Distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria

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Front cover photo: Adult female Red Deer and calf in a pine plantation, Gippsland, February 2012 (photo: Rohan Bilney).

Edited by Organic Editing

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Acknowledgements

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Summary

Background

Introduced deer species can have negative impacts on agricultural and environmental values. There is concern that deer species are expanding their Victorian distributions through natural and human-assisted dispersal, increasing the biosecurity risk to Victoria. Understanding the current distributions of deer species in Victoria will help inform their management, including as an important game resource. In general, preventing the establishment of 'new' populations provides a higher return on investment than eradication, and containment provides a higher return on investment than managing the impacts of widespread species. Understanding the distribution of deer species at various time-steps following their establishment will assist in the delineation of management areas. The Biosecurity Division of the Department of Environment and Primary Industries[1] commissioned the Arthur Rylah Institute for Environmental Research (ARIER) to investigate the historical and current wild distributions of deer species in Victoria. The wild distributions of Sambar Deer (*Rusa unicolor*), Rusa Deer (*Rusa timorensis*) and Sika Deer (*Cervus nippon*) in Victoria were described in a previous report (Forsyth et al. 2015). This report describes the wild distributions of Fallow Deer (*Dama dama*), Red Deer (*Cervus elaphus scoticus*), Hog Deer (*Axis porcinus*) and Chital Deer (*Axis axis*) in Victoria. All of these species can be legally hunted in Victoria (Game Management Authority 2015).

Objective

To determine the historical and current distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria.

Methodology

We obtained information on the historical and current breeding distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria from four sources: first, from books, journal articles and published/unpublished reports; second, from sightings recorded in the Victorian Biodiversity Atlas and the Atlas of Living Australia; third, from ARIER staff and contractors; fourth, from interviews with people with expert knowledge of deer in Victoria (and New South Wales. ACT and South Australia).

Sightings of deer were collated in spreadsheets. The breeding distributions of deer were aggregated onto hard-copy maps and digitised in ArcMap 10.1 (ArcGis 10.1 for Desktop, ESRI software). Shapefiles of hand-drawn polygon features, representing the distributions of the deer species, were created using the construction tools in ArcMap. The deer sightings were then projected onto these distribution polygons and displayed on maps of Victoria.

Results and Conclusions

There was insufficient information to robustly delineate the historical distributions of the four deer species in Victoria. However, the historical information we collected helped us determine the current breeding distributions of these species in Victoria.

Three of the four species were confirmed to have wild, self-sustaining breeding populations in Victoria in 2015: Fallow Deer (n = 61 populations), Red Deer (n = 27 populations) and Hog Deer (n = 1 population). The current breeding distributions of these three deer species in Victoria were estimated to be 21,400 km^2, 3900 km^2 and 2336 km^2, respectively.

[1] The Biosecurity Division transferred to the Department of Economic Development, Jobs, Transport and Resources on 1 January 2015.

Fallow Deer and Red Deer have greatly increased their distributions since the 1980s, due to deliberate releases, escapes from farms, and dispersal from established populations. It is likely that the distributions of Fallow Deer and Red Deer will continue to increase in Victoria.

In contrast, the distribution of Hog Deer (which is confined to the coastal strip between Tarwin River and Point Hicks) has not increased since at least the 1980s. This suggests that the current distribution of this species in Victoria is limited by biophysical factors and will not further increase from natural dispersal. However, there is a possibility that one or more new Hog Deer populations could establish in the coastal strip in western Victoria from deliberate releases or escapes from farms.

Chital Deer are being held in captivity in Victoria, and two males have been shot (one an escape and one almost certainly released), but there is no evidence of a wild, self-sustaining breeding population of this species in Victoria. However, Chital Deer could potentially establish a population and are, therefore, a biosecurity risk for Victoria.

Recommendations

Encouraging the general public (including hunters) and agency staff to enter their observations of introduced species (including wild deer) into the Victorian Biodiversity Atlas would greatly improve our knowledge of their distributions and aid their management.

A pilot study should be conducted to assess the potential of molecular techniques for identifying the sources of 'new' deer populations and for helping managers understand the potential for reinvasion if eradication of a new population is attempted. Molecular analysis would also assist in defining genetic populations and potential management units, which is critical for understanding disease epidemiology and emergency disease preparedness.

The probability of eradicating a deer population is highest when the population is smallest (in distribution and abundance). Managers wishing to eradicate a new deer population should, therefore, implement an appropriate eradication plan as soon as possible.

The distributions reported here can be used to develop policy to delineate areas of deer distribution within which deer are managed as game and areas within which deer are managed differently.

The distributions of most wild deer species in Victoria are likely to change and should be reassessed every decade.

1 Introduction

Introduced deer are a challenging wildlife management issue in Victoria. In some situations deer have negative impacts on agricultural (Lindeman and Forsyth 2008) and environmental (Department of Sustainability and Environment 2009; Bennett and Coulson 2011) values. However, some deer species are also important game animals (Department of Environment and Primary Industries 2013; Moloney and Turnbull 2013; Game Management Authority 2015). From both biosecurity and game management perspectives, there is concern that deer species are expanding their Victorian distributions through natural and human-assisted dispersal. One approach to managing deer populations is to delineate areas of their distribution within which they are to be managed as game and to manage them differently in other areas. Understanding the distributions of deer species at various time-steps following their establishment can assist in the delineation of management areas. In general, preventing the establishment of 'new' populations provides a higher return on investment than eradication, and containment provides a higher return on investment than managing the impacts of widespread species (Department of Environment and Primary Industries 2014).

The Biosecurity Division of the Department of Environment and Primary Industries[2] commissioned the Arthur Rylah Institute for Environmental Research (ARIER) to investigate the historical and current wild distributions of deer species in Victoria. The wild distributions of Sambar Deer (*Rusa unicolor*), Rusa Deer (*Rusa timorensis*) and Sika Deer (*Cervus nippon*) in Victoria were described in a previous report (Forsyth et al. 2015). This report describes the wild distributions of Fallow Deer (*Dama dama*), Red Deer (*Cervus elaphus scoticus*), Hog Deer (*Axis porcinus*) and Chital Deer (*Axis axis*) in Victoria. All four species can be legally hunted in Victoria (Game Management Authority 2015): in the 2012–2013 financial year, an estimated 9282 Fallow Deer, 1671 Red Deer and 197 Hog Deer were harvested by hunters (Moloney and Turnbull 2014).

An open season for Chital Deer was prescribed in 2009 (Z. Powell, Game Management Authority, pers. comm.), but none have been reported harvested (Moloney and Turnbull 2014). The current wild status of Chital Deer in Victoria is unclear. It is possible that, if established in Victoria, this species could substantially further increase its distribution.

2 Objective

To determine the historical and current distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria.

[2] The Biosecurity Division transferred to the Department of Economic Development, Jobs, Transport and Resources on 1 January 2015.

3 Methodology

3.1 Data sources

We obtained information on the historical and current breeding distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria from four sources. First, we searched books, journal articles and published/unpublished reports. Second, we searched the Victorian Biodiversity Atlas (VBA; Department of Environment, Land, Water and Planning 2015) and the Atlas of Living Australia (ALA) for records of these four deer species. The VBA is a Web-based information system for managing information about wildlife in Victoria. Dated and georeferenced records of wildlife (including deer) can be uploaded to the VBA by registered users; all records are vetted by experts before being accepted, with those outside the accepted range receiving additional vetting. The VBA records used in our analyses were current at 18 August 2015. We discarded the indirect sightings (i.e. sighting type = 'indirect evidence' or 'heard' or 'identified from hair' or 'pers. comm.' or 'literature') and included the sighting types 'seen' or 'observation' or 'observation with supporting evidence'. Third, we asked ARIER staff and contractors for sightings of deer that had not been entered into the VBA. Fourth, we used our networks to identify people with potential knowledge of the distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria. We conducted telephone and/or face-to-face interviews, or corresponded by email, with those people with the objective of recording new or edge-of-distribution sightings of these deer species.

Like most mammals, male deer typically have larger home ranges and disperse more frequently and further than female deer (Catchpole et al. 2004; Kjellander et al. 2004; Loe et al. 2009). These traits have important implications for understanding and delineating the distributions of deer. First, male deer may be seen many tens of kilometres from the nearest females (sensu Caughley 1970). For example, in 1971 an adult male Sambar Deer was photographed near Berrigan, NSW, at least 130 km from the nearest breeding population (Bentley 1998). Such males may either be dispersing (i.e. moving through an area) when they are sighted or have dispersed and established a home range in which they are sighted. We used Caughley's (1970) definition of 'breeding distribution' (i.e. where males and females with offspring are known to be present) to differentiate between sighting locations of dispersing/dispersed males and where the species is breeding. This definition has management implications because long-distance male dispersers will eventually die out if females do not establish in that area. We, therefore, believe that knowing 'breeding distribution' is more useful than knowing 'total distribution'.

The objective of this study was to compare the historical and current distributions of these four deer species in Victoria. However, we could find no historical maps of the distribution of these species within Victoria that were sufficiently accurate for this purpose. The four previous summaries of wild deer distributions (Murray and Snowden 1976; Wilson et al. 1992; Moriarty 2004; West 2011) were conducted at the national scale and did not delineate the distributions of deer within Victoria at a scale useful for our purposes. Bentley (1998) and other Victorian deer experts did not accurately map the historical distributions of deer in Victoria. We, therefore, could not sensibly delineate the historical distributions of deer in Victoria. Rather, we used the historical records of deer sightings and descriptions in the literature to help inform the current breeding distributions and to assess the potential for further expansion.

Breeding distributions were transcribed onto maps by—or in consultation with—the interviewee. Distributions were usually transcribed onto Gregory's Victoria Map 319 Edition 5 (scale = 1:975,000), although larger-scale maps were sometimes used, depending on the scale of the information provided by the interviewee. We also asked whether that person could recommend other people for us to interview. The people interviewed, and their affiliations (if any), are listed in Appendix 1. Some information was provided to us confidentially, and we include this with 'name withheld'.

There were too many breeding populations of Fallow Deer and Red Deer to describe individually within the text of this report. We, therefore, describe the main breeding populations within each of the Department of Environment, Land, Water and Planning's (DELWP) six geographic regions (Hume, Gippsland, Port Phillip, Grampians, Loddon Mallee and Barwon South West; Department of Environment, Land, Water and

Planning 2016) for Fallow Deer and Red Deer. These six regions (Appendix 2) are useful for this purpose because they delineate the state according to biophysical attributes that are broadly applicable to deer and are meaningful for government agency staff.

3.2 Data storage and visualisation

Sightings of deer were collated in a spreadsheet. The breeding distributions of deer were aggregated onto hard-copy maps and digitised in ArcMap 10.1 (ArcGis 10.1 for Desktop, ESRI software). Shapefiles of hand-drawn polygon features, representing the distributions of the deer species, were created by overlaying a blank polygon layer on road, locality, hydrology, and land tenure shapefiles available through the DELWP Corporate Spatial Data Library. Polygons were drawn using the construction tools in ArcMap. The deer sightings were then projected onto these distribution polygons and displayed on a map of Victoria.

4 Results

4.1 Fallow Deer

There were 136 sighting records (i.e. classified as 'seen', 'observation' or 'observation with supporting evidence') of Fallow Deer that were spatially and temporally referenced and, hence, could be mapped by decade (Figure 1). Distributional information gleaned from the literature and interviews was not sufficiently detailed to include as sighting records, but was used to delineate the breeding distribution of Fallow Deer. The first and last sightings in the VBA were 1973 and 2015, respectively.

Based on the sighting records and distributional information gleaned from the literature and interviews, the current (2015) Victorian Fallow Deer breeding distribution was estimated to be 21,400 km^2 (Figure 2). There were 61 Fallow Deer breeding populations.

4.1.1 Gippsland Region

There is a continuous population of Fallow Deer that extends along the upper Snowy River from the New South Wales border south to Suggan Buggan and through to the farmland at Black Mountain (Roger Bilney, pers. comm.). Fallow Deer are patchily distributed southwards along the farm–forest interface, through Seldom Seen, Butchers Ridge, Murrindal, Timbarra and Buchan South, with the latter two populations having been established since at least 1983 (Norris et al. 1983). There is a population of Fallow Deer living in pine plantations and private land east of Bendoc (C. Anderson, pers. comm.) and another population east of Tubbut (Roger Bilney, pers. comm.). Fallow Deer are also present at Deddick (C. Anderson, pers. comm.), but it is unclear if this population is contiguous with the Snowy and Bonang populations (we assumed it was not).

Further south, a Fallow Deer population was established at Club Terrace in c. 2000 and has colonised up the Erinundra River valley (C. Anderson, pers. comm.). There is a substantial Fallow Deer population on and around the farm–forest interface at Hinnomunjie, Omeo and Benambra (G. Burston, pers. comm.). Bindi Station (near Omeo) has a particularly high Fallow Deer density (J. Pardew, pers. comm.). There are small numbers of Fallow Deer, originated from escapees, around Mt Taylor, near Bairnsdale (D. Young, pers. comm.). Fallow Deer are breeding in Providence Ponds Nature Reserve and on private land around Perry Bridge (T. Mitchell and Rohan Bilney, pers. comms). Fallow Deer are also breeding at Dutson Downs (S. White, pers. comm.).

In South Gippsland, Fallow Deer were deliberately released onto Sunday Island (Corner Inlet) in 1967 and are now common there (D. Forsyth, pers. obs.). Fallow Deer are breeding in and around Mt Worth State Park (Rohan Bilney, D. Young and C. Davies, pers. comms; Davies 2014) and in some other parts of the

Strzelecki Ranges (S. White, D. Young and D. Smith, pers. comms). Fallow Deer occur from Walkerville to Sandy Point (M. Harrison, pers. comm.).

4.1.2 Hume Region

There is a large Fallow Deer population near the Murray River, extending from Tallangatta in the west to south-east of Corryong. This population originates from a legal release of 19 animals into plantation forest at Koetong in 1978 (Phillips 1986), and its distribution includes Mount Granya State Park, Jarvis Creek Regional Park (D. Forsyth, pers. obs.), Shelley Plantation, Burrowa–Pine Mountain National Park, Mount Mitta Mitta Regional Park, Lucyvale, Nariel Gap and south-east of Corryong (J. Turnbull, pers. comm.).

Further west, Fallow Deer are breeding in Barmah National Park (B. Fahey, pers. comm.) and extend along the Murray River from Bundalong eastward through Corowa to near Wodonga. Further south, ARIER staff have recorded Fallow Deer on remote cameras at Kancoona South, Gonzaga Ridge and Long Corner Creek (Forsyth et al. 2014). There is a sizeable Fallow Deer population north of Mansfield, and several smaller populations around Lake Eildon and Mangalore (G. McClure, S. McGlashan, M. Harrison and K. Pearce, pers. comms). Fallow Deer are present in the Murrundindi–Strath Creek–Yea–Glenburn area (K. Pearce, pers. comm.).

4.1.3 Port Phillip Region

In the west, Fallow Deer are breeding in Plenty Gorge Park (A. Keratanios, pers. comm.) and in Warrandyte State Park (B. van Lith, pers. comm.). In the east, Fallow Deer are abundant in Yellingbo State Park, where there is a culling program (D. Hudson, pers. comm.), and they occur throughout the Dandenong Ranges National Park (D. Hudson and N. Davis, pers. comms), including in Cardinia Reservoir (M. Harrison, pers. comm.). Fallow Deer are present throughout Bunyip State Park; they occur at the forest–pasture interface between Moe and Woori Yallock and inland as far as the road from Launching Place to Noojee. The first Fallow Deer appeared in Bunyip State Park in the early 1990s, and had ear tags (M. Harrison, pers. comm.). There is a small Fallow Deer herd at Moondarra (D. Young, pers. comm.).

4.1.4 Loddon Mallee Region

Fallow Deer are widespread in parts of the Loddon Mallee Region, from Murrayville on the South Australian border along the Murray River to Echuca (M. Jones, unpublished data). Fallow Deer are present along the western boundary (South Australian border) of the Big Desert (R. Carter, pers. comm.), but are not apparently present in Wyperfeld or Murray–Sunset national parks. Fallow Deer occur patchily along the Murray River from Nyah westward to Mildura, and around Swan Hill. Fallow Deer have a significant distribution on mainly private land continuous from Wychitella Nature Conservation Reserve up the Loddon River to St Arnaud (R. Carter and H. Dunstan, pers. comms).

4.1.5 Grampians Region

Fallow Deer are present in Little Desert National Park west of Highway C206 through to the South Australian border (A. Braithwaite, pers. comm.) and extend North along the border through Big Desert Wilderness Park to the southern border of Murray–Sunset National Park, and inland to Murrayville (M. Jones, pers. comm.).

Fallow Deer are established in the area between Toolondo Reservoir and Black Range State Park (H. Dunstan, pers. comm.), and there is a separate population on the farm–forest interface on the eastern side of Grampians National Park (D. Panther, pers. comm.). There is also a population in The Pyrenees (H. Dunstan, pers. comm.).

Further east, Fallow Deer are established from Lake Eppalock north-east through Heathcote–Graytown National Park to Murchison (K. Pearce, pers. comm.). There are unconfirmed reports of Fallow Deer in Greater Bendigo National Park (H. Dunstan, pers. comm.). Fallow Deer are established in Wombat State Forest and Trentham Common (east of Wombat State Forest) (R. Holmes, pers. comm.), Lerderderg State Park (including the Pyrete Range area) (C. Dickie and G. Kilburn, pers. comms) and Creswick Regional Park (P. Fernando, pers. comm.). Fallow Deer are also present in parts of the Brisbane Ranges (C. Dickie, pers. comm.).

4.1.6 Barwon South West

Fallow Deer occur throughout the Lower Glenelg and Cobboboonee national parks, and adjacent pine (*Pinus* spp.) and Tasmanian Blue Gum (*Eucalyptus globulus*) plantations from the South Australian border east to Narrawong Flora Reserve (M. Murphy, D. Ryan, and L. Woodford, pers. comms). Fallow Deer are also common from Heywood northward to Casterton (M. Murphy and D. Ryan, pers. comms). Further east, Fallow Deer are present in Mount Eccles National Park (D. Forsyth, pers. obs.) and Mount Napier State Park (name withheld).

Fallow Deer are widespread in the area between Dartmoor northward to the Glenelg Highway, centred on the Wilkin Flora and Fauna Reserve, and in the wedge between the South Australian border, the Casterton–Penola Road and the Casterton–Apsley Road (B. McKinnon, J. Matthews and R. Hill, pers. comms). There are Fallow Deer in parts of Dergholm State Park and in small areas south-east of Casterton, west of Chetwynd, and in the Dundas Range (north of Coleraine) (B. McKinnon, J. Matthews and R. Hill, pers. comms).

There are at least three Fallow Deer populations around Timboon, including Cooriemungle Creek Flora Reserve, with approximately 80 culled since 2002 by the Curdies Valley Landcare Group (D. Drayton, pers. comm.). Fallow Deer are also present in Jancourt Flora and Fauna Reserve (C. Hurrell, pers. comm.).

Fallow Deer are present at the western and eastern ends of Great Otway National Park. In the west, there is a large population near Simpson and Kennedys Creek through to near Johanna (name withheld). In the east, there is an almost continuous population from Anglesea Heath through to Bambra and Deans Marsh. Fallow Deer are present in the You Yangs (K. Pearce, pers. comm.) and at Reedy Lake/Lake Connewarre (K. Pearce and C. Hurrell, pers. comms).

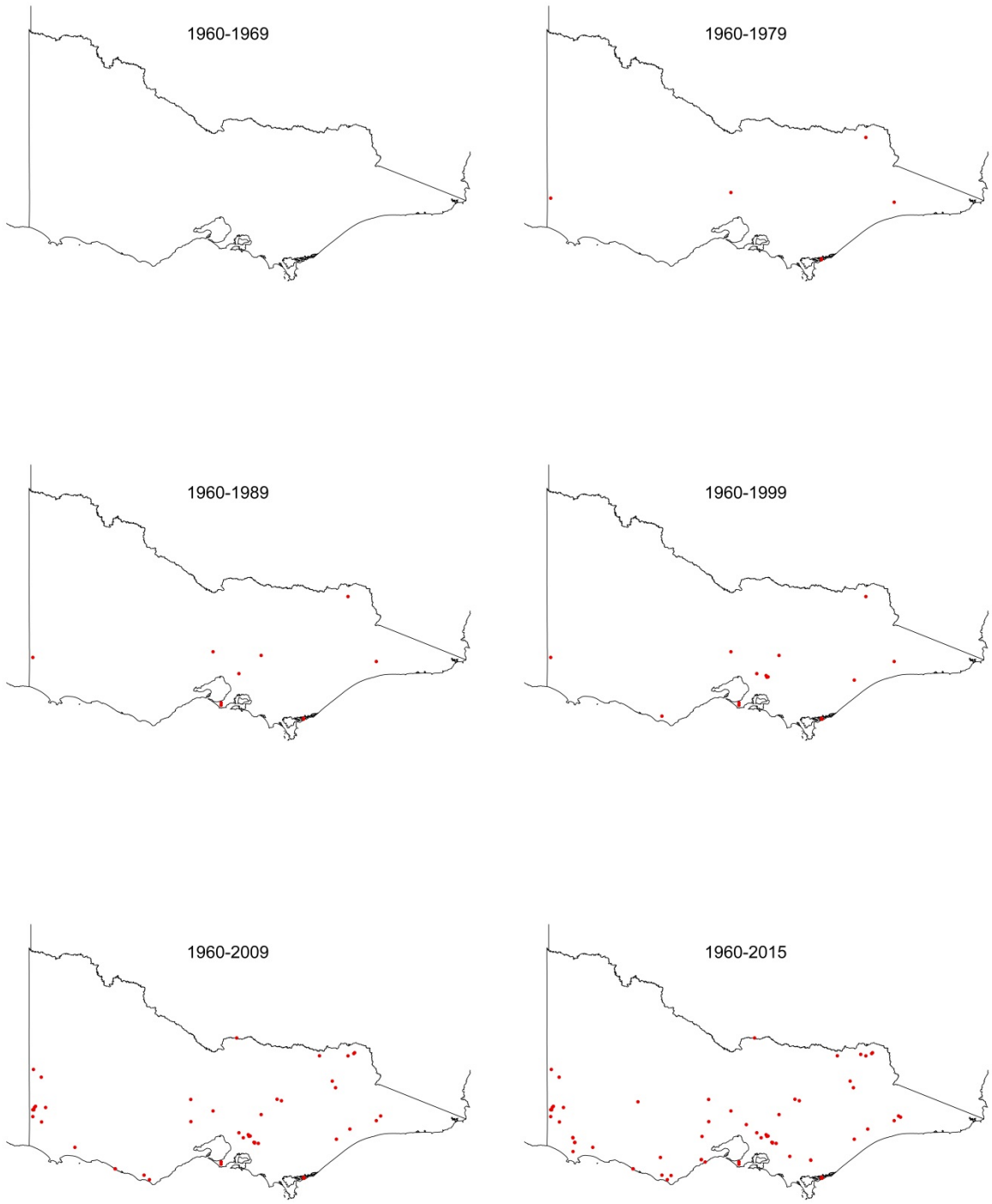

Figure 1. Sighting records of Fallow Deer in Victoria, 1960–2015
Records are shown cumulatively for each decade (for 1960–2009) or half-decade (for 2010–2015). Data sources are described in the Methodology and Results.

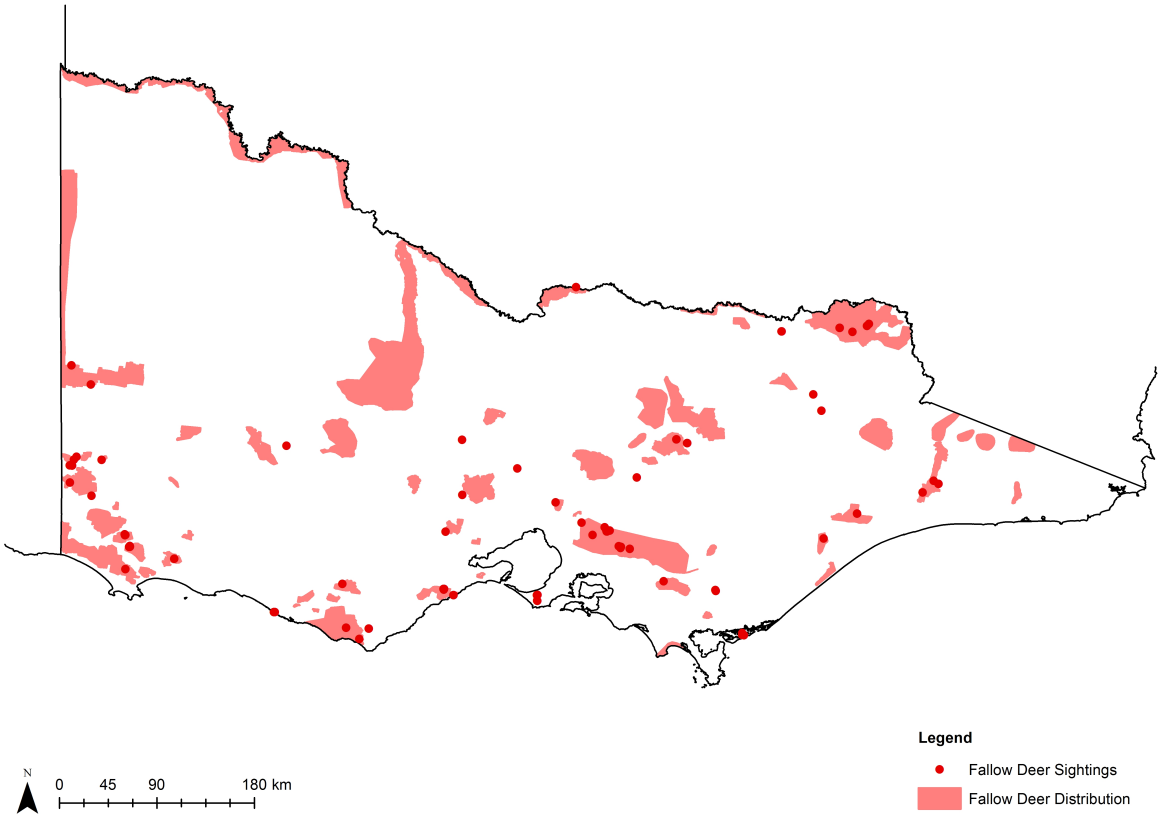

Figure 2. Current (2015) breeding distribution of Fallow Deer in Victoria overlaid on the 136 sighting records

4.2 Red Deer

There were 41 sighting records (i.e. classified as 'seen', 'observation' or 'observation with supporting evidence') of Red Deer that were spatially and temporally referenced and, hence, could be mapped by decade (Figure 3). The first and last sightings in the VBA and ALA were in 1967 and 2008, respectively. Based on the sighting records and distributional information gleaned from the literature and interviews, the current (2015) Victorian Red Deer breeding distribution was estimated to be 3900 km^2 (Figure 4). There is one large population that has been established for many years (termed the 'Grampians' Red Deer population; 2811 km^2) and 26 smaller populations (Figure 4).

4.2.1 Grampians Red Deer population

The Grampians Red Deer population descends from multiple releases/escapes of Red Deer occurring in western Victoria dating back to at least 1851 (Bentley 1998; Panther 2010) and includes all but three of the sightings in the VBA (Figure 4). The population distribution includes all of Grampians National Park through to the western side of Rocklands Reservoir and some adjacent farmland.

4.2.2 Other Red Deer populations

In Barwon South West Region, there are two small Red Deer populations around Timboon (D. Drayton, pers. comm.). Red Deer are also present from Dartmoor north to the Glenelg Highway, centred on the Wilkin Flora and Fauna Reserve, and are also present on both sides of the Glenelg River at Bahgallah. There are populations of Red Deer near Stoneyford/Swan Marsh (southern end of Lake Corangamite) and near Beech Forest (C. Hurrell, pers. comm.).

In Loddon Mallee Region, there are scattered records of Red Deer in the Riverine strip along the Murray River and its tributaries, including at Murrabit (M. Jones and R. Carter, pers. comms). However, it is unclear if these constitute a resident breeding population (we assumed not).

In Grampians Region, two Red Deer were seen in Dry Diggings State Forest in 2014 (R. Holmes, pers. comm.), and there may be up to 20 Red Deer in Bendigo Regional Park (H. Dunstan, pers. comm.). There are Red Deer near the South Australian border in Kanawinka State Forest and Dorodong Nature Conservation Reserve, and in and around Tooloy–Lake Mundi Wildlife Reserve. Further east, Red Deer are breeding in Enfield State Park (C. Hurrell, pers. comm.). There are rumours of Red Deer in Wombat State Forest, but it is unclear if this is a breeding population (Z. Powell, pers. comm.).

In Gippsland Region, there is a small population of Red Deer east of Bendoc (C. Anderson, pers. comm.). Escaped Red Deer have been shot at Buchan (D. Young, pers. comm.), but there is no evidence of a breeding population there. A Red Deer stag was seen at New Yard Plain, in the headwaters of the Buchan River, in 2013 (Roger Bilney, pers. comm.). Red Deer (some with ear tags) are present at Dutson Downs (Rohan Bilney, pers. comm.).

In Port Phillip Region, Red Deer were recorded in the Yan Yean catchment in 2001, most likely escapees from a deer farm (Liddicoat 2008). Line transect sampling estimated that there were 47 Red Deer in the 20 km^2 catchment in 2008 (Liddicoat 2008). Red Deer are also breeding in the Silvan, Cardinia and Sugarloaf reservoirs (M. Harrison, pers. comm.), with the latter population including parts of Warrandyte State Park (B. van Lith, pers. comm.).

In Hume Region, Red Deer are breeding near Yarck, Snobs Creek and Taggerty (G. McClure and S. McGlashan, pers. comms). Near the Murray River, Red Deer are present in parts of Jarvis Creek Regional Park and Mount Granya State Park, and there are small populations near Harrietville and in the Tallangatta Valley (G. McClure, pers. comm.). The Hume Region populations are all thought to have originated from deer farm escapes (G. McClure, pers. comm.).

Figure 3. Sighting records of Red Deer in Victoria, 1960–2015
Records are shown cumulatively for each decade (for 1960–2009) or half-decade (for 2010–2015). Data sources are described in the Methodology and Results.

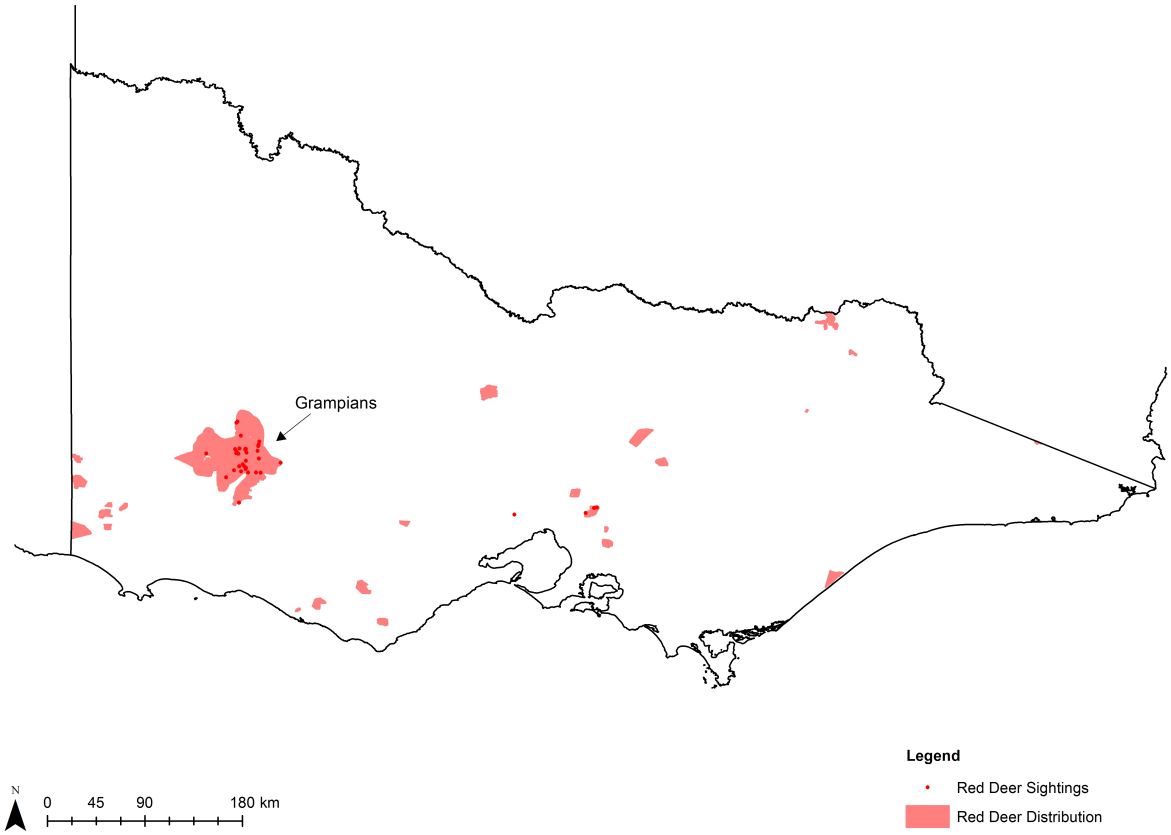

Figure 4. Current (2015) breeding distribution of Red Deer in Victoria overlaid on the 41 sighting records

4.3 Hog Deer

There were 302 sighting records (i.e. classified as 'seen', 'observation' or 'observation with supporting evidence') of Hog Deer that were spatially and temporally referenced and, hence, could be mapped by decade (Figure 5). The first and last sightings were in 1968 and 2010, respectively.

Based on the sighting records and distributional information gleaned from the literature and interviews, the current (2015) Victorian Hog Deer breeding distribution was estimated to be 2336 km^2, consisting of one discrete population restricted to a coastal strip between Tarwin Lower and Point Hicks (Figure 6, Figure 7, Figure 8). The most eastern confirmed sighting of a Hog Deer within this range was of a male in the Bald Hills Track area near Point Hicks in 2004 (J. Pardew, pers. comm.), but tracks attributed to Hog Deer have been seen near Wingan Inlet (J. Pardew, pers. comm.). In the western part of this range, Hog Deer are regularly seen at Tarwin Lower (name withheld). Deer are strong swimmers and are present on Snake, Little Snake, Sunday and Margaret islands in the Nooramunga Marine and Coastal Reserve (Mayze and Moore 1990; name withheld). Hog Deer are present in Macleod Morass (Bairnsdale) (D. Young, pers. comm.), common in nearby Blonde Bay State Game Reserve (M. Salmon, pers. comm.) and are at Dutson Downs (R. Bilney, pers. comm.).

We note that 17 records (representing nine locations) of Hog Deer (16 in the VBA and one in the ALA) are outside the 2015 breeding distribution of this species (Figure 6). We have assessed all of these sightings and are confident that Hog Deer are not breeding at those locations. Some of the sightings were likely dispersing male Hog Deer. Another possibility is that a breeding population was present at the time of the sighting, but was extinct in 2015 (e.g. as likely occurred at Tonimbuk and Bunyip; see Discussion).

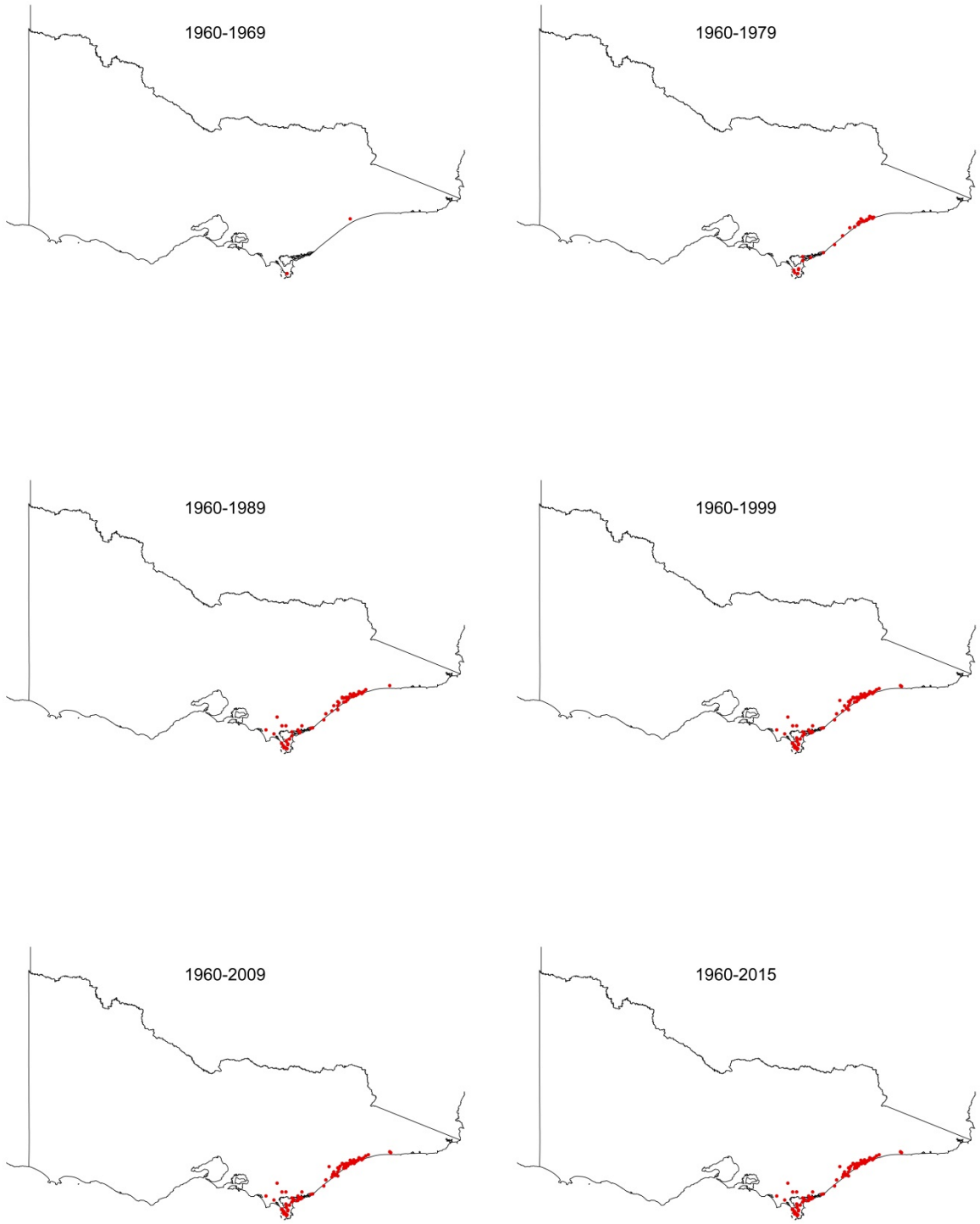

Figure 5. Sighting records of Hog Deer in Victoria, 1960–2015
Records are shown cumulatively for each decade (for 1960–2009) or half-decade (for 2010–2015). Data sources are described in the Methodology and Results.

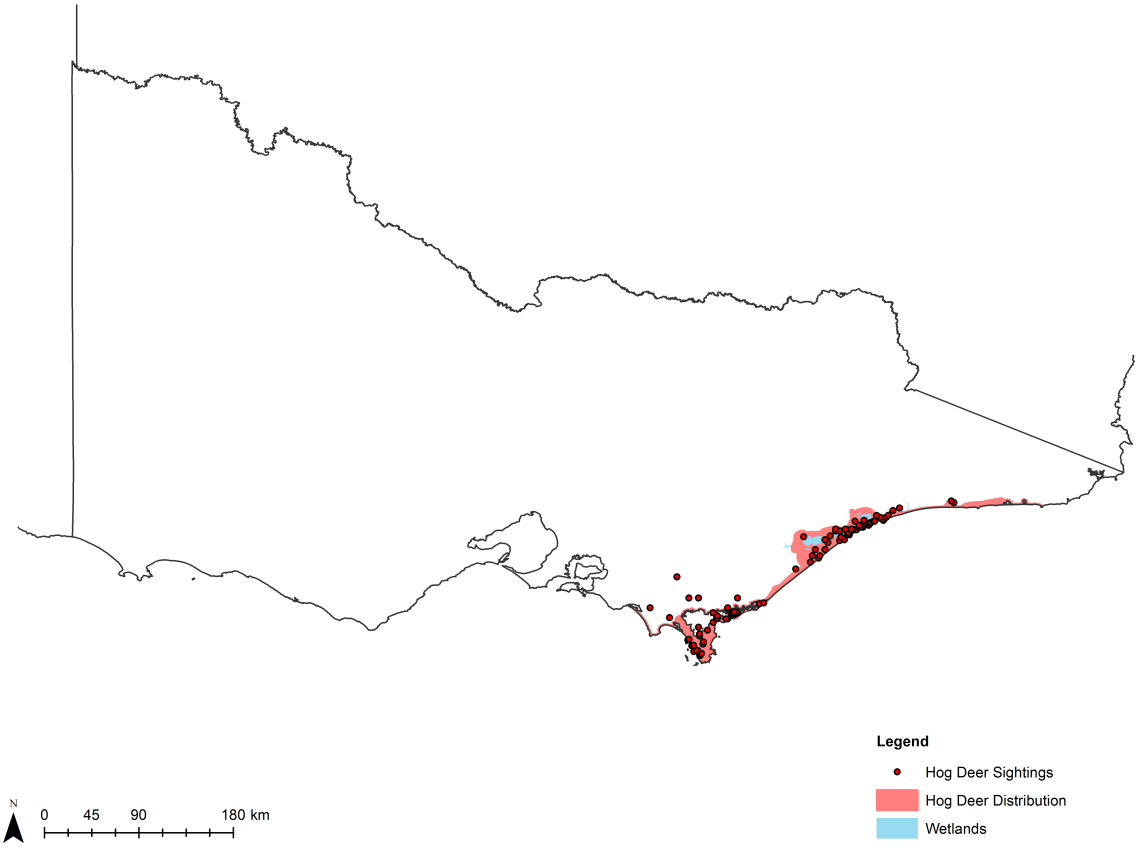

Figure 6. Current (2015) breeding distribution of Hog Deer in Victoria overlaid on the 304 sighting records

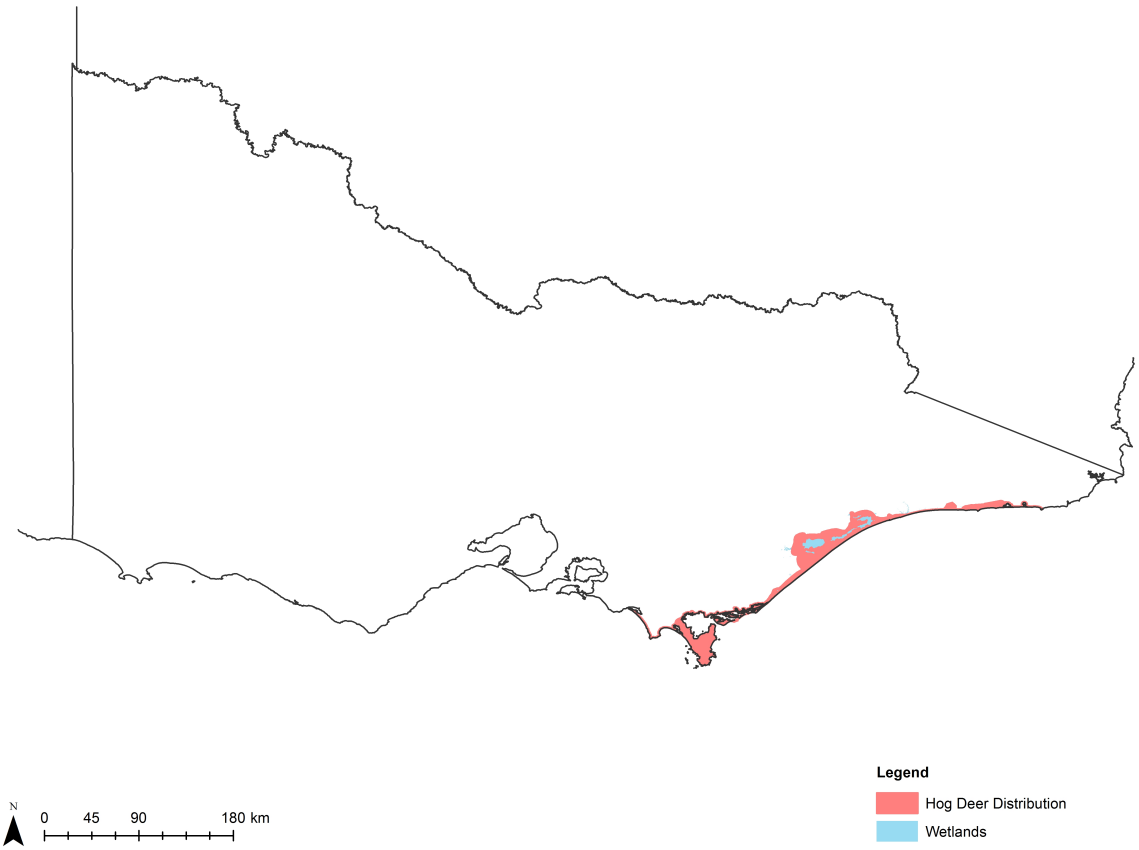

Figure 7. Current (2015) breeding distribution of Hog Deer in Victoria

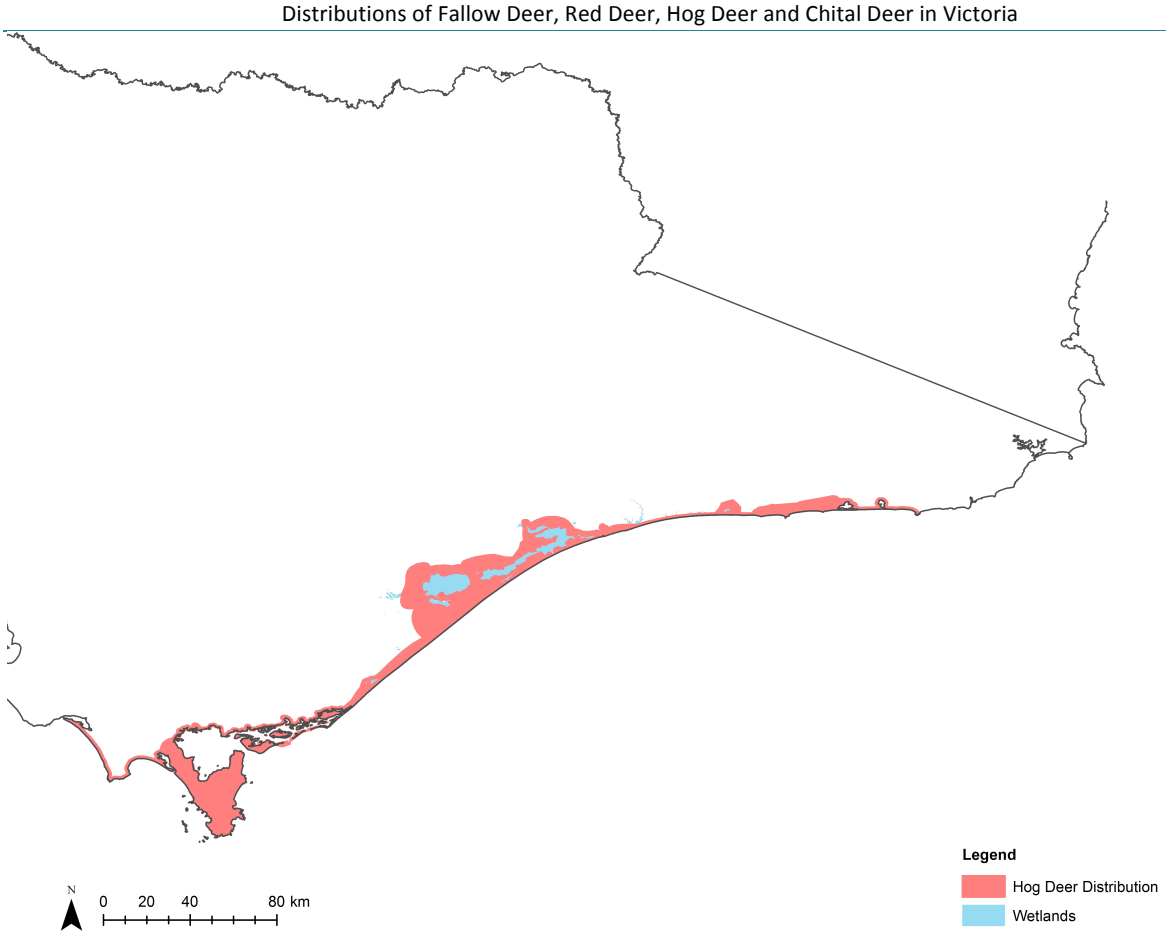

Figure 8. Larger-scale map of the current (2015) breeding distribution of Hog Deer in Victoria

4.4 Chital Deer

There were no sightings of Chital Deer in the VBA or the ALA. However, there has long been a large wild Chital Deer population in North Queensland (Allison 1969; Jesser 2008); more recently, populations have established in New South Wales and South Australia (Jesser 2008; A. Moriarty, pers. comm.). Although the New South Wales and South Australian wild populations are a long way from Victoria, the species is being kept on several game estates in Victoria. An escaped male Chital Deer was shot near Longford in 2009 (Z. Powell, pers. comm.): this animal likely originated from a nearby game estate known to have Chital Deer. Another male Chital Deer was shot in the Barwon South West region (location unknown) in 2014 (H. Dunstan, pers. comm.) and was almost certainly deliberately released (H. Dunstan, pers. comm.). Chital Deer are breeding in captivity on several game estates/farms in Victoria (S. White, pers. comm.), but there is no evidence of this species breeding in the wild in Victoria.

5 Discussion

We delineated the current breeding distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer using sightings recorded in the VBA and expert knowledge. Although thousands of Fallow Deer, Red Deer and Hog Deer have been legally harvested in Victoria (Moloney and Turnbull 2013, 2014), there are a total 485 records of these three species in the VBA, with an average of only 11 added annually during the decade beginning in 2000. If hunters provided locations for even 10% of deer that they harvested (and some of those that were seen but not harvested), then our understanding of historical changes in the distributions of Fallow Deer, Red Deer and Hog Deer would be much greater. Understanding the distribution of any

introduced species is necessary for its effective management (Pereira et al. 2012; Department of Environment and Primary Industries 2014). Encouraging the general public (including hunters) and agency staff to enter their observations of introduced species (including wild deer) into the VBA would greatly assist with their management. Interviewing all people with knowledge of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria was impractical; instead, we interviewed people with robust knowledge of these deer in selected parts of Victoria. The people interviewed (see Appendix 1) were, therefore, from a wide range of locations and agencies.

5.1 Fallow Deer

Fallow Deer have been released in Victoria since the 1860s (Menkhorst 1995; Bentley 1998). However, many of the populations that established from those early releases have since died out, perhaps because this species requires access to improved pasture and, hence, is vulnerable to overhunting (Bentley 1998). By the 1970s, only two small Fallow Deer populations existed in Victoria, one at Narbethong–Healesville and the other at Yarra Glen (Bentley 1998). In 2000, there were an estimated 17 Fallow Deer populations in Victoria (Moriarty 2004). Our study revealed 61 Fallow Deer populations in Victoria in 2015, occupying a total of 21,400 km^2. Although we did not attempt to estimate the number of deer in each of these herds, the area now occupied and the annual reported harvest (9282 in the 2012–2013 financial year; Moloney and Turnbull 2014) indicates that the total Victorian Fallow Deer population must be at least several tens of thousands.

Of the 17 populations reported in Moriarty (2004), 11 descended from translocations (deliberate releases) and six from deer farm escapes. The causes of accidental deer farm escapes include fallen trees and fire damaging fences, poor construction or maintenance of fences, and gates being left open (Fraser et al. 2000; see below). In our study, several interviewees noted that, following the decline in profitability of Fallow Deer as livestock in the 1990s, some farmers “opened their gates to get rid of them”. Other interviewees noted that live Fallow Deer could be purchased for “less than $100 each”, enabling people to easily purchase sufficient individuals to translocate and establish a new population. The smaller size of Fallow Deer also makes new populations of this species difficult to detect, and it is likely that there are more small Fallow Deer herds present in Victoria than we have documented.

The large Fallow Deer populations along the New South Wales border in East Gippsland and along the South Australian border in western Victoria almost certainly originated from natural dispersal of animals from established herds in New South Wales and South Australia, respectively (Bentley 1998). One of the other large Fallow Deer populations (in the Hume Region) originates from a legal release at Koetong in 1978 (Phillips 1986).

Although we have documented many new Fallow Deer populations, small populations reported to be extant at Narbethong–Healesville and Yarra Glen in the 1970s by Bentley (1998) have apparently gone extinct. Hunting and wildfires may have played roles in the apparent demise of these and other Fallow Deer populations.

We believe that Fallow Deer will further increase their distribution in Victoria in the coming decades, due to natural expansion of existing herds, new escapes from deer farms, and further translocations.

5.2 Red Deer

The progeny of captive Red Deer were disseminated widely for release in Victoria after about 1880 (Bentley 1998). There were many releases of Red Deer in western Victoria, and by 1900 there were small wild populations on the Volcanic Plain, Wimmera, Otway Range, and Midlands. However, these populations had mostly died out by the 1950s, with only one major population remaining—in the Grampians (Menkhorst 1995; Bentley 1998; Panther 2010). In 2000, there were an estimated 12 Red Deer populations in Victoria (Moriarty 2004). Our study revealed 26 Red Deer populations in Victoria in 2015, occupying a total of 3900 km^2. Although we did not attempt to estimate the number of deer in each of these herds, the area occupied and the annual reported harvest (1671 in the 2012–2013 financial year; Moloney and Turnbull 2014) indicate that the total Victorian Red Deer population must be in the thousands.

The largest Red Deer population in Victoria, in terms of both area (2811 km^2) and numbers of animals, is the long-established Grampians population. Panther (2010) suggested that the entire Grampians Red Deer herd was 350–500 animals following the Grampians fire of January 2006. The herd may have increased in number since then; however, the Grampians Red Deer population has not changed its distribution for many decades (Panther 2010), apparently because animals that disperse into the surrounding farmland from the current breeding range are shot (Panther 2010; D. Panther, pers. comm.).

Red deer are thought to have persisted in parts of the eastern Otway Range until at least the mid-1980s (Conole and Baverstock 1983), but the nearest population to that location in 2015 was at Beech Forest, suggesting that the eastern Otway Range population(s) is/are now extinct.

Red Deer were also released (or escaped) at Gembrook, and a small population persisted in West Gippsland until the late 1940s (Bentley 1998). Red Deer were occasionally seen in East Gippsland until about 1950 and were most likely dispersers from a wild population near Delegate, New South Wales (Bentley 1998). The small Red Deer population near Bendoc almost certainly originated from the Delegate population. The Red Deer population at Dutson Downs originated from deer farm escapes (Rohan Bilney, pers. comm.).

As is the case for Fallow Deer, the widespread farming of Red Deer means that this species has the potential to further increase its distribution in Victoria through escapes and translocation; this has occurred in New Zealand (Fraser et al. 2000) and elsewhere in Australia (Moriarty 2004). Fences can be compromised such that deer escape, for example when Wapiti (*Cervus elaphus canadensis*; a red deer subspecies commonly farmed in Victoria) escaped into the Grampians during the 2006 bush fires (Panther 2010; this subspecies is larger than Red Deer and has some phenotypic and vocal differences). Some of these escaped Wapiti were shot (Panther 2010), and the extent to which the two subspecies have interbred is unknown. The reduced value of farmed Red Deer means that some farmers may have opened their gates to deliberately let them escape (as has apparently occurred for Fallow Deer); also, live animals can be purchased cheaply and in sufficient numbers to illegally release them and establish a new population. Just three Red Deer (of mixed sex) can establish a wild, self-sustaining population (Forsyth and Duncan 2001). We, therefore, believe that Red Deer, like Fallow Deer, will further increase their distribution in Victoria in the coming decades, due to natural expansion of existing herds, new escapes of farmed animals and further translocations.

5.3 Hog Deer

The Eastern Victorian Hog Deer population originates from releases at Wilsons Promontory (1865), Gembrook (1871) and Sale (1873) (Mayze and Moore 1990). The largest release was at Wilsons Promontory (nine females and three males), and from that release Hog Deer dispersed eastward, being abundant in South Gippsland, including Snake Island, by 1914 (Mayze and Moore 1990). By the 1940s, Hog Deer were present at Lakes Entrance, and there was a sighting at Wombat Creek (east of Lake Tyers) in 1948 (Bentley 1998). Hog Deer did not expand far into the Strzelecki Ranges, perhaps because it is too cold there in winter (Bentley 1998). Hog Deer were culled on the Oberon Bay flats in Wilsons Promontory National Park in 1953 and 1954 (Bentley 1998).

Bentley (1998) considered that the 1871 release of two males and six females “20 miles north-east of Berwick” did not last more than a few years. However, Mayze and Moore (1990) believed it was the origin of the Tonimbuk–Bunyip population, which was extant until at least the 1990s (M. Harrison, pers. comm.). Except for several males (which may be escapees or dispersers from the Eastern Victorian population), no animals have been sighted in this area since the Black Saturday fires of February 2009, and we believe that it is now extinct.

Moriarty (2004) reported three small Hog Deer populations (each <100 animals) in Victoria that are outside the breeding range we have delineated. The western-most population reported by Moriarty (2004) is near the Otway Ranges and most closely matches the Timboon reports of Hog Deer. Although Hog Deer have been seen and shot at Timboon (Figure 9), we did not find any evidence of breeding; the most likely explanation for these animals is that they escaped from nearby deer farms/game estates or were deliberately released. Captive Hog Deer were observed at Timboon in October 2014 (D. Forsyth, pers. obs.).

Consistent with our conclusion that Hog Deer are not breeding in the wild at Timboon, West (2011) did not report Hog Deer westward of our breeding range.

Mayze and Moore (1990: 87) considered the Hog Deer distribution in Victoria to be the coastal strip from Tarwin River to Marlo, but that "there is little doubt that populations exist east of the Snowy River at Marlo". West (2011) reported Hog Deer in coastal far-east Gippsland (around Mallacoota) and extending north into New South Wales. We did not find reliable evidence that Hog Deer were present in Victoria east of Point Hicks, with rumoured sightings of Hog Deer around Mallacoota likely to be dispersing male Hog Deer and not a breeding population.

Figure 9. Adult male Hog Deer shot near Timboon in January 1994 (source: D. Drayton, Curdies Valley Landcare Group)

Several interviewees suggested that the eastward expansion of Hog Deer has been limited by the presence of dingoes/wild dogs (*Canis lupus dingo/familiaris*). There is no direct evidence of dingoes/wild dogs killing Hog Deer, and the presence of Hog deer in the scats of dingoes/wild dogs in Gippsland [and also in the scats of red foxes (*Vulpes vulpes*)] (Davis et al. 2015) could be the result of those carnivores scavenging rather than killing deer.

There have been sporadic sightings of Hog Deer outside the distribution delineated in Figure 6–8. The population(s) in the Tonimbuk – Bunyip River headwaters no longer appear to be extant: except for one male in the Bunyip Main Drain, Hog Deer have not been seen in this area since the Black Saturday bushfires of February 2009 (M. Harrison, pers. comm.). A small population at Tonimbuk appears to have gone extinct in the 1990s (M. Harrison, pers. comm.). A male Hog Deer was photographed by remote camera in Yellingbo State Park in 2012, but there is no evidence of a breeding population there (D. Hudson, pers. comm.). This animal may have escaped from a captive herd at Wandin (D. Hudson, pers. comm.). There may have been a wild Hog Deer population near Flowerdale, but none have been sighted there since the Black Saturday fires of February 2009 (name withheld).

There are several farms and game estates in Victoria with Hog Deer, and there is no requirement to register them (M. Salmon, pers. comm.). Hog Deer could escape (or be deliberately released from) farms and game estates. For example, a Hog Deer was filmed in the wild at Glenlofty (north of Mount Cole in western Victoria) in 2013 (the senior author has seen the video), and this animal most likely escaped from a farm. There have been rumours of wild Hog Deer near Timboon for many years, and an adult male was shot there in January 1994 (D. Drayton, pers. comm.; Figure 9). However, these Hog Deer appear to be escapees from a local farm, and we could not confirm that there is a wild, self-sustaining population at Timboon. A

designed surveillance program would be required in order to confirm the absence of Hog Deer with a defined level of confidence.

Three Hog Deer have been reportedly harvested in western Victoria since 2000 (Z. Powell, pers. comm.). These animals may have been harvested at Timboon. However, eight Hog Deer were seen at Kentbruck Heath (north-west of Portland) in 2009–2010 (P. Scott, pers. comm.); this was almost certainly a deliberate release, but there is no evidence that the population established.

Finally, it has been suggested that Hog Deer have recently naturally colonised new habitat in the area bounded by Rosedale, Calrossie and Greenmount (bounded by the Hyland Highway and the A440) (M. Salmon, pers. comm.). However, we could not verify this suggestion.

In contrast to Fallow Deer and Red Deer, we do not believe that Hog Deer will greatly increase their distribution in Victoria in the coming decades. This is because their distribution has changed little in many decades, and in eastern Victoria it appears to be limited by biophysical factors. There is potential for Hog Deer to establish in the coastal strip in western Victoria, but a population there could only establish from translocations or deer farm escapes.

5.4 Chital Deer

Chital Deer are present on farms and game estates in Victoria, but we did not find evidence of any wild, self-sustaining breeding populations in Victoria in 2015. Of the two males known to have been shot in the wild in Victoria, one had escaped from a farm and the other was almost certainly deliberately released. There was no evidence supporting the current existence of the three small Victorian Chital Deer populations (each <100 animals) reported by Moriarty (2004). This finding is consistent with West (2011), who reported populations in Queensland, New South Wales and South Australia—but not in Victoria.

Chital Deer were released at several locations in Victoria in the 1860s, including at Waterloo Bay on Wilsons Promontory and at Longerenong Station near Horsham. The Longerenong release established a breeding population that by 1868 “spread over an area of at least sixty miles” (Bentley 1998: 110). The Longerenong population persisted until the 1920s, but there have been no confirmed reports since then (Bentley 1998; Menkhorst 1995). Although there is no evidence of Chital Deer breeding in the wild in Victoria, this species could potentially establish a population and is therefore a biosecurity risk for Victoria.

6 Conclusions

Of the four species considered in this report, only Chital Deer did not have a wild, self-sustaining breeding population in Victoria in 2015. The number of populations and breeding distributions of the three other species were: Fallow Deer, n = 61 populations, 21,400 km^2; Red Deer, n = 27 populations, 3900 km^2; and Hog Deer, n = 1 population, 2336 km^2.

Fallow Deer and Red Deer have greatly increased their distributions since the 1980s, due to deliberate releases, escapes from farms, and dispersal from established populations. It is likely that the distributions of Fallow Deer and Red Deer will continue to increase in Victoria.

In contrast, the distribution of Hog Deer (which is confined to the coastal strip between Tarwin River and Point Hicks) has not increased since at least the 1980s. This suggests that the current distribution of this species in Victoria is limited by biophysical factors and will not further increase from natural dispersal. However, there is a possibility that one or more new Hog Deer populations could establish in the coastal strip in western Victoria from deliberate releases or escapes from farms.

Chital Deer are being held in captivity in Victoria, and one animal has escaped and been shot, but there is no evidence of a wild, self-sustaining breeding population of Chital Deer in Victoria.

7 Recommendations

Encouraging the general public (including hunters) and agency staff to enter their observations of introduced species (including wild deer) into the Victorian Biodiversity Atlas would greatly improve our knowledge of their distributions and aid their management.

A pilot study should be conducted to assess the potential of molecular techniques for identifying the sources of 'new' deer populations and for helping managers understand the potential for reinvasion if eradication of a new population is attempted. Molecular analysis would also assist in defining genetic populations and potential management units, which is critical for understanding disease epidemiology and emergency disease preparedness.

The probability of eradicating a deer population is highest when the population is smallest (in distribution and abundance). Managers wishing to eradicate a new deer population should, therefore, implement an appropriate eradication plan as soon as possible.

The distributions reported here can be used to develop policy to delineate areas of deer distribution within which deer are managed as game and areas within which deer are managed differently.

The distributions of most wild deer species in Victoria are likely to change and should be reassessed every decade.

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Appendix 1

Individuals consulted about distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer. Affiliations are shown for people employed by State/Territory Government agencies and are correct on the date on which they were interviewed; –, no affiliation. Individuals are listed alphabetically by surname for each State/Territory.

Name	Agency
Victoria	
Jerry Alexander	Department of Environment and Primary Industries
Chris Anderson	Department of Environment and Primary Industries
Richard Appleton	HVP Plantations
Helen Barker	Parks Victoria
Ami Bennett	University of Melbourne
Roger Bilney	–
Rohan Bilney	–
Alan Braithwaite	Parks Victoria
Michael Bryce	Department of Defence
Dash Burns	Parks Victoria
Geoff Burston	–
David Butterworth	Parks Victoria
Rodney Carter	Game Management Authority
Andy Cowan	Deer Industry Association of Australia
Chris Davies	Federation University
Naomi Davis	University of Melbourne
Charles Dickie	Parks Victoria
Mick Douglas[1]	Parks Victoria
Dean Drayton	Curdies Valley Landcare Group
Heath Dunstan	Game Management Authority
Ben Fahey	Parks Victoria
David Farrar	Parks Victoria
Paul Fernando	Parks Victoria
Charlie Franken	Department of Environment and Primary Industries
Andrew Hammond	Department of Environment and Primary Industries
Mike Harrison	Australian Deer Association
Richard Hill	Department of Environment, Land, Water and Planning

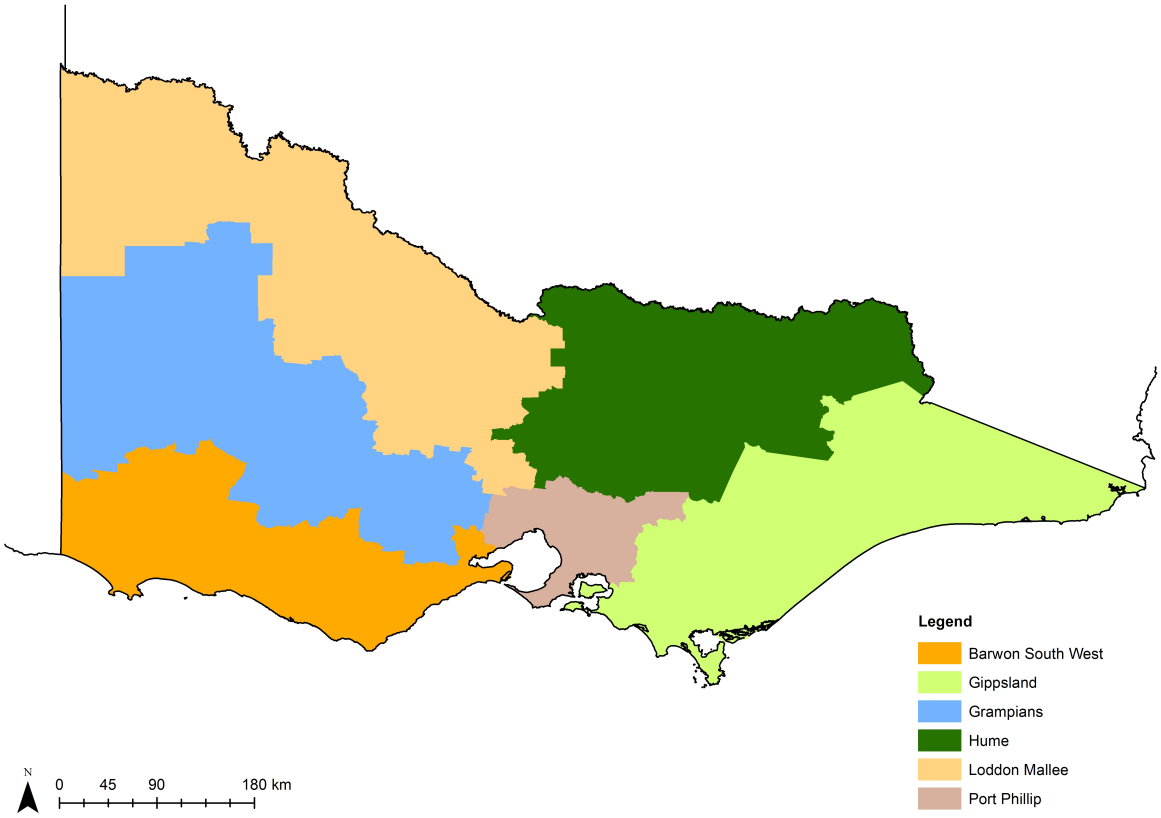
Name	Agency
Robin Holmes	Department of Environment and Primary Industries
John Hosking	Parks Victoria
Danny Hudson	Parks Victoria
Caleb Hurrell	Department of Economic Development, Jobs, Transport and Resources
Greg Ivone	Department of Environment and Primary Industries
Mark Jones	Game Management Authority
Angelo Keratanios	Parks Victoria
Glenn Kilburn	Game Management Authority
David Klippel	Department of Environment and Primary Industries
John Matthews	Department of Environment and Primary Industries
Ron Mayze	–
Geoff McClure	Department of Environment and Primary Industries
Stewart McGlashan	Game Management Authority
Brian McKinnon	Parks Victoria
Tony Mitchell	Department of Environment and Primary Industries
Geoff Moore[1]	Australian Deer Research Foundation
Mat Murphy	Department of Environment and Primary Industries
Jesse Nation	Parks Victoria
Dwayne Needham	Department of Environment and Primary Industries
Darryl Panther	–
James Pardew	Department of Environment and Primary Industries
Ken Pearce	Australian Deer Association
Des Peters	Parks Victoria
Chela Powell	VicForests
Zachary Powell	Game Management Authority
Phil Reichelt	Parks Victoria
Jim Reside	Wildlife Unlimited
Keith Reynolds	Parks Victoria
Matt Rijs	–
Euan Ritchie	Deakin University
Dave Ryan	Parks Victoria
Steve Saddleir	–
Matt Salmon	Game Management Authority

Name	Agency
Andrew Scott	Victoria Police (Mallacoota)
Pete Scott	Department of Environment and Primary Industries
Michael Scroggie	Department of Environment and Primary Industries
Ken Slee	Australian Deer Association
David Smith	Department of Environment and Primary Industries
Dave Stephenson[1]	Parks Victoria
Trent Tonissen	Department of Environment and Primary Industries
Mark Tucker	Melbourne Water
John Turnbull	Game Management Authority
Bernie van Lith	Parks Victoria
Tony Venes	Parks Victoria
Jim Whelan	Parks Victoria
Stuart White	Australian Deer Association
David Young	Department of Environment and Primary Industries
ACT	
Ollie Orgill	ACT Parks and Conservation Service
New South Wales	
Bruce Cameron	New South Wales Department of Primary Industries
Andrew Claridge	Office of Environment and Heritage NSW
Rob Hunt	Office of Environment and Heritage NSW
Dan Lunney	Office of Environment and Heritage NSW
Andrew Moriarty	New South Wales Department of Primary Industries
Duane Shorecross	New South Wales NPWS
Tony Stubbs	New South Wales NPWS
Peter West	New South Wales Department of Primary Industries
South Australia	
David Peacock	Biosecurity SA

[1]Interviewed previously to this project.

Appendix 2

The six DELWP regions (Department of Environment, Land, Water and Planning 2016) that were used to describe the main breeding distributions of Fallow Deer and Red Deer in Victoria.



www.delwp.vic.gov.au/ari