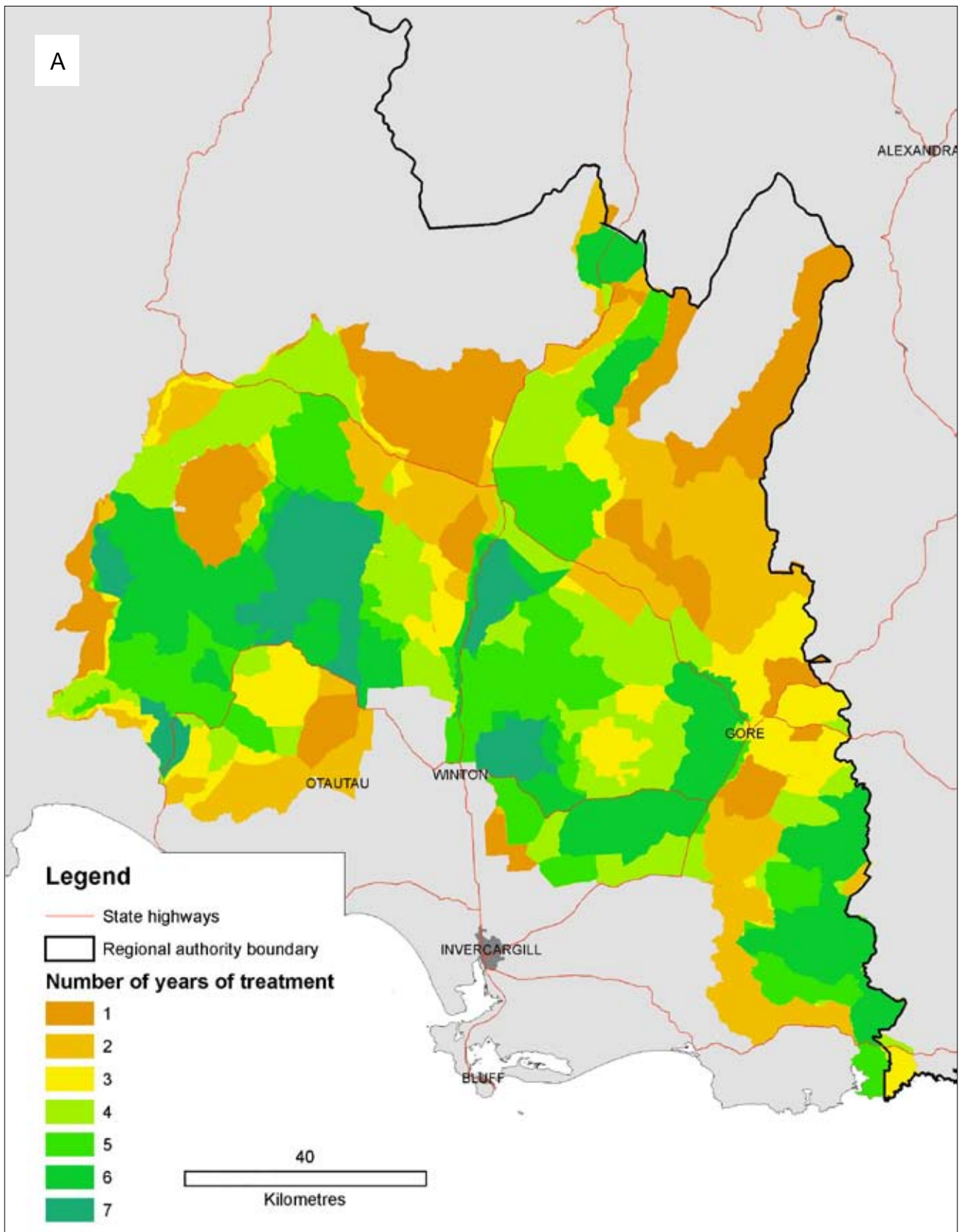
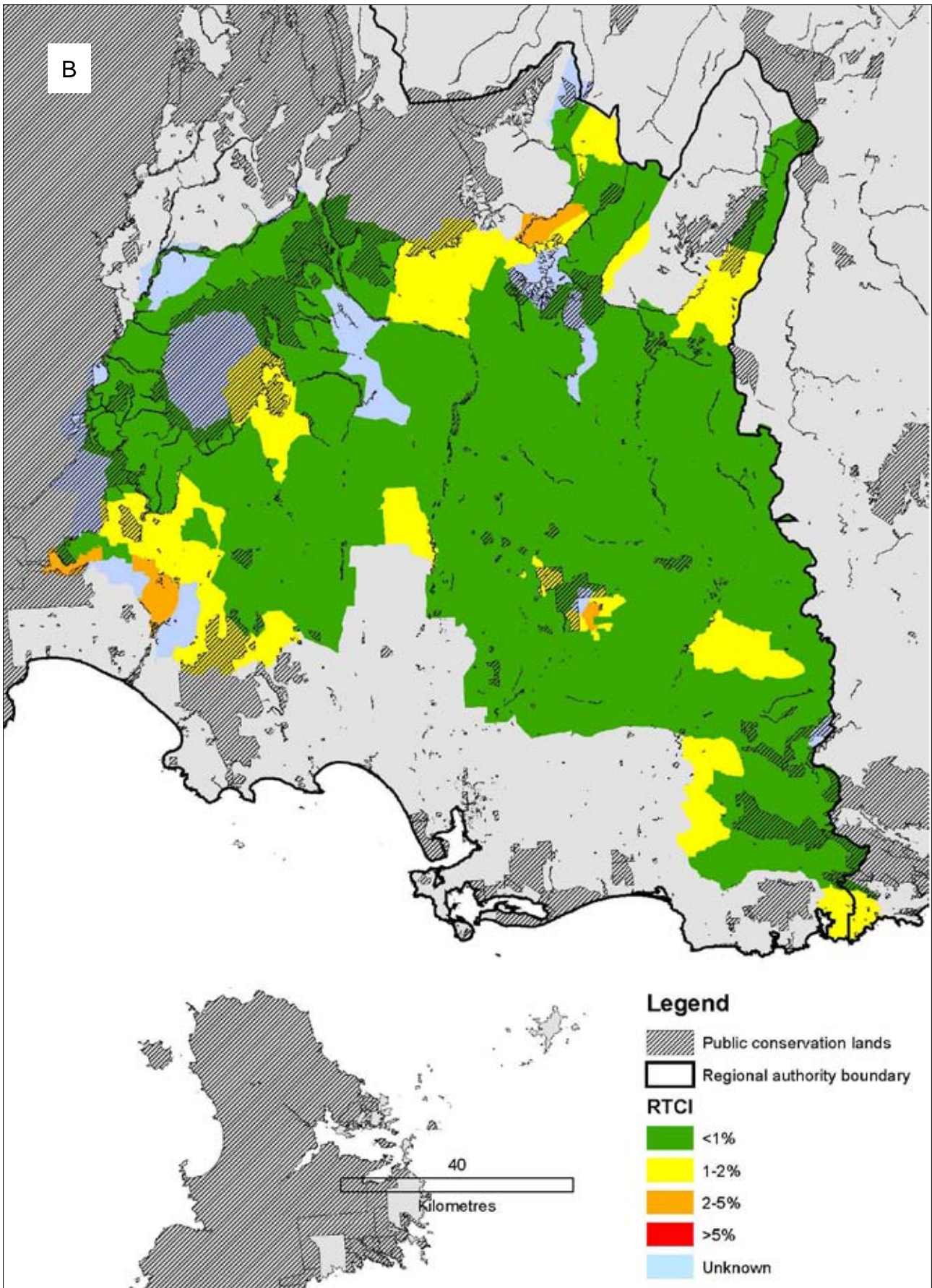


Figure 13. Southland Region. A: Number of years that some form of Animal Health Board-funded possum control has been undertaken in operational polygons (control data were collected from 1997/98 to 2003/04). B: The most recent residual-trap-catch index (RTCI) recorded within each operational control area under some form of Animal Health Board-funded possum control. Public conservation lands are shown (hatched area).



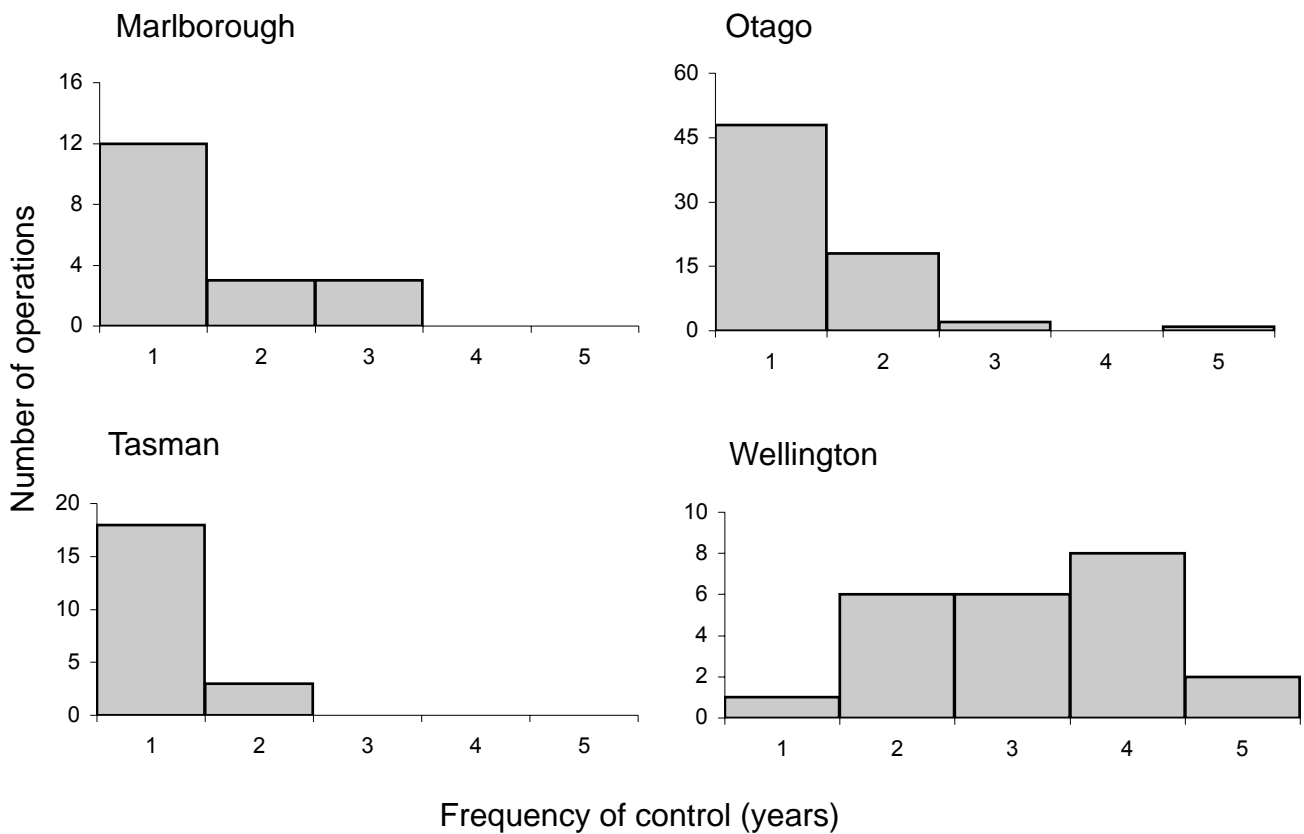


Figure 14. Frequency of control by the Animal Health Board (years between the same control polygon being treated) for the four regions where identical control polygons were used over time.

5.5 RESIDUAL-TRAP-CATCH INDICES AS INDICATORS OF CONSERVATION BENEFIT

Post-control monitoring data for the 2002/03 and 2003/04 years indicate that very low possum densities were achieved over much of the public conservation land that was controlled in the eight regions where we collected information (Figs 6B, 7B, 8B, 9B, 10B, 11B, 12B, 13B & 15). In 2002/03 and 2003/04, >62% and >78%, respectively, of the forest and scrub habitat in the treated public conservation lands had an RTCI $\leq 2\%$. We excluded Manawatu-Wanganui from the latter year's figures as only 40% of operations in that area achieved such a low average RTCI.

Possum numbers increase after each control operation, so the average possum density at each place, and therefore the possums' assumed impact on biodiversity values, depends on the frequency (and intensity) of control. The RTCIs described above represent possum density indices at the time, after any control operation (i.e. RTCI assessments are normally undertaken within several months of an area receiving treatment). Therefore, where control is undertaken infrequently (e.g. large areas of forest typically had a frequency of treatment of > 3 years), the average possum densities between control operations will be higher than the RTCI figures presented here.

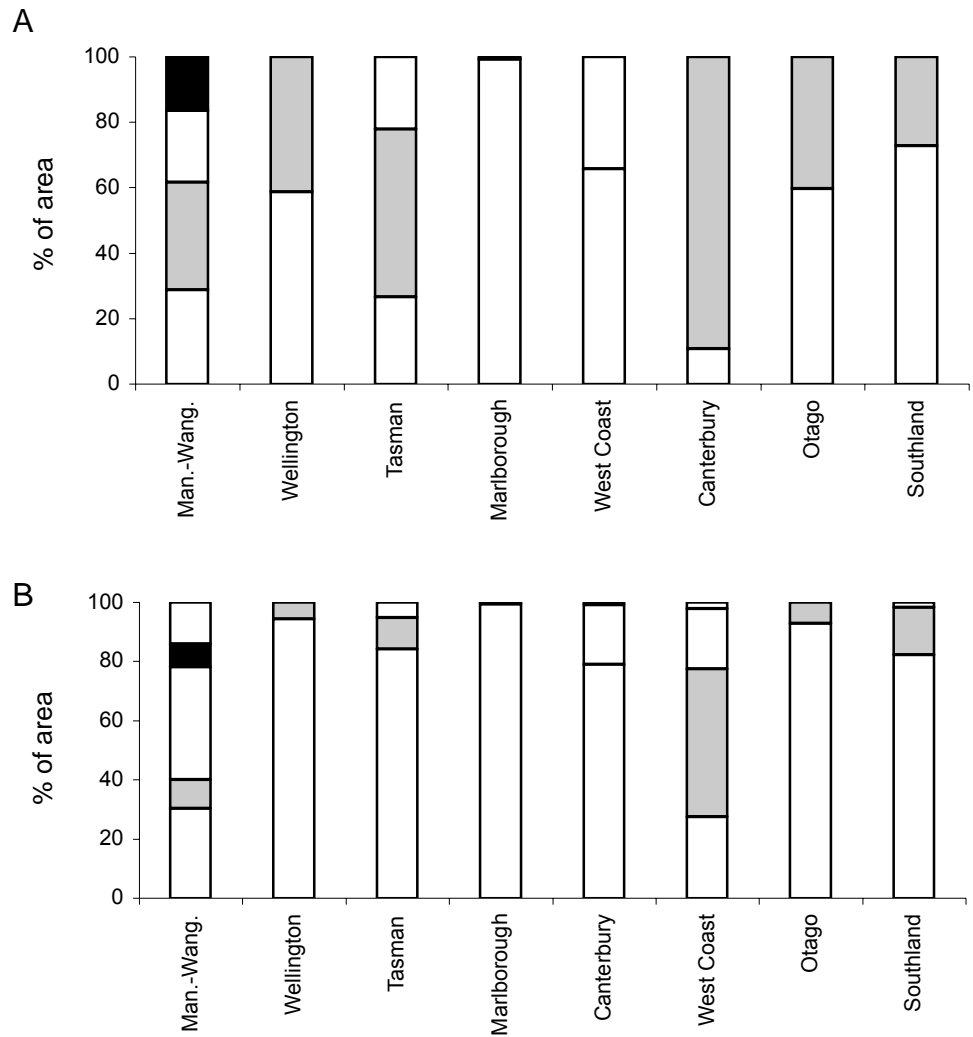


Figure 15. Percentage of the total area of forest and scrub habitat on public conservation lands within each of the RTCI categories (horizontal lines < 1%; grey 1-2%; downward-sloping diagonal 2-5%; black 5%; white unknown) that have received possum control in A. 2002/03 and B. 2003/04 financial years. The total area ($\times 1000$ ha) per region is shown above each bar.

6. Discussion

This project is the first detailed summary of the area, location, type and frequency of AHB-funded possum control on public conservation lands. The combined total annual area of public conservation lands within AHB control operation boundaries in the eight regions over the period 2000/01–2003/04 ranged from c. 250 000 ha to c. 460 000 ha, with the majority of these areas having received two or more possum treatments. The absence of AHB control information, particularly from the Waikato and Hawke's Bay Regions, prevented the assessment of a national picture of AHB control on public conservation land.

Possums have direct impacts on forests, causing canopy defoliation that may result in tree death and compositional change in some forests (e.g. Rose et al. 1993; Pekelharing et al. 1998; Payton 2000; Sweetapple et al. 2002). They also prey on invertebrates (e.g. Cowan & Moeed 1987; Cowan 2001) and vertebrates (e.g. Innes 1995; Innes et al. 1996; Sadleir 2000). However, the significance and magnitude of indirect effects from possums (which may include modification of habitat for fauna, alteration of nutrient cycling and competition for food) are largely unknown (Veltman 2000).

The project has not formally assessed conservation benefits that may accrue from the AHB-control; however, about 60% of the public conservation lands on which the AHB conducted possum control within the last 4 years have RTCIs significantly below 5%. Such areas provide some indication of the likely benefit of AHB-funded possum control on public conservation lands. Generally, the fewer the possums, the less their impact. The limitation of assessing conservation benefits that may accrue from control based on RTCIs is that the relationship between possum density and their impacts is neither linear (Nugent et al. 2001) nor consistent for many native species and communities (e.g. Bellingham et al. 1999; Norton 2000; Payton 2000; Veltman 2000). For example, the RTCI required for protection has been shown to range from as low as 3% for mistletoe at Hauhungaroa (Sweetapple et al. 2002), <7–9% for Northern rata forest canopy at Waipoua (Payton et al. 1997), <10% for kohekohe at Motatau, and <25% for common broadleaf species at Matamateonga (Nugent et al. 2001). The results from these studies suggest that a reduction in possum densities to very low levels would protect the most vulnerable species or communities, thereby providing protection to other less vulnerable species and communities of the ecosystem (Warburton et al. 2005). However, there have been no robust assessments (i.e. with replication and non-treatment areas) of changes in 'natural character' (to use DOC's terminology) following AHB-funded possum control to validate the generalisation that fewer possums equals reduced impacts at these sites.

Potentially, there is considerable possum population monitoring and control operation information available, but its utility is limited by the difficulty in obtaining and then standardising the data, and by its inconsistent quality, particularly for data pre-2000/01. The quality of data collected for our study is also extremely variable between regions, with considerable inconsistency in the way details of control operations and related monitoring results had

been collated and stored over time. We believe that the AHB's new Vector Management Information System (VMIS) or a similar such system would ensure that information relating to possum control operations is recorded efficiently and appropriately. We recommend that as a minimum, the data categories surveyed in this project should be collated for all possum control operations.

At a strategic level, if further resources are to be invested in data collection, the aim should be to complete a picture of AHB-funded possum control on public conservation lands by obtaining recent data (e.g. from the Waikato and Hawke's Bay regions, which undertake significant areas of possum control but did not have their data collected in this project), rather than obtaining additional historical data from the regions already surveyed.

There was a general lack of institutional memory of possum control operations throughout the regions surveyed, which is a common problem for pest control operators (see Reddiex et al. 2004). Consistency in standards of reporting possum control operations and collating and storing data between the AHB and DOC would enable seamless integration of control and possum population information for these two key organisations involved in possum control on public conservation lands (Fraser et al. 2004). There would be obvious benefit to DOC in obtaining information on AHB-funded possum control operations on public conservation lands; in addition, this data collection would also provide DOC with information on what is happening in terms of possum management in privately-owned areas adjacent to DOC-managed land.

The data collected during this project are held at Landcare Research, and provide a robust foundation for identifying potential study sites for future research that may address questions on the biodiversity benefits of AHB-funded possum control.

7. Conclusions

- The AHB has controlled possums over c. 800 000 ha of public conservation lands in recent years, of which about 655 000 ha has received ≤ 3 years of control over the 4–11-year period that data were collected.
- Over the period 2000/01–2003/04, on public conservation lands, the total area of forest habitat receiving possum control per year ranged from c. 156 000 ha to c. 314 000 ha; and of scrub habitat, c. 14 000 ha to c. 45 000 ha.
- Generally, immediate post-control densities of possums have been very low (less than 1% RTCI) and have rarely exceeded 5% RTCI. Although it has not been measured, it is likely that conservation benefits have accrued from such low possum densities.
- It was not possible to determine which areas presently receiving possum control should continue to receive control once the AHB halts its efforts from this report. Such decisions would be based on an independent assessment of the values at risk in each area relative to one another and to sites on public conservation lands already controlled by DOC or regional councils for biodiversity reasons.

8. Recommendations

- The Animal Health Board (AHB) and/or vector managers need to collate and store data from possum control operations and any associated monitoring in a way that is both accessible to managers and amenable to future meta-analysis. Such information ideally should be recorded on a permanent database, include information on the type and cost of possum control carried out, the resulting RTCI levels obtained, and be linked with spatial data on the control location.
- To speed up the data collection process and to ensure accurate and complete responses, future studies of this nature should consider building into the project the cost of data provision for surveyed organisations.
- Appropriately designed experiments are required to improve understanding of possum density-impact relationships, and the benefit of AHB-funded possum control on public conservation lands bearing in mind the many indirect effects that are likely to be involved.

9. Acknowledgements

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Appendix 1

FIELD STUDY ON CONSERVATION BENEFITS OF POSSUM CONTROL BY THE ANIMAL HEALTH BOARD

Introduction

The Department of Conservation (DOC) commissioned Landcare Research to undertake a study to determine the ecological benefits of Animal Health Board (AHB)-funded possum control on land administered by DOC. This appendix presents the results from a single study site in Southland that was sampled prior to the objectives of the project being modified, and hence no formal analyses have been undertaken. For information on the project experimental design, including rationale for selection of response variables and sample sizes, see Reddiex & Parkes (2003).

Methods and results

Two response variables (foliar canopy condition of palatable indicator species, and bird activity) were assessed at one paired site (i.e. one site that had received annual possum control for over 5 years, and one that had not received possum control) in February 2003 in Southland. The possum control site was located in the Catlins Forest Park (west of Waikawa Harbour), while the no-possum-control site was located to the north in the Waikawa Valley. An objective comparison of the vegetation at the 'paired' study sites was undertaken by analysing historical Recce plots held in the National Vegetation Survey database. This analysis confirmed similar vegetation composition between the two treatment areas.

In the possum control area, possum numbers have been monitored annually and the residual trap catch index (RTCI) calculated. The RTCI was found to be <5% for at least 4 years prior to the study. In contrast, RTCIs in the no-possum-control area ranged from 22% to 47% over the period 1999/2000–2001/02. In February 2003, we assessed possum abundance at the no possum control area using the standard National Possum Control Agencies protocols (National Possum Control Agencies 2001). This gave an RTCI of 11.4% from 10 randomly located monitoring lines. There was anecdotal evidence that possums had been privately harvested from this area in recent years.

Monitoring of foliage condition of canopy tree species and bird activity was undertaken on ten randomly located 1-km transects in each treatment area at the same time possum abundance was assessed. Foliage condition was assessed at 20-m radius plots at the start, and every 100 m along each transect. Foliage cover was measured on a 10-point scale (ten 10% classes from 5% to 95%), and crown dieback and possum browse on a 5-point scale (0, 1–25, 26–50, 51–75, and >75%) (see Payton et al. 1999). There was no clear trend in canopy cover of the six palatable canopy species between sites receiving

possum control and those not receiving possum control (Table A1.1). The no-possum-control area had a significantly higher proportion of trees with sign of browse than the area receiving possum control but, in most instances, the percentage browse was small.

The activity of forest birds was assessed using five-minute bird counts (Dawson & Bull 1975) at 200-m intervals along the transects. All birds heard calling or seen were recorded. Counts were made by two observers, each alternating between sites on successive days, in relatively wind- and rain-free conditions to minimise variation, including observer bias, and the changing conspicuousness of birds according to time of day and weather. Independent pairs of observers surveyed both treatment sites on the same day to reduce any effect of weather on the results. There was a clear trend that indices of bird activity (particularly of frugivorous species) were higher in the sites that have been receiving possum control (Table A1.2).

References

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- Reddix, B.; Parkes, J. 2003: Conservation benefits of Animal Health Board possum control on public conservation lands. I. Experimental design. Landcare Research Contract Report: LC023/62. Landcare Research, Lincoln, New Zealand (unpublished).

TABLE A1.1. MEAN FOLIAR COVER INDICES (FCI; WITH STANDARD ERROR) AND PERCENTAGE BROWSE FOR ALL TREES SAMPLED IN THE POSSUM CONTROL AND NO-POSSUM-CONTROL AREAS.

	POSSUM CONTROL				NO-POSSUM-CONTROL			
	SAMPLE SIZE	MEAN FCI (%)	SE	BROWSE (%)	SAMPLE SIZE	MEAN FCI (%)	SE	BROWSE (%)
<i>Fuchsia excorticata</i>	50	64.0	1.8	0.0	59	59.7	2.0	33.9
<i>Pseudopanax simplex</i>	70	62.1	1.4	0.0	52	56.9	1.6	26.9
<i>Pseudopanax crassifolius</i>	24	57.3	3.6	0.0	31	63.9	1.7	0.0
<i>Weinmannia racemosa</i>	69	82.4	5.9	0.0	66	73.1	1.1	0.0
<i>Pseudopanax colensoi</i>	68	61.5	1.4	0.0	65	63.3	1.2	11.1
<i>Aristotelia serrata</i>	52	58.8	1.6	0.0	50	59.0	1.7	32.0
<i>Podocarpus ballii</i>	26	24.0	3.8	3.8	16	56.9	3.7	12.5
<i>Metrosideros umbellata</i>	63	74.9	0.9	0.0	1	75.0	0.0	0.0

TABLE A1.2. MEAN NUMBER OF BIRDS (WITH STANDARD ERROR) PER 5-MINUTE BIRD COUNT IN POSSUM CONTROL AREAS ($n = 54$ COUNTS) AND NO-POSSUM-CONTROL AREAS ($n = 53$ COUNTS) IN SOUTHLAND.

SPECIES	COMMON NAME	POSSUM CONTROL		NO-POSSUM-CONTROL	
		MEAN NUMBER PER 5 MINUTES	SE	MEAN NUMBER PER 5 MINUTES	SE
<i>Antbornis melanura</i>	Bellbird	3.69	0.22	2.64	0.13
<i>Rhipidura fuliginosa</i>	Fantail	0.26	0.08	0.17	0.05
<i>Gerygone igata</i>	Grey warbler	0.96	0.11	0.60	0.09
<i>Hemiphaga novaeseelandiae</i>	New Zealand pigeon	0.87	0.18	0.09	0.04
<i>Petroica macrocephala</i>	Tomtit	1.06	0.09	1.00	0.09
<i>Moboua novaeseelandiae</i>	Brown creeper	0.69	0.17	1.08	0.23
<i>Zosterops lateralis</i>	Silvereye	1.65	0.26	0.60	0.12
<i>Carduelis carduelis</i>	Goldfinch	0.02	0.02	0.08	0.05
<i>Carduelis flammea</i>	Redpoll	0.50	0.17	0.19	0.06
Unknown		0.04	0.04	0.00	-
<i>Eudynamys taitensis</i>	Long-tailed cuckoo	0.00	-	0.06	0.04
<i>Turdus merula</i>	Blackbird	0.17	0.05	0.00	-
<i>Prosthemadera novaeseelandiae</i>	Tui	0.07	0.05	0.00	-
<i>Gymnorhina tibicen</i>	Australian magpie	0.02	0.02	0.00	-
<i>Ninox novaeseelandiae</i>	Morepork	0.02	0.02	0.00	-
<i>Prunella modularis</i>	Hedge sparrow	0.02	0.02	0.00	-
<i>Acanthisitta chloris</i>	Rifleman	0.06	0.04	0.00	-
<i>Cyanoramphus</i> spp.	Parakeet species	0.00	-	0.00	-

Appendix 2

EXAMPLE SURVEY FORM

CONSERVATION BENEFITS OF AHB-FUNDED POSSUM CONTROL ON DOC LAND

EXAMPLE

Region	Canterbury	
Control area name	Waitohi Okuku Gorge	
Control operation name	Waitohi Okuku Gorge 2003	
Size of the control area (in ha)	7081	HA
THIS IS THE SIZE OF THE AREA OF POSSUM HABITAT BEING CONTROLLED, NOT THE SIZE OF THE OVERALL MANAGEMENT UNIT		
How have the control area details been supplied?	Electronic GIS file _M	Paper map _P
Polygon identifier - VM	Waitohi03	Polygon identifier - Landcare Landcare use only

Type of control operation?	TICK ONE BOX	Maintenance _M	Initial _I
If the type of control was 'Maintenance', what habitats were controlled?	TICK ONE OR MORE BOXES	Forest-pasture margin _M	Farmland _F
		Forest buffer strip _S	Forest block _B
If the maintenance control included a 'forest buffer strip', what was the average width?			- _M

What type of control was used?	TICK ONE OR BOTH	Aerial _A	Ground _G
AERIAL CONTROL		GROUND CONTROL	
Size of area (in ha)	5988	HA	Size of area (in ha) 1093 HA
Control start date	06/03	MM/YY	Control start date 07/03 MM/YY
Control finish date	07/03	MM/YY	Control finish date 10/03 MM/YY
Type of bait used	Carrot		Method of control used Traps
TICK ONE BOX	Cereal (pellets)		Poison
	Other		Traps and poison
Was pre-feeding used?	Y/N	N	If poison was used, what was the bait/toxin?
Was GPS used?	Y/N	Y	TICK ONE OR MORE BOXES
Sowing rate for toxic baits	4	KG/HA	1080 pellets
Toxin used	1080		1080 gel
Toxic loading	0.08%		Cyanide paste
Was there an RTCI target?	Y/N	Y	Feratox
If 'Yes', what was the target RTCI?		2%	Feracol
Was post-control monitoring done?	Y/N	Y	Brodifacoum
If 'Yes', what was the mean RTCI?		0.8%	Campaign
NOTES:			If poison used, was pre-feeding done? Y
			Was there an RTCI target? Y/N Y
			If 'Yes', was the target RTCI? 2%
			Was post-control monitoring done? Y/N Y
			If 'Yes', what was the mean RTCI? 1.7%
			NOTES:

Appendix 3

SUMMARY OF THE GENERAL CHARACTERISTICS OF CONTROL OPERATIONS ON PUBLIC CONSERVATION LAND

TABLE A3.1. DETAILS OF AERIAL POSSUM CONTROL OPERATIONS FOR ALL SURVEYED REGIONS COMBINED FOR THE PERIOD 2000/01-2003/04.

CONTROL DETAILS		PERCENTAGE OF OPERATIONS (%)	NUMBER OF OPERATIONS*
Bait type	Carrot	6.5	62
	Pellet	93.5	62
Pellet type	16 mm	25.0	24
	20 mm	75.0	24
Toxin = 1080		100	78
Toxic sowing rate	1 kg/ha	1.8	57
	2 kg/ha	43.9	57
	3 kg/ha	50.8	57
	4 kg/ha	3.5	57
Toxic loading	0.08 mg/kg	0.0	60
	0.15 mg/kg	100	60
Post-control monitoring undertaken		98.0	64

* Operations where detailed control information was supplied only.

TABLE A3.2. DETAILS OF GROUND POSSUM CONTROL OPERATIONS FOR ALL SURVEYED REGIONS COMBINED FOR THE PERIOD 2000/01-2003/04.

CONTROL DETAILS		PERCENTAGE OF OPERATIONS (%)	NUMBER OF OPERATIONS*
Control type	Traps	88.4	491
	Poison	91.0	491
Poison type	1080 pellets	22.5	448
	1080 carrot	0.9	448
	1080 gel	0.0	448
	1080 paste	4.0	448
	1080 apple	0.0	448
	Cyanide paste	24.3	448
	Feratox®	90.8	448
	Feracol®	22.3	448
	Campaign®	1.6	448
	Brodifacoum	9.4	448
Post-control monitoring undertaken		99.4	724

* Operations where detailed control information was supplied only.

Appendix 4

CLASSIFICATION OF LAND COVER DATABASE VERSION 2 HABITAT CATEGORIES

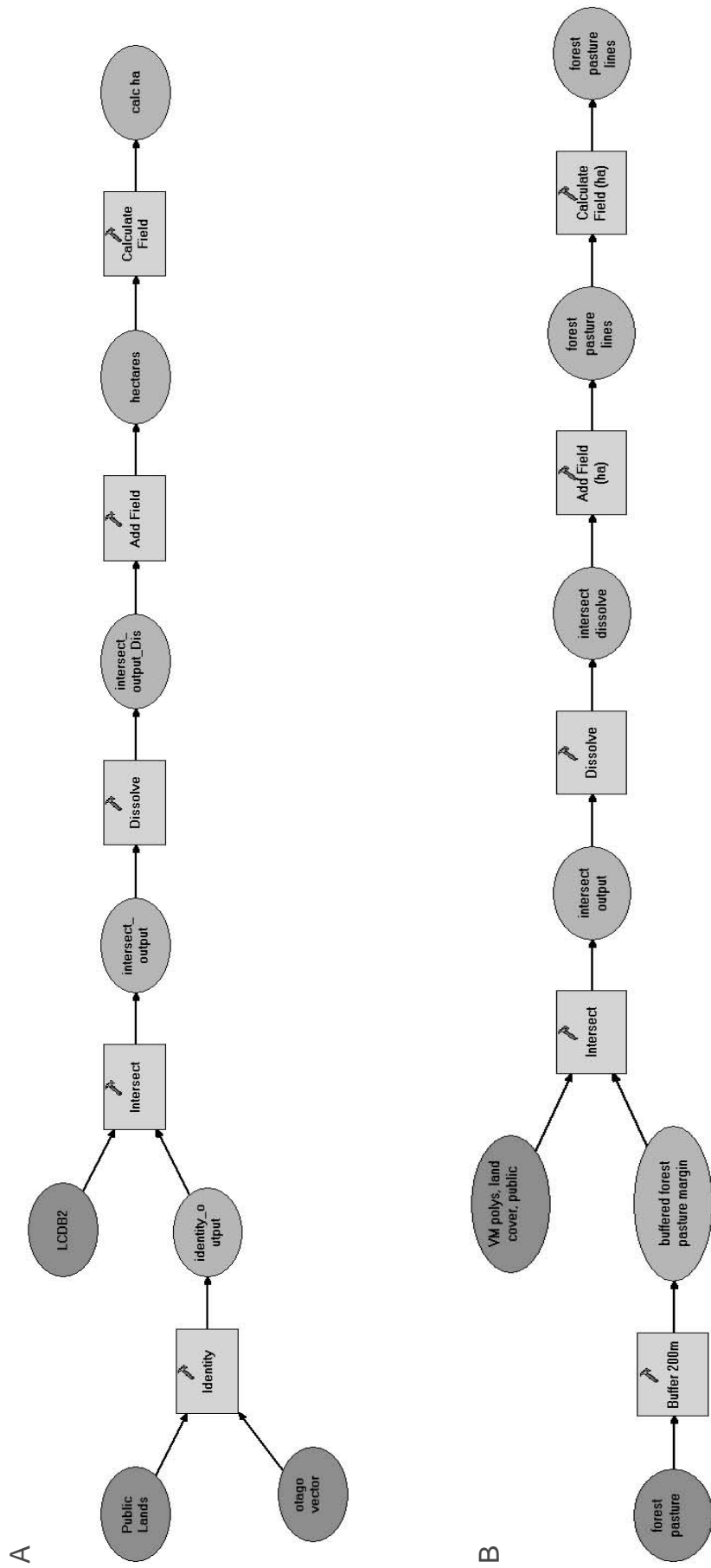
Classification of Land Cover Database Version 2 (LCDB2) habitat categories into habitat categories used in this project (LCDB2 data supplied by Ministry for Environment, July 2004).

HABITAT CATEGORY IN THIS STUDY	LCDB2 HABITAT CATEGORY
Forest	Afforestation
	Broadleaved/indigenous hardwoods
	Deciduous hardwoods
	Forest harvested
	Indigenous forest
	Other exotic forest
	Pine forest—closed canopy
	Pine forest—open canopy
Scrub	Gorse and broom
	Grey scrub
	Manuka and/or kanuka
	Matagouri
	Mixed exotic shrubland
	Subalpine shrubland
Pasture/other	Orchard and other perennial crops
	Alpine gravel and rock
	Built-up area
	Coastal sand and gravel
	Dump
	Estuarine open water
	Fernland
	Flaxland
	Herbaceous freshwater vegetation
	Herbaceous saline vegetation
	Lake and pond
	Landslide
	Low-producing grassland
	Major shelterbelts
	Orchard and other perennial crops
	River
	River/lakeshore gravel/rock
	Short-rotation cropland
	Surface mine
	Transport infrastructure
Urban parkland/open space	

Appendix 5

GIS APPROACH USED TO CALCULATE AREA OF CONTROL

The Geographic Information Systems (GIS) approach used to calculate:
A. the area of forest and scrub that had received possum control on public conservation lands when the habitat type 'forest block' was deemed to be treated, and B. area of forest within 200 m of a forest-pasture margin that had received possum control on public conservation lands when the habitat type 'forest buffer' or 'forest-pasture margin' was deemed to be treated.



Appendix 6

TOTAL AREA OF CONTROL OPERATIONS IN SURVEYED REGIONS

TABLE A6.1. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE MANAWATU-WANGANUI REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1999/00	134 096	20 311			19 438	489	19 438	489
2000/01	366 931	32 609			29 446	1774	29 446	1774
2001/02	847 642	103 995	15 019	696	77 558	4177	92 577	4873
2002/03	793 567	105 241	9313	325	85 698	6639	95 011	6964
2003/04	841 719	106 826			98 441	4829	98 441	4829

TABLE A6.2. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE WELLINGTON REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1993/94	5926	5897	5627	200			5627	200
1994/95	31 158	28 002	25 707	2068			25 707	2068
1995/96	17 701	3429	2349	944			2349	944
1996/97	14 082	9557	8869	458			8869	458
1997/98	33 425	15 577	11 895	1475			11 895	1475
1998/99	16 965	12 731	10 324	413			10 324	413
1999/00	15 895	7037	6269	193			6269	193
2000/01	28 122	14 038	11 362	1294	271		11 633	1294
2001/02	29 562	13 090	11 419	1440			11 419	1440
2002/03	20 206	13 145	11 445	610			11 445	610
2003/04	34 391	13 452	8675	650	3117	13	11 792	663

TABLE A6.3. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE TASMAN REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
2000/01	56 602	19 110	16 601	1385			16 601	1385
2001/02	80 181	22 774	13 606	2780	1		13 607	2780
2002/03	230 208	115 568	90 430	13 215			90 430	13 215
2003/04	245 555	137 908	108 432	14 504	1554	697	109 986	15 201

TABLE A6.4. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE MARLBOROUGH REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1997/98	11 803	153	18	92			18	92
1998/99	47 943	709	226	228			226	228
1999/00	90 225	2878	1845	567			1845	567
2000/01	124 132	3062	1802	378			1802	378
2001/02	157 884	9171	2905	2473			2905	2473
2002/03	212 043	11 629	4289	2445	35	5	4324	2450
2003/04	193 767	11 219	3126	2654	151	82	3277	2736

TABLE A6.5. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE WEST COAST REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1993/94	13 185	11 055	10 257	554			10 257	554
1994/95	179 382	63 315	51 318	2804			51 318	2804
1995/96	211 101	72 453	33 973	26 339			33 973	26 339
1996/97	189 111	36 853	16 900	5886			16 900	5886
1997/98	192 355	36 145	18 704	3516			18 704	3516
1998/99	189 933	35 625	21 314	277			21 314	277
1999/00	215 282	54 207	35 317	3793			35 317	3793
2000/01	198 153	37 593	20 993	1226			20 993	1226
2001/02	219 407	55 598	31 953	8121			31 953	8121
2002/03	215 605	55 430	30 128	10 198			30 128	10 198
2003/04	205 390	45 417	23 635	6743			23 635	6743

TABLE A6.6. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE CANTERBURY REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1996/97	29 929	43			3	9	3	9
1997/98	80 127	1351	475	408			475	408
1998/99	269 236	32 583	4523	7	1039	1607	5562	1614
1999/00	378 254	36 191	5498	2549	890	1401	6388	3950
2000/01	448 034	30 681	4863	20	181	101	5044	121
2001/02	333 208	14 232	468	83	161	110	629	193
2002/03	641 254	19 118	1238	74	93	33	1331	107
2003/04	489 583	35 135	2412	1610	4858	5926	7270	7536

TABLE A6.7. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE OTAGO REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1996/97	76 850	188	7		34	3	41	3
1997/98	69 497	1031	450		7		457	0
1998/99	292 553	10 005	3439	710	188	11	3627	721
1999/00	448 117	27 843	15 101	2851			15 101	2851
2000/01	560 971	30 448	16 557	1123	128	33	16 685	1156
2001/02	669 701	45 980	22 503	3298	128	33	22 631	3331
2002/03	1 004 722	84 597	46 293	6652	128	33	46 421	6685
2003/04	935 453	45 701	9479	2053			9479	2053

TABLE A6.8. TOTAL AREA (ha) OF CONTROL OPERATIONS IN THE SOUTHLAND REGION, THE AREA OF PUBLIC CONSERVATION LANDS (PCL) WITHIN THAT AREA, AND THE AREA OF FOREST AND SCRUB CONTROLLED ON PUBLIC CONSERVATION LANDS (KNOWN AREA = HABITAT TYPES RECORDED AS KNOWN IN THE SURVEY; POTENTIAL AREA = HABITAT TYPES UNKNOWN IN THE SURVEY).

YEAR	TOTAL AREA OF CONTROL OPERATIONS (ha)	TOTAL AREA OF CONTROL OPERATIONS (ha)	POSSUM CONTROL ON PCL (ha)					
			KNOWN AREA CONTROLLED		POTENTIAL AREA CONTROLLED		COMBINED KNOWN AND POTENTIAL AREAS	
			FOREST	SCRUB	FOREST	SCRUB	FOREST	SCRUB
1997/98	159 071	30563			27 070	770	27 070	770
1998/99	662 979	95 500			51 779	8688	51 779	8688
1999/00	533 016	70 605			44 742	4307	44 742	4307
2000/01	696 362	82 002	59 700	5439	3528	1114	54 228	6553
2001/02	804 249	81 157	51 729	5630			51 729	5630
2002/03	549 458	57 782	30 707	3580	4694	1662	35 401	5242
2003/04	535 454	59 994	37 944	2030	1709	1483	39 653	3513

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