SOCIOLOGICAL AND ECOLOGICAL IMPACTS OF INTRODUCED DEER POPULATIONS

MARIAMA MATTILA

PhD Thesis

University of Turku

Faculty of Science and Engineering

Department of Biology

Supervised by

Professor Pekka Niemela

Biodiversity unit

University of Turku

Finland

Reviewed by Professor Sami Kurki and Outi Ratamäki

Opponent: Professor Juha Hiedanpää

Cover image: European Fallow Deer (Dama dama dama), Lemnos Island, Greece. Photo by Mariam Mattila

CONTENTS

ABSTRACT **4**

TIIVISTELMÄ **5**

LIST OF ORIGINAL PUBLICATIONS **7**

1. INTRODUCTION **8**

1. *Introduced feral deer in Australia* **8**
2. *Introduced deer in Finland* **9**
3. *Introduced deer in Greece, Lemnos island* **10**
4. *Introduced deer in Sweden* **11**
5. *Aims of the thesis* **11**

2. **MATERIALS AND METHODS** **12**

1. Interviews in Greece and Finland **12**

2. Study design in Greece, Lemnos island **12**

3. Study design in southwestern Sweden, Västra Götaland province, Koberg estate **12**

4. Statistical analyses in Greece, Lemnos island **13**

5. Statistical analyses in southwestern Sweden, Västra Götaland province, Koberg estate **13**

3. RESULTS AND DISCUSSSION **13**

1. The feral urban deer dilemma in Australia, Greece, Finland and Sweden **13**

2. Stakeholder attitudes toward deer in Australia, Greece and Finland **13**

3. Deer population size and hunting in Australia, Greece and Finland **14**

4. Deer-vehicle collisions in Australia, Greece and Finland **15**

5. Urban environmental damage in Australia, Greece, Finland and Sweden **16**

4. CONCLUSIONS **17**

ACKNOWLEDGEMENTS **20**

REFERENCES **21**

Annex 1 **26**

Annex 2 **28**

ABSTRACT

Human-deer interactions form an integral segment of the complex social, ecological and economic network that is important to keep in balance. As observed elsewhere, deer introductions can lead to conflict among stakeholders. Compared with deer management in rural areas, however, there is limited information on deer management in urban areas (defined as including peri-urban and semi-rural areas. It is important to investigate what the different local conditions and impacts caused by introduced deer presence in different environments and countries are, and answer the questions: What are the general public attitudes against introduced deer in populated (semi-urban/urban) areas? What factors/impacts are important in shaping these public attitudes? What are the ecological impacts? What might the management solutions be to overcome these impacts? This research was conducted in four countries: Australia, Greece, Sweden and Finland. In Australia and Finland only the social aspects of deer population growth and distribution were studied with the aim to understand differences in attitudes towards deer population presence and development; in Greece both social aspects and feeding behavior were studied, and in Sweden the focus was on forest management and deer feeding preferences. Introduced deer management in all four countries has resulted in intense debate among stakeholders, including landowners, recreational hunters, animal welfare groups, conservation organizations etc. The results give insights into general attitudes on deer, which depend on the balance between positive impacts (game value; aesthetic etc. values) vs. negative impacts (traffic accidents; browsing damage; indirect effects through changes in the abundance of other species such as predators). E.g. the development of positive attitudes toward Australia's feral deer is contrasted by a simultaneous negative view of them as pests and / or a hunting resource. In Greece, our interviews revealed a general positive attitude of all respondents for deer presence on the study island, and in Finland approximately 90% of the respondents 'appreciated' having deer on their properties. The overall problem is uncontrolled introduced deer population spread over suburban territory, and no actual management. Despite the claim that recreational hunters of e.g. Australia serve to control feral deer, deer numbers are increasing, at least near major urban centres such as Brisbane, Melbourne, and Sydney. Deer-vehicle collisions are one of the major impacts in Australia, Greece and Finland caused by introduced deer populations. Browsing damage was not a major problem, as in e.g. Sweden spruce was the least preferred species and in Finland and Greece people were providing supplemental feeding during winter. Management issues related to introduced deer that need further attention include environmental and hunting legislation/policy, population monitoring (i.e. monitoring translocations, habitat use and feeding behavior), compliance to and enforcement of regulations, and the education and awareness of local communities. The current legislative approach to deer management is predominantly geared toward game hunting, with limited consideration of other values and effects. To underpin the future management of suburban deer, there is a need to involve all major decision makers – all local residents dealing on a daily basis with issues caused by deer. Additional calculations are needed to understand the economic impacts of introduced deer populations. The socioeconomic effects of introduced deer mostly depended on local needs and community awareness and

there cannot be a generic approach to management in all situations or for all deer species; however, it is possible to manage deer not as pests but as a part of suburban habitat and culture.

TIIVISTELMÄ

Ihmisten ja kauriseläinten väliset vuorovaikutukset muodostavat kokonaisuuden, joka koostuu sosiaalisista, ekologisista ja taloudellisista tekijöistä. Kauriiden siirtoistutukset ovat johtaneet paikallisiin konflikteihin sidosryhmien välillä. Taajamien läheisyydessä elävien kauriskantojen hoitoon liittyvistä tekijöistä tiedetään kuitenkin vähän. Ihmisten ja kauriiden välisten suhteiden ymmärtämiseksi ja tasapainottamiseksi tarvitaankin lisätietoa kauriiden läsnäolon vaikutuksista erilaisissa ympäristöissä. Väitöstyön tarkoituksena on tutkia siirtoistutettujen kaurispopulaatioiden vaikutuksia eri maiden eroavissa olosuhteissa ja vastata näistä vaikutuksista nouseviin kysymyksiin – miten siirtoistutettuihin kauriisiin suhtaudutaan taajama-alueilla, mitkä tekijät vaikuttavat näihin asenteisiin, mitkä ovat ekologiset vaikutukset ja miten keskeisiin vaikutuksiin voitaisiin vaikuttaa?

Tutkimus toteutettiin neljässä maassa: Australia, Kreikka, Ruotsi ja Suomi. Australiassa ja Suomessa tarkasteltiin kaurispopulaatioiden kasvun ja levittäytymisen sosiaalisia vaikutuksia, pyrkimyksenä ymmärtää asenteellisia eroja suhtautumisessa kauriiden läsnäoloon ja kannanmuutoksiin; Kreikassa selvitettiin lisäksi ravinnon käyttöä. Ruotsissa tutkimus keskittyi metsänhoitoon ja kauriiden ravinnonvalintaan. Luonnonvaraistuneiden kauriskantojen hoito on johtanut kaikissa maissa intensiiviseen keskusteluun sidosryhmien, kuten maanomistajien, metsästäjien sekä eläin- ja luonnonsuojelujärjestöjen, välillä. Väitöstyön tulokset auttavat ymmärtämään yleisiä asenteita, jotka riippuvat myönteisten ja kielteisten vaikutusten tasapainosta. Tutkimuksen mukaan myönteisinä vaikutuksina koettiin metsästyksen ja esteettisten elämysten kaltaiset tekijät, kielteisinä puolestaan liikenneonnettomuudet, laidunnuksen aiheuttamat tuhot sekä epäsuorat vaikutukset muiden eläinten, kuten petojen, runsauteen. Australiassa myönteisten asenteiden vastapainona on näkökulma, jonka mukaan kauriit ovat tuholaisia. Kreikassa haastattelututkimukset paljastivat yleisesti myönteisen asenteen kauriiden läsnäoloon, samoin Suomessa noin 90% vastaajista arvosti kauriiden läsnäoloa maillaan. Perusongelmaksi havaittiin siirtoistutettujen kaurispopulaatioiden rajoittamaton leviäminen taajamien ympäristöön. Huolimatta väitteistä, joiden mukaan metsästäjät rajoittavat kauriskantoja esimerkiksi Australiassa, kauriskannat kasvavat ainakin tärkeimpien asutuskeskusten ympäristössä, esimerkkeinä Brisbane, Melbourne ja Sydney. Hirvieläinkolarit ovat yksi merkittävimmistä vaikutuksista Australiassa, Kreikassa ja Suomessa. Laidunnuksen aiheuttamia tuhoja ei puolestaan koettu keskeiseksi ongelmaksi; Ruotsissa kaupallisesti tärkeä kuusi ei ollut haluttua ravintoa, Suomessa ja Kreikassa kauriille tarjottiin lisäruokaa talvikaudella. Kannanhoidossa tulisi jatkossa kiinnittää huomiota kannanseurantaan, valistukseen, ympäristö- ja metsästyslainsäädäntöön sekä säädösten täytäntöönpanoon. Nykylainsäädäntö painottuu metsästykseen, muut arvot ja vaikutukset jäävät vähemmälle huomiolle. Kauriiden kannanhoidossa tulisi huomioida kaikki sidosryhmät ja taloudelliset vaikutukset tulisi selvittää tarkemmin. Siirtoistutettujen kauriskantojen sosioekonomiset vaikutukset riippuvat paikallisista tarpeista

ja yhteisön valveutuneisuudesta. Tästä syystä kaikkiin tilanteisiin ja kaurislajeihin soveltuvaa menettelytapaa ei ole. Kauriisiin ei kuitenkaan tarvitse suhtautua tuholaisina vaan kantoja voidaan hoitaa osana taajamien ympäristöä ja kulttuuria.

Kauriskantojen hoidossa tulisi kiinnittää kasvavaa huomiota kauriskantojen seurantaan, taloudellisiin vaikutuksiin, lainsäädäntöön, politiikkakysymyksiin, hoitotoimenpiteiden hyväksyttävyyteen sekä koulukseen ja valistukseen. Nykyinen lainsäädäntö painottaa metsästystä enemmän kuin muita arvoja ja vaikutuksia. Kun huomioidaan, että kauriskantojen kasvu ja levittäytyminen tapahtuvat samanaikaisesti ihmispopulaatioiden kasvun kanssa, odotettavissa on konfliktien lisääntyminen. Kauriskantojen hoidon tueksi on tarve ennakoida konfliktitilanteet ja niihin johtavat tekijät. Toimivimpien ratkaisumallien ja hoitosuunnitelmien löytämiseksi päätöksentekoon tulisi osallistaa kaikki asukasryhmät, jotka ovat päivittäin tekemisissä kauriiden vaikutusten kanssa. Siirtoistutettujen kaurispopulaatioiden sosioekonomiset vaikutukset riippuvat paikallisista tarpeista ja yleisön tiedon määrästä, joten kaikkiin tilanteisiin tai kaikkiin kaurislajeihin sopivaa yleistä hoitosuunnitelmaa tuskin löytyy. Silti kaurispopulaatioita on mahdollista hoitaa osana taajamien luontoa ja kulttuuria sen sijaan, että ne nähtäisiin vain tuholaisina.

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications, hereafter referred to in the text by their Roman numerals:

I Burgin S, Mattila M, McPhee D, & Hundloe T. 2015. Feral deer in the suburbs: An emerging issue for Australia? Human Dimensions of Wildlife; Vol. 20, Issue 1: pp 65 – 80. (http://www.tandfonline.com/doi/abs/10.1080/10871209.2015.953274)

II Mattila M, Hadjigeorgiou I. 2015. Conservation and management of fallow deer (Dama dama dama L.) on Lemnos Island, Greece; Turkish Journal of Veterinary and Animal Sciences; TÜBİTAK; Vol. 39: pp. 560-567 (http://journals.tubitak.gov.tr/veterinary/issues/vet-15-39-5/vet-39-5-8-1501-28.pdf)

III Mattila M, Kjellander P. 2016. The tree species matrix, influence on level of herbivore browsing in mixed forest stands in southwest Sweden; Scandinavian Journal of Forest Research; Taylor & Francis Group; pp 1-5. (http://www.tandfonline.com/doi/abs/10.1080/02827581.2016.1181202)

IV Burgin S, Mattila M. (submitted) Attitudes of Hunters toward Introduced White-Tailed Deer Odocoileus virginianus in Finland

AUTHOR CONTRIBUTIONS TO THE ORIGINAL MANUSCRIPTS

	I	II	III	IV
Original idea and planning	SB, MM, DM, TH	MM, IH	MM, PK	MM, SB
Field work		MM	MM	MM
Statistical analysis		MM	MM	MM
Writing and commenting	SB, MM, DM, TH	MM, IH	MM, PK	SB, MM

Authors are listed in decreasing order of contribution for each section.

Author abbreviations: MM = Mariam Mattila, SB = Shelley Burgin, DM = Daryl McPhee, TH = Tor Hundloe, IH = Ioannis Hadjigeorgiou, PK = Petter Kjellander.

1. INTRODUCTION

Human activity linked to deer presence has its origins in prehistory; e.g. herding and hunting has played an important role in the development of the human socialization process, which is also heavily influenced by geography and gender (Heberlein et al. 2002; Smalley 2005). For many ethnic groups, herding, farming and hunting are activities that have traditionally helped meet a wide range of social needs within communities. These social benefits are substantially larger than the simple subsistence value of the skin, meat and other sub-products (Burger 1999). Human-deer interactions form an integral segment of the complex social, ecological and economic network which is important to keep in balance (Dewar et al. 2006). As observed elsewhere (McShea et al., 1997), deer introductions can lead to conflict among stakeholders (Moriarty, 2004b). Compared with deer management in rural areas, however, there is limited information on deer management in urban areas (defined to include peri-urban and semi-rural areas (McLeod, 2009). It is important to investigate what the different local conditions and impacts caused by introduced deer presence are in different environments and countries.

1. Introduced feral deer in Australia

Australia is the only inhabited continent without endemic deer. Deer were introduced in the 18th century (Groves & Bishop, 1989, Hall & Gill, 2005) and have been farmed since 1803 by acclimatization societies for game and aesthetics (Frith, 1973). The deer industry, based on captive animals, was modest until the 1970s/1980s when its popularity exploded with a 'massive' increase in farmed stock. However, the boom was short-lived. The industry collapsed in the 1990s due largely to low commodity prices (MacDonald, 1995; Moriarty, 2004 a, b). Of the 18 deer species introduced, six species formed feral populations: chital (*Axis axis*), hog (*Axis porcinus*), red (*Cervus elaphus*), rusa (*Cervus timoriensis*), sambar (*Rusa unicolor*), and fallow deer (*Dama dama*) (Bentley, 1978, Strahan, 1995). Four (fallow, red, rusa, chital) have established in Queensland and New South Wales (DAFF, 2012, 2013).

In Australia, deer have historically represented a minor component of the fauna, but feral populations are now widespread. All current feral deer herds originated from either escapes or illegal translocations from defunct farms into bushland for game hunting (Low, 1999). Deer have transitioned from small isolated herds of 500 to more than 10,000 individuals (Moriarty, 2004a, 2004b), forming the 200,000 feral deer population in Australia. Feral deer have formed 96 herds in New South Wales (NSW), compared with 32 in Queensland. In addition, they are a recognised issue in urban areas abutting Royal National Park (e.g. Southern Sydney, Moriarty, 2004b; Wollongong, WCC, 2013). Unlike in the United States of America (e.g. Conover et al., 1995; Cornicelli et al., 1996), urban feral deer are only just becoming an issue in Queensland.

The alarming increase in numbers during recent decades (Moriarty, 2004a) has paralleled an increase in the human population in urban areas (Raik, Lauber, Decker, & Brown, 2005). By 2011, for example, approximately 90% of Australians lived in urban areas, with a predicted continuing rise in population (ABS, 2013). With the continuance of this trajectory and the associated expansion of urban areas, road density, and traffic volume (Ramp & Roger, 2008), the associated issues with managing urban deer will inevitably increase (Moriarty, 2004a). Based on current indications (e.g. McCathy, 2013) and

the known pattern of increase of deer (Jesser, 2005) and humans (ABS, 2013), we consider that policy/legislative instruments should be developed before the agenda is driven by necessity, since as observed elsewhere (e.g. New Zealand; McShea, Underwood, & Rappole, 1997), feral deer can lead to conflict among stakeholders (Moriarty, 2004b).

2. Introduced deer in Finland

White-tailed deer (*Odocoileus virginianus*) are endemic to most of Central America, southern Canada and mainland of United States of America, (where white-tailed deer are the most widespread and abundant deer) (Bissonette et al., 2008; Burgin et al., 2015; Iverson, & Iverson, 1999). The species has been introduced to other countries outside of its natural range including New Zealand (Stewart & Burrows, 1989), Jamaica (Chai, 2007), and Europe (e.g. Finland, Czech Republic, Slovakia; Blood et al., 2000; Gallina, & Lopez 2008; Hovi et al., 2016; Oja, & Oja, 2006). These introductions have typically been carried out to develop hunting opportunities and for aesthetic reasons (Burgin et al., 2015; Frith, 1973; Moriarty, 2004 a).

The initial introduction of five (1 male; 4 females) white-tailed deer to Finland was at the Laukko Estate (Vesilahti) in 1934, with six further males introduced in 1948. They were introduced to develop hunting opportunities (Hovi et al., 2016; Long, 2012; Nummi, 2000). Long (2012) reported that by 1949 there were 100 animals, and there were 1,000 in 1961. This number expanded to 2,500 during the 1960s. More recently it has been reported that more than 20,000 are taken annually (The Hunting Consortium Ltd, 2012). Due to the historic increase in numbers since the initial introductions, Lipponen, Pouttu, Varama, Heikkilä, & Henttonen (2002) reported that white-tailed deer caused damage to agriculture and forestry in the south and southwest of the country. One reason for the success of white-tailed deer in Finland may be that the founding population came from Minnesota (in the U.S.), a colder part of the species' natural range, so that the introduced individuals were compatible with the cold climate (Nummi, 2000; Vankova et al., 1999). In Finland, the preferred habitat is the ecotone between agricultural fields, young coniferous forests and areas with abundant shrubs and small size trees (Oja, & Oja, 2006).

Allocating more time to feeding than to any other activity, white-tailed deer consume a broad variety of food items while browsing on leaves of woody plants, herbs, and grasses. They select the most nutritious forage available during the growing season. Farm crops are also an important year-round source of high quality forage, but in forested areas the deer avoid mature trees and concentrate their browsing on leaves of woody plants, herbs, and grasses (Chai, 2007; Crete et al., 2001; Oja, & Oja, 2006).

As has occurred in other countries where white-tailed deer have been successfully introduced (e.g. Jamaica - Chai, 2007; Czech Republic - Vankova et al., 1999), their introduction into Finland has also been successful and numbers have grown steadily. They have also readily dispersed from the original point of introduction into areas throughout Southwest Finland (Hovi et al., 2016). In some areas, the population has grown particularly rapidly, especially in areas where large predators have been removed from the landscape. As a consequence, the population density of white-tailed deer in Finland is highest in the south (Gallina, & Lopez, 2008; Oja, & Oja, 2006). Indeed, they have been so successful in Finland

that they are now an important game species, second only to elk *Alces alces* (Hovi et al., 2016). However, to ensure that they do not become a pest, as has occurred, for example, in the U.S., may require active management. As has been previously recognized in North America (Blood et al, 2000, Decker, & Gavin, 1987), successful sustainable management of wildlife populations requires the cooperative involvement of major stakeholders. This needs to include the integration of planning, research, and public involvement in the decision-making process. A first step in this process is to understand public knowledge and opinions (Agarwal, 2010; Bonnington, 2011; Burger, 1999). This type of information is lacking for white-tailed deer management in Finland.

3. Introduced deer in Greece, Lemnos island

Worldwide, there has been a connection between humans and deer dating back thousands of years (Gordon 1997, Sykes et al. 2013), and many examples can be found in ancient Greek mythology. Archaeological findings from the Greek region of Macedonia revealed domestic cattle bones, and remains from red deer (*Cervus elaphus* L.), roe deer (*Capreolus capreolus* L.), and fallow deer (*Dama dama* L.) were commonly found together (Hubbard 1995), indicating the more practical aspects of human-deer connections.

The European fallow deer is one of the most common deer species in the world; however, since it was indigenous to a small area in the eastern Mediterranean, it has now been extirpated from most of its historical range (Sykes et al. 2013). Their current worldwide distribution derives from introductions as farm or game animals (Massetti et al. 2009). One of the earliest introductions, probably dating from Neolithic times, was to the island of Rhodes in the Aegean Sea (Massetti et al. 2006). Fallow deer on the island of Rhodes nowadays represent a distinct genetic cluster characterized by an 80-bp mitochondrial DNA (mtDNA) lineage not found elsewhere (Massetti et al. 2006). The fallow deer population on Rhodes may retain a greater proportion of the original genetic diversity of the indigenous population than other populations of this species. Thus, the preservation and management of the fallow deer of Rhodes is an important conservation objective (Massetti et al. 2006).

Various "daughter populations" from the Rhodes island population established on other islands in the Aegean and Eastern Mediterranean seas, which can safeguard this genetic variant against loss in their native range (Massetti et al. 2009). As a first introduction, two females and a male fallow deer from Rhodes were introduced to the island of Lemnos (NE Aegean Sea) between 1968 and 1970 (Massetti 2002), as a gift from Rhodes' mayor to the mayor of Lemnos. Deer were released to and inhabited the ruined Byzantine fortress peninsula in Myrina, the capital of Lemnos (Massetti 2002). The purpose of the introduction was to provide a sense of nobility to the town; however, soon deer became a tourist attraction and were depicted on tourist maps and souvenirs. The deer population in Myrina increased to 70 by 2006 (Migli 2006) and was managed by local politicians making decisions based on community tolerance and affection, rather than science (Massetti 2002, Migli 2006). However, recent interviews with local stakeholders revealed their viewpoint that this population is currently in decline.

4. Introduced deer in Sweden

The forest is the most important natural resource in Sweden (70% of the land area) as well as an essential part of the national economy (12% of the Swedish export income) ("Swedish forestry" 2012). The present high densities of elk and roe deer in Sweden cause heavy economic losses in forestry, due to direct consumption of biomass, trampling, stripping of the bark, fraying, and breaking of the stems (Kalen & Bergquist 2004). For the forest owners, browsing damages may increase regeneration costs and fencing is a necessity, but hunting is also important. Since Koberg estate is considering both sources of incomes – hunting and forestry (Count Niclas Silfverschiöld, personal communication) – it is necessary to adapt density to the local biological conditions if the aim is to optimize the benefits from forestry and hunting (Hörnberg 2001).

There are two main alternative ways to decrease browsing damage, either by lowering the animal density (Gordon 1997) or by increasing the availability of preferred food (Marquis & Brenneman 1981; Kalen 2005); the greatest challenge is to maintain both alternatives at the landscape level. At the plant community level, the spatial distribution of preferred and unpreferred plants may influence the probability of browsing on a certain plant (Milchunas & Noy Meir 2002; Takada et al. 2003; Bergvall et al. 2005, 2008; Rautio et al. 2008). For example, preferred plants in a matrix of unpreferred allospecific vegetation may remain undetected by the herbivore and thereby escape consumption (Bergvall 2007). This phenomenon is also known as associational resistance, associational defense, associational refuge, or plant-defense guilds (Tahvanainen & Root 1972; Pfister & Hay 1988; Holmes & Jepson-Innes 1989; Danell et al. 1991).

In parts of southern Sweden, the introduced fallow deer (*Dama dama dama* L.) is the dominant large herbivore species, suspected to depress densities of other sympatric large herbivores (Carlström & Nyman 2005). The fallow deer is a non-selective herbivore; its morphophysiological digestive system is placed in Hofmann's (1989) scheme between the mixed feeder and grazer style, meaning that fallow deer are opportunistic and highly adaptable, so their diet in most cases is determined by what is locally available. However, within what is available due to their digestive system, they prefer to feed selectively on the highest quality food high in protein. Thus we would expect to find patterns of associational defense in an area dominated by fallow deer.

5. Aims of the thesis

The main idea of this research was to review introduced deer populations' different sociological and ecological impacts in different countries under different conditions, and answer the questions: What are the general public attitudes against introduced deer in populated (semi-urban/urban) areas? What factors/impacts are important in shaping public attitudes? What are the ecological impacts? What might the management solutions be to overcome these impacts? All studies had one unifying factor: the presence of introduced deer populations in a semi-urban area and no current evidence of actual management of their impact. Since each case had different local needs, the methodologies were also (deliberately) slightly different. In Australia, the main aim of the study was to assess current awareness of urban feral deer, review the status and potential increased population of urban deer in the whole of

Australia, consider the associated issues, and make recommendations for management of urban and suburban deer (I). In Finland, our objective was to seek opinions of male and female hunters, and landholders and non-landholders, to white-tailed deer, including seeking their views on recent population changes, current impacts including predation, and hunting preferences (IV). In Greece, our objectives were to provide an estimate of the current fallow deer population size in Myrina (Lemnos), to carry out a vegetation cover inventory and assess the carrying capacity of the peninsula based on food availability. We also aimed to evaluate the key stakeholders' (those associated with suburban deer management on Lemnos) attitudes towards fallow deer on the island (II). In Sweden, we tested the hypothesis that preferred woody plants can protect unpreferred conspecific and allospecific woody species against herbivory in a system with one dominant, introduced generalist herbivore, the fallow deer. We also tested the difference in conspecific browsing amount and preference in plants standing in conspecific groups vs. solitarily growing individuals (III).

2. MATERIALS AND METHODS

1. Interviews in Greece and Finland

In Greece, those interviewed to determine awareness of suburban feral deer and to assess (Seidl & Tisdell 1999) tolerance of urban deer were not chosen randomly and their attitudes do not represent those of the whole island or state; rather, they represent the position of the decision-making group (II, IV). The online survey was distributed in 18 regions of Finland (the regions where there are white-tailed deer) with the 'Webpropol' software system (IV, Annex 1). To encourage participation, the details of the survey were also announced in the Finnish Wildlife Agency magazine "Metsästäjä" and on the Agency's website. In addition, information was provided directly to the Game Management Districts and the Finnish Hunters Association. In Greece, we used face-to-face interviews (II, Annex 2).

2. Study design in Greece, Lemnos island

Fallow deer groups occur around the end of winter or early spring, when deer females, fawns and yearlings are in herds (Feldhamer et al. 1988), so in order to estimate fallow deer populations, we worked at Lemnos in late January 2013 (II).

We established 27 transects on the peninsula, inside and outside the fortress, evenly distributed on relatively flat vegetated surfaces, spaced at least 50 m apart, to measure vegetation cover and availability. We recorded ground cover, and measured the height of shrubs and the amount of dry grass matter (II).

3. Study design in southwestern Sweden, Västra Götaland province, Koberg estate

We used a plot sampling method, resulting in 120 plots (1508 m2). Within each plot, all living woody plants were identified and browsing damage to them was recorded based on visual examination of the current year's or earlier damage. A browsing severity index consisting of four categories was determined for each individual plant. Within a plot, the height of each individual tree and the projected ground coverage (0–100%) of shrub vegetation (Cain & de O Castro 1959) were also recorded. (III).

4. Statistical analyses in Greece, Lemnos island

We analyzed vegetation cover data using Minitab® 16.2.2 (Minitab Inc., State College, PA, USA). We described the ground cover classes (rocky outcrops, shrubs, and grass) in each transect and in the whole study area, assessed and compared ground cover distribution and availability of each cover class, and displayed all data from the transect areas, as well as compared the frequency of occurrence of all recorded shrub species (II).

5. Statistical analyses in southwestern Sweden, Västra Götaland province, Koberg estate

All data were analyzed using the program Minitab® 16.2.2 software (Minitab Inc., State College, PA, USA). We evaluated the level of browsing of plants growing in conspecific groups and standing solitarily, calculated "food choice" and "preference ranking" measures, and analyzed differences in preference between species and differences in preference between solitary growing and conspecific group standing plants (III).

3. RESULTS AND DISCUSSSION

1. The feral urban deer dilemma in Australia, Greece, Finland and Sweden

Feral deer management in all four countries has resulted in an intense debate among stakeholders, including landowners, recreational hunters, animal welfare groups, conservation organizations etc. (I, II, III, IV). The current legislative approach to deer management is, however, predominantly geared toward game hunting, with limited consideration of other values and effects (Forsyth, 2009) (I, II, III, IV).

The literature on deer-human interaction, particulary in urban areas, is also limited; this paucity of research on deer suggests that the associated issues have not become significant (I, II, III, IV, V). However, given parallel increases in deer numbers and range extent, coupled with increases in human populations, there will be more conflict. To underpin the future management of suburban deer, there is a need to investigate the current level of awareness of stakeholders (i.e. society in general and decision makers). One aspect of managing the increasing deer numbers that are already encroaching on suburban areas, or have the potential to do so, is for governments to engage with recreational hunters (Finch et al., 2014) (I, II, III, IV).

2. Stakeholder attitudes toward deer in Australia, Greece and Finland

Most Australians live within urban areas (ABS, 2013) and typically have limited contact with wildlife or rural industry. Despite this lack of direct exposure, many residents will develop an opinion on deer management and these often uninformed views influence management. Within this context, Jesser (2005) suggested that it was essential that information be available to assist individuals in developing a balanced view of relationships among rural stakeholders (e.g. primary producers, deer hunters), deer, and the environment. Positive attitudes toward deer have been attributed to the ‘bambi syndrome’ (Hastings, 1996; Nietschmann, 1977). In contrast to the development of positive attitudes toward Australia’s feral deer, there is also a negative view of them as pests and / or a hunting resource (Hall & Gill, 2005). These polarized views emerge repeatedly in deer management. It was acknowledged that urban deer

management was problematic, e.g. there was a need to raise awareness, educating licensed drivers with warning signs in deer-prone areas (I).

In Greece, interviews revealed a general positive attitude of all respondents for deer presence on the island (II). There was an overall desire to have such an emblematic animal (based on Greek history and myths) for aesthetic reasons and as a tourist attraction. However, the majority of respondents also prefer deer to be restricted to the fortress to avoid conflicts with agriculture and private property. All key decision maker respondents (n = 21) identified problems of habitat suitability and food availability on the fortress peninsula. Respondents suggested that to maintain the population in the area, additional forage and water would have to be provided to the animals as is stated in the Food and Agriculture Organization of the United Nations deer farming guidelines (II).

In Finland, approximately 90% of the respondents 'appreciated' having deer on their properties in Finland (IV). Males were more likely to report that they 'appreciated' white-tailed deer than female respondents, and male hunters were more likely to give supplementary feed during winter (IV).

3. Deer population size and hunting in Australia, Greece and Finland

In Australia, the Sporting Shooters' Association of Australia (SSAA) records that it has 150,000 members of whom 80% hunt regularly (SSAA, 2013), although Finch et al. (2014) estimated that there were between 200,000 and 300,000 recreational hunters in Australia in 2011-2012. These numbers have, however, subsequently remained static (SSAA, 2014). It was estimated in 2012 that the State's feral deer population was between 200,000 and 350,000 (Gray, 2012). More recently, Gray (2013) suggested that these numbers could be "hundreds of thousands." Despite the claim that recreational hunters of Australia serve to control feral deer (Jesser, 2005), deer numbers are increasing, at least near major urban centres such as Brisbane (McCarthy, 2013), Melbourne (Gray, 2012, 2013), and Sydney (Moriarty, 2004a, 2004b). The spread of this species is undoubtedly exacerbated by translocation for recreational hunting (Moriarty, 2004b) and thus, presumably, more regional urban centres will become affected (I).

On the fortress peninsula of the island of Lemnos, we recorded a total of 47 fallow deer and 7 goats – 15 fallow deer were observed within a 1 km radius of the peninsula. Earlier reports on the population size of the fortress peninsula state that the herd ranged from 65 to 70 individuals (Massetti 2002, Migli 2006), of which 60% were adult females (Migli 2006). The decline in herd size on the fortress peninsula, the absence of mature males and the small number of fawns is an indication of the difficulties encountered by this population (II). Despite the fact that deer are protected species in Greece (European Commission 2011), illegal hunting occurs on the island of Lemnos in rural and suburban areas (however no official data on poaching are available), partly causing the decrease in the number of deer on the fortress peninsula and in the nearby areas (II).

In Finland, respondents were asked if they perceived a change in the populations of local deer, elk, and/or the introduced white-tailed deer (prey) and lynx (predator) over the previous 5 years. At least half of the respondents who actually hunted considered that all species of deer had declined over the period, and most considered that lynx (a major predator of white-tailed deer in Finland) had increased in number. The major reasons were that there had been an increase in lynx and wolf predation, that

competition for food with cattle grazing had reduced fodder for white-tailed deer, and that hunting of white-tailed deer had increased in intensity. Those who considered that the population of white-tailed deer had increased thought that the major reason for the increase was supplementary food provision during winter. Such change in wildlife populations would also potentially have an impact on agricultural production for those hunters who were also landowners. It is likely, that rural dwellers witha dual interest in hunting and the impact of white-tailed deer on their economic income would be more interested in the predator - prey dynamics than urban-based hunters. However, the answers were equivalent irrespective of gender and place of residence. Of the game species hunted, only elk was a more popular target than introduced white-tailed deer, a larger proportion of males than females reported that they hunted this species (IV).

4. Deer-vehicle collisions in Australia, Greece and Finland

In Australia, a major issue associated with deer encroachment into urban areas is that they can be traffic hazards (Brockie & Sadleir, 2009). In 2004 in Michigan (U.S.), for example, one deer-vehicle collision occurred approximately every eight minutes (Havlick, 2004). Outcomes include vehicle damage and injury or death to humans and / or the deer involved (Bissonette et al. 2008; Hobday & Minstrell, 2008). In common with rapidly increasing numbers of Australian feral deer (Moriarty, 2004b), white-tailed deer in the U.S. have become overabundant in many urban areas (Cromwell et al, 1999), and deer-vehicle collisions are a nationwide problem (Nielsen et al, 2003) (I). In 1980, for example, 200,000 deer were killed on U.S. roadways (Danielson & Hubbard, 1998), broadly equivalent to the total number of feral deer estimated for Australia (Moriarty, 2004b). However, annual deaths on U.S. roads increased significantly in the 1990s (Romin & Bissonette, 1996) and by 1997, an estimated 1.5 million deer-vehicle collisions occurred annually (Mastro et al, 2008).

In Australia, data on the number of deer-vehicle collisions are unavailable. Accidents are not officially recorded; instead deer are recorded as “animal,” together with other taxa that are not required to be explicitly named (Ng et al., 2008; Ramp et al., 2005). With these caveats, and generally using data collected between 2001 and 2005, there were probably substantially more than 11,600 wildlife-vehicle collisions in Australia (Rowden et al., 2008).

In Finland, when rural hunters were questioned about the impact of white-tailed deer, ‘traffic hazard risk’ was listed most frequently (IV). For example in the year 2015, the statistics report 3659 deer collisions compared with 1808 elk collisions with the larger native ungulate *Alces alces* (Finnish Transport Agency statistics web page). Deer-vehicle collisions occur all over Finland – in large numbers on busy two-lane main roads. In 2012 a total of 1,321 elk accidents and 3,880 deer accidents on highways were reported to the police. In 2012, 108 people were injured in elk accidents while in 2011, 103 were injured and three people died. The estimated costs of elk and deer accidents on highways in 2012 amounted to 56 million euros (22 million for deer and 34 million for elk accidents (Finnish Transport Agency, 2013)).

5. Urban environmental damage in Australia, Greece, Finland and Sweden

In Australia, there are limited data on deer impacts on urban open spaces (Putman & Moore, 1998) despite evidence that they are increasingly encroaching on urban areas in many countries such as the United Kingdom (Ward, 2005), the U.S. (Cornicelli et al., 1996; Rondeau & Conrad, 2003) and Australia (Doherty, 2004; Moriarty, 2004a, 2004b). In urban areas, tolerance of deer decreases both with increasing numbers and the extent of their establishment (Loker et al., 1999) (I). The damage to specific plant taxa, however, may vary with deer species. Rusa deer in Australia, for example, avoid ferns and sedges (Keith & Pellow, 2005), but other species (e.g. fallow deer) have a preference for this vegetation (Hart, 2009). Garden plants are also preferred.

In Finland, questionnaire results showed that there was no significant difference between males and females in their opinion about whether white-tailed deer caused agricultural and/or forest damage to their properties. Reasons provided by those who did consider that deer cause damage reported that the greatest issue was that they cause traffic hazard risks > attracted predators (wolf, lynx) > damaged crops > browse the damaged forest > damaged private property (gardens, yards) > competed with roe deer (IV). If grazing and/or browsing was of substantial economic importance for rural landholders, it would be expected to be viewed as the major issue. It would also be expected that they would be less likely to provide supplementary fodder during winter than urban-based hunters. However, a larger percentage of rural males reported that they provided fodder for deer than either females or urban-based hunters. These observations, together with the majority of rural-based hunters reporting that white-tailed deer numbers (and elk) had diminished in the previous five years, indicated that white-tailed deer were not perceived to be an important agricultural/forestry pest in Finland (IV); however, more detailed research needs to be done.

In Greece, it was essential to examine food availability for the fallow deer population. All subplots had mostly similar plant species, but the species were found in different proportions throughout the 27 transects. Shrubs and grasses comprised 71% of the area (II). Average available dry grass mass was 192 g/m2 with an average height of 2.8 cm; fallow deer may require up to 3.0 kg of good quality dry matter per day, or even larger amounts when lactating (Putman et al., 1993). According to previous studies (Ramanzin et al., 1997) and our data, total forage dry matter production on the peninsula is estimated to be about 38 tons per year, which can support approximately 35 ungulates (fallow deer and goats; the food supply is thus not enough for the whole population). Most of the trees (> 90%) in sample plots were heavily browsed or frayed, probably due to attacks by male fallow deer during the rut (II).

On Koberg Estate, Sweden, where (spruce) forest management is aligned with hunting management, it was important to investigate whether plant species composition affects the level of browsing damage by deer. Based on the examined individuals, the least browsed tree species was Norway spruce (*P. abies*) (III). The most preferred (browsed/total numbers) woody plants were common hazel (*C. avellana*), common juniper (*J. communis*), red raspberry (*R. idaeus*), rowan (*S. aucuparia*) and English oak (*Q. robur*) (III). Browsing differed between solitary plants and plants in conspecific groups for *J. communis* (50% browsed when solitary and 100% when in conspecific groups), *P. abies* (1% vs. 10%), *B.*

pendula (35% vs. 71%), *B. pubescens* (50% vs. 78%), *P. sylvestris* (32% vs. 70%), and *Salix sp.* (27% vs. 59%) (III). In the absence of the avoided *P. abies*, the most preferred species were *J. communis* and *C. avellana*, followed by *B. pubescens*, *Salix sp.*, *P. sylvestris* and *B. pendula*. In cases where *P. abies* grew close to focal plants, the most palatable species were *C. avellana*, *S. aucuparia* and *Q. robur*, followed by *R. idaeus* and *Salix sp.*, then by *B. pubescens*, *P. sylvestris*, and *B. pendula* (III).

Sayre et al. (1992) surveyed homeowners in New York (U.S.) and found that the median loss to householders in the southern area of the state was $200 annually and in the western areas it was $90 annually. Extrapolated to all homeowners within their study areas, losses could be millions of dollars. Study outcomes were comparable to previous research in the same state (Connelly et al., 1987), but with increased deer numbers since that time in many U.S. urban areas (Nielsen et al., 2003) damage would be greater than Sayre et al. (1992) calculated.

4. CONCLUSIONS

As observed elsewhere (e.g. in New Zealand; McShea, Underwood, & Rappole, 1997), introduced deer can lead to conflict among stakeholders (Moriarty, 2004b). Therefore, the main tasks are to predict deer-human conflict situations and understand what their real root is. To involve all major decision makers, all local residents dealing on a daily basis with deer-caused issues (e.g. landowners, hunters, suburban communities etc). And to explore what the best possible solutions could be and make a road map or action plan on how to manage introduced deer populations. To underpin the future management of urban deer, there is a need to investigate the current level of awareness within communities, deer-vehicle collisions, damage to the urban landscape and associated damage to property (Kilpatrick & Walter, 1997; Stout et al, 1997), transmission of disease (Kilpatrick & Walter, 1997; Stout et al., 1997) such as Lyme disease (Hayes & Piesman, 2003), and social distress (e.g. vocalising, fighting at night, barking dogs; Connelly et al. 1987; Moriarty, 2004a).

The results of this thesis give insights to the general attitude towards deer, which depends on the balance between positive vs. negative impacts (I, II, III, IV). This thesis identifies the most important positive (game value; aesthetic etc. values) and negative (traffic accidents; browsing damage; indirect effects through changes in the abundance of other species such as predators) factors. Traffic accidents seem to play a major role in (semi)urban areas while the other impacts may be more important in areas with less traffic or low forage availability relative to deer density. These general findings link the case studies inspecting different local conditions, which may be understood as points along a general continuum of local conditions. The results of this thesis also give insights into complex social and ecological impacts of introduced deer in various countries and environments.

I found that there is a general acceptance that deer are increasing in numbers. In e.g. Australia there is no doubt that deer are increasingly encroaching on urban areas (e.g. Melbourne, Webb, 2013; Wollongong, WCC, 2013; Brisbane, McCarthy, 2013), and with 94% of Queensland herds having developed in the past 20 years, it is inevitable that the issues of urban deer will increase. Similarly to what Warren (1997) predicted for the U.S., we suggest that management of urban deer will become one of the

‘greatest challenges’ in Queensland, and ‘undeniably’ the most complicated due to the polarisation of views associated with deer.

For economic, environmental, and social reasons, further encroachment of deer into urban areas requires increased emphasis on the strategic development of management regimes. In addition, there cannot be a generic approach to management in all situations or for all deer species. Not all species are sedentary and urban areas are not the preferred habitat of deer either, due to stresses imposed by cars, people, lights, and dogs. Deer move into these areas because their habitat has become suboptimal (I). In Victoria, Australia, for example, extensive bushfires since 1997 have changed the landscape to benefit grazing deer and, subsequently, an increase in deer numbers and associated movements into urban areas have occurred (Gray, 2012).

Deer management issues that need further attention include legislation, policy, population monitoring, compliance to and and enforcement of regulations, and education and awareness. Wildlife management in urban areas has, however, been widely perceived as difficult (I). Management, therefore, requires ingenuity and experimentation with approaches in the context of conflicting social expectations (Decker & Chase, 1997). Urban deer management requires community education, management of the source of urban deer, and addressing the presence of deer within the confines of urban areas including roadways. Currently, the major debate over deer management is focused on recreational shooting (e.g. translocation of deer to form new herds for game hunting; Moriarty, 2004b). Recreational hunting, however, is not currently a successful management tool for feral deer (I). Female hunters' involvement in deer management planning is important (Heberlein et al., 2008; Herzog, 2007), though female participation in hunting deer appears to be typical of female participation in hunting more generally (IV).

A first step in extending deer management to all stakeholders may be the provision of stronger penalties for the deliberate release or translocation of deer. If all stakeholders agree on deer translocation, the population must be strictly controlled to prevent the possibility of deer spreading throughout the territory increasing damage to crops and gardens already under pressure from other wildlife (Kontsiotis et al. 2013). The new area must have suitable social and ecological carrying capacity to sustain deer populations, so that deer don’t need to adapt their diet or search for alternatives outside the allocated area, leading to their potential spread from the area and uncontrolled damage (II). Supplemental feeding can be provided to keep deer in a certain area, as is a quite common practice in Europe, e.g. in Scotland (Sharman 1978), Finland (Kurkela 1976), the Netherlands (Oostvaardersplassen) (Lumeij & Oosterbaan 2000) etc.

Secodly, habitat (e.g. agricultural and/or forest) and deer management could be kept aligned if both are managed keeping deer behavior and their woody plant preferences (in a matrix of unpreferred conspecific and allospecific woody species) in mind (III). The results of our study from Sweden show that the most commonly appearing species, P. abies (42%), was the most avoided, while the rarely occurring species (<1% of the total number of examined individuals) were the most preferred for browsing. To increase positive associational susceptibility of the surrounding allospecific species, e.g. keep *P. abies* protected from browsing and drive deer to browse other preferred species in larger amounts,

it is important to maintain a high density of alternative species in the undergrowth until the regeneration phase is completed or till the first precommercial cuttings (Mattila, 2010).

Thirdly, community-wide initiative for mitigating deer-vehicle collisions are needed. Actions could include the introduction of more widespread and informative signs alerting drivers to the presence of deer in the vicinity, and these should be placed in locations where deer-vehicle collisions are likely. In addition, information noticeboards, fact sheets, information on local government web sites, libraries and other public places could enhance awareness of local deer issues, such as the status of deer locally and how to respond when deer are encountered, where and how to report sightings, and tips on coexisting with deer in urban areas (I, II). Within established urban areas, fencing and / or natural vegetation barriers, or vegetation removal could be used strategically along roadside verges and around wetlands and parks (I, II).

Fourthly, the development and application of public awareness campaigns should be planned to maintain positive attitudes in the general public. This should involve local media, training of farmers in environmental skills, information to tourists to raise their awareness of deer habits (i.e. decreasing disturbance to deer), and educating local deer-feeding volunteers in nutrition and the public about local flora and fauna interactions to avoid conflict caused by deer damage to crops and gardens.

Finally, monitoring of the numbers of deer and their spread into urban areas is required to underpin priority management decisions. A regular assessment of the population size and culling of surplus animals would be useful in maintaining a healthy population and protecting the landscape.

Warren (1997) predicted that the overabundance of urban deer in the U.S. would become a major challenge for organizations and persons responsible for wildlife management. He further predicted that management would become more complicated with increased human populations and concomitant urban development, together with societal value changes and a diversity of those values. Further studies are needed to develop a deeper understanding of the issue in Australia, Greece, Finland and Sweden and sub-urban introduced deer populations in general. Additional study is needed to understand the economic impacts of introduced deer populations.

ACKNOWLEDGEMENTS

This kind of transboundary project cannot be accomplished by one single person; I am sincerely thankful for the many people who have helped me during the travels and field work of these research projects as I completed my thesis.

First, I would like to thank my supervisor, Professor Pekka Niemelä for supporting this "not very standard-looking idea" to do research in four different countries. I am very grateful he believed in this project and let me collaborate with many institutions and many people who helped me the whole way through. I am thankful that he was always very supportive and truly supervised my path even when I became a full-time working PhD student.

I have had the opportunity to collaborate with a number of really wonderful people during this project, and I would like to thank my co-authors involved in the publications for this thesis: Emeritus Professor Shelley Burgin (Bond University, Gold Coast, Australia), Dr. Daryl McPhee (Bond University, Gold Coast, Australia), Professor Tor Hundloe (Bond University, Gold Coast, Australia), Assistant Professor Ioannis Hadjigeorgiou (Agricultural University of Athens, Athens, Greece) and Professor Petter Kjellander (Swedish University of Agricultural Sciences, Grimsö, Sweden). I really appreciate all the hard work you have put into the project and I have enjoyed working with and learning from all of you very much! Additional personal thanks to all of you for being very hospitable, understanding, helping and supportive. Many of you became my true friends – thank you!

Thanks to all the people involved as supporters during the field work and to those who helped and organized my stay in Australia (Shelley Burgin, thanks a million, I am so glad I know you), in Greece (Foteini Etmektsoglou and Ioannis Hadjigeorgiou, thank you so much for supporting me and becoming my friends, Anna Tosounoglou, thanks for climbing with me up and down the hills in the fortress peninsula, Dimitris Boulotis, thank you for organization and interviews) and in Sweden (Petter, tack så mycket for everything, big thanks to Silfverschiöld family for letting us work on their land, to Anders Friberg for helping with practical issues, to the staff at Grimsö Wildlife Research station).

Thanks to the funding sources for this project: the Turku University Foundation, the BIOINT Graduate School, Agricultural University of Athens, Swedish University of Agricultural Sciences and Professor Pekka Niemelä's projects, which provided funds for me to make these travels happen and attend several international conferences – I have really enjoyed and appreciated these opportunities.

I am very thankful for the support of the respondents and the work of Game manager, Antti Impola, and Manager of Game Management, Mikko Toivola, Finnish Wildlife Agency (Suomen Riistakeskus), and researchers Ashley Selby and Leena Petäjistö from the Finnish Forest Research Institute (METLA) in developing the survey for the Finnish study.

Thank you very much to everybody who helped with multiple reviews of the articles when they were submitted to journals: Prof. R. Putman (University of Glasgow), Emeritus Prof. S. Burgin (Bond University) and Dr M. Grund (Minnesota Department of Natural Resources, Minnesota State University). Last but not least, a big thanks to my beloved family – my husband and my daughter for going this path together step-by-step! Thank you for your support and encouragement, I could not have done this alone.

REFERENCES

ABS (2013) 34102.0 Australian Social Trends, April 2013: The 'average' Australian. Australian Bureau of Statistics. http://www.abs.gov.au/ (Nov. 18, 2013)

Agarwal BS (2012) Gender and green governance: The political economy of women's presence within and beyond community forestry. New York: Oxford University Press.

Bentley A (1978) An introduction to the deer of Australia. Melbourne: The Koetong Trust Fund and the Forrest Commission, Victoria.

Bergvall UA (2007) Food choice in fallow deer – experimental studies of selectivity [doctoral dissertation]. Department of Zoology, Stockholm University

Bissonette JA, Kassar CA, Cook LJ (2008) Assessment of costs associated with deer-vehicle collisions: Human death and injury, vehicle damage, and deer loss. Human-Wildlife Conflicts 2:17-27

Blood DA, Hatter I, Harcombe G, Stanlake L, Bethune A (2000) White-tailed deer in British Columbia, ecology, conservation and management. Vancouver: British Columbia Ministry of Environment, Lands and Parks

Bonnington C, Jew E (2011) Socio-demographic factors influence the attitudes of local residents towards trophy hunting activities in the Kilombero Valley, Tanzania. African Journal of Ecology 49:277–285

Brockie RE, Sadleir RMFS (2009) Long-term wildlife road-kill counts in New Zealand. New Zealand Journal of Zoology 36:123-134

Burger J (1999) American Indians, hunting and fishing rates, risk, and the Idaho. Environmental Research 80:317-329

Cain SA, Castro GM (1959) Manual of vegetation analysis. Harper, New York, USA

Carlström L, Nyman M (2005) Dovhjort. Kristianstad (Sweden): Jägareförlaget. 160 p.

Chai SL (2007) Establishment of the invasive white-tailed deer in Portland, Jamaica. Jamaica: Conservation and Development Trust

Conover MR, Pitt WC, Kessler KK, DuBow TJ, Sanborn WA (1995) Review of human injuries, illness, and economic losses caused by wildlife in the United States. Wildlife Soc. B. 23:407-414

Connelly NA, Decker DJ, Wear S (1987) Public tolerance of deer in a suburban environment: Implications for management and control. Third Eastern Wildlife Damage Control Conference, 1987, Paper 8. Retrieved from http://digitalcommons.unl.edu/ewdcc3/8

Cornicelli L, Woolf A, Roseberry JL (1996) White-tailed deer use of a suburban environment in Southern Illinois. Transactions of the Illinois State Academy of Science 89:93-103

Crete M, Ouellet J, Lesage L (2001) Comparative effects on plants of caribou/reindeer, moose and white-tailed deer herbivory, Arctic 54:407-417

Cromwell JA, Warren RJ, Henderson DW (1999) Live-capture and small-scale relocation of urban deer on Hilton Head Island, South Carolina. Wildlife Society Bulletin 27:1025-1031

DAFF (2012) Deer (feral). Brisbane: Department of Agriculture, Fisheries and Forestry. Foot and mouth disease. Orange: Department of Primary Industries

DAFF (2013) Feral red deer (Cervus elapus). Brisbane: Department of Agriculture, Fisheries and Forestry Biosecurity

Danell K, Edenius L, Lundberg P (1991) Herbivory and tree stand composition: moose patch use in winter. Ecology. 72:1350–1357

Danielson BJ, Hubbard MW (1998) A literature review for assessing the status of current methods of reducing deer-vehicle collisions. Report for the task force on animal collisions. Iowa Department of Transportation & Iowa Department of Natural Resources. Retrieved from http://www.peopleandwildlife.org.uk/crmanuals/deervehicles.pdf

Decker DJ, Chase LC (1997) Human dimensions of living with wildlife – a management challenge for 21st century. Wildlife Society Bulletin 25:788-795

Decker D, Gavin TA (1987) Public attitudes toward a sub-urban deer herd. Wildlife Society Bulletin 16:53-75

Doherty L (2004) Don't worry, deer, today you can roam on the range. In D. Lunney &. S. Burgin (Eds.), Urban wildlife: More than meets the eye Mosman: Royal Zoological Society of New South Wales:184-185

European Commission (2011) Communication from the Commission to the European Parliament, the Council, the Economic and Social Commitee and the Commitee of the Regions. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Brussels, 3.5.2011. COM (2011) 244 final

Feldhamer GA, Farris-Renner KC, Barker CM. (1988) Dama dama. Mammalian species. The American Society of Mammalogists 317:1-8

Finch N, Murray P, Hoy J, Baxter E (2014) Expenditure and motivation of Australian recreational hunters. Wildlife Research 41:76-83

Finnish Transport Agency, Transport and Infrastructure Data. (2013). Research reports of the Finnish Transport Agency 5/2013. Helsinki.

Finnish Transport Agency statistics web page: http://www.liikennevirasto.fi/tilastot/tietilastot/liikenneonnettomuudet-maanteilla#.WWsvWHmQzSH (July 16, 2017) Frith H (1973) Wildlife conservation. Sydney: Angus and Robertson

Forsyth DM (2009) How can research contribute to the management of wild deer in Australia? In S. McLeod (Ed.), Workshop proceedings: What are the issues for the management of wild deer in Australia Canberra: Invasive Animals Cooperative Research Centre: 7-21

Gallina S, Lopez AH (2008) Odocoileus virginianus. The IUCN Red List of Threatened Species. Version 2014(3). Retrieved from: http://www.issg.org/database/species/ecology.asp?si=1327&fr=1&sts=&lang=EN

Gordon I. (1997) Controlled reproduction in horses, deer and camelidis in I. Gordon, author. Controlled reproduction in farm animals series. Centre for agriculture and biosciences International Publishing, Wallingford, New York, USA 4:168-184

Gray D (2012) Record 41,000 deer cull but thousands more roaming free. The Age

Gray, D. (2013) Deer numbers spark call for a Victorian cull. The Age

Groves CP, Bishop JF (1989) Cervidae. In: Walton, D.W. and Richardson, B.J., eds., Fauna of Australia, Volume B1 Mammalia, Canberra: CSIRO Press

Hadjigeorgiou I. (2011) Past, present and future of pastoralism in Greece http://www.pastoralismjournal.com/content/1/1/24

Hall GP, Gill KP (2005) Management of wild deer in Australia. Journal of Wildlife Management 69:837-844

Hart S (2009) Management of deer: RSPCA Australia perspective. In S. McLeod (Ed.), Workshop proceedings: What are the issues for the management of wild deer in Australia (pp.30-31). Canberra: Invasive Animals Cooperative Research Centre.

Hastings AW (1996) Bambi and the hunting ethos. Journal of Popular Film and Television 24:53-59

Havlick D (2004) Road kill. Conservation in Practice 5:30-33

Hayes EB, Piesman J (2003) How can we prevent Lyme disease? New England Journal of Medicine, 348, 2424-2430

Heberlein TA, Serup B, Ericsson G (2008) Female hunting participation in North America and Europe, Human Dimensions of Wildlife 13:443-458

Herzog HA (2007) Gender differences in human – animal interactions. Anthrozoos 20:7-21

Hobday AJ, Minstrell ML (2008) Distribution and abundance of roadkill on Tasmanian highways: Human management options. Wildlife Research 35:712-726

Holmes RD, Jepson-Innes K (1989) A neighbourhood analysis of herbivory in Bouteloua gracilis. Ecology 70:971–976

Hovi A, Kehvola H, Rautiainen O (2016) Human dimensions of invasive alien species. ME 408 Specific Topics in Forest Ecology. Helsinki: University of Helsinki

Hörnberg S (2001) Changes in population density of moose (Alces alces) and damage to forests in Sweden. Forest Ecol Manag 149:141–151

Hubbard RNLB (1995) Fallow deer in prehistoric Greece, and the analogy between faunal spectra and pollen analyses; A case-study: prehistoric Sitagroi-Photolivos. Antiquity 69:264

Iverson AL, Iverson LR (1999) Spatial and temporal trends of deer harvest and deer-vehicle accidents in Ohio. Ohio Journal of Science 99:84-94

Jesser P (2005) Deer in Queensland: pest status review series - Land protection. Brisbane: Department of Natural Resources and Mines

Kalen C (2005) Deer browsing and impact on forest development. In: Kristina Blennow K, Niklasson M, editors. Sustainable forestry in southern Sweden: The SUFOR research project. Food Products Press: 53–64

Kalen C, Bergquist J (2004) Forage availability for moose of young silver birch and Scots pine. Forest Ecol Manag 187:149–158

Keith D, Pellow B (2005) Effects of Javan rusa deer (Cervus timorensis) on native plant species in the Jibbon-Bundeena area, Royal National Park, New South Wales. Proceedings of the Linnean Society of New South Wales, 126, 99-110

Kilpatrick HJ., Walter WD. (1997) Urban deer management: A community vote. Wildlife Society Bulletin, 25:388-391

Kontsiotis VJ, Bakaloudis DE, Xofis P, Konstantaras N, Petrakis N, Tsiompanoudis A (2013) Modelling the distribution of wild rabbits (Oryctolagus cuniculus) on a Mediterranean island. Ecol Res 28: 317-325

Koskela & Nygren (2002) Hirvenmetsästysseurueet Suomessa vuonna 1999. Suomen Riista 48: 65–79

Kurkela P (1976) Prospects for reindeer husbandry based on grass and silage feeding. Acta vet. scand. suppl 60:5-75

Lipponen K, Pouttu A, Varama M, Heikkilä R, Henttonen H (2002) Biotic and abiotic forest damage in 2001. Metsätuhot vuonna 2001. In: Rautjärvi, H., Ukonmaanaho, L., & Raitio, H. (eds.). Forest condition monitoring in Finland. National report 2001. Metsäntutkimuslaitoksen tiedonantoja - The Finnish Forest Research Institute, Research Papers 879:95-98

Loker CA, Decker DJ, Schwager SJ (1999) Social acceptability of wildlife management actions in suburban areas: Three cases from New York. Wildlife Society Bulletin, 27:152-159

Long JL (2012) Introduced mammals of the world: their history, distribution and influence. Collingwood: CSIRO Press

Lumeij JT, Oosterbaan J (2000) Large grazers in the Dutch wetland "de Oostvaardersplassen." Reaction to the "Guide to Large Grazers" of the State Secretary for Agriculture, Nature Management and Fisheries. Tijdschr Diergeneeskd 125: 230-234

MacDonald I (1995) The Complete Deer Farming Guide. Traralgon: Gippsland Printers Pty Ltd

Marquis D, Brenneman R (1981) The impact of deer on forest vegetation in Pennsylvania. General Technical Report. U.S. Department of Agriculture Forest Service

Massetti M (2009) A possible approach to the "conservation"of the mammalian populations of ancient anthropochorous origin of the Mediterranean islands. Folia Zool. 58:303-308

Massetti M, Cavallaro A, Pecchioli E, Cristiano V (2006) Artificial Occurrance of the Fallow Deer, *Dama dama dama* (L., 1785), on the Island of Rhodes (Grece): Insight from mtDNA Analysis. Hum Evol 21: 167-175

Massetti M (2002) Island of deer. Natural history of the fallow deer of Rhodes and of the vertebrates of the Dodecanese. Environment Organization of City of Rhodes (Greece), Rhodes

Mastro LL, Conover MR, Frey SN (2008) Deer-vehicle collision prevention techniques. Human-Wildlife Conflicts, 2, 80-92.

Mattila M (2010) The importance of undergrowth vegetation and browsing pattern on oak seedlings [Master thesis no. 151]. Alnarp (Sweden): Swedish University of Agricultural Science (SLU)

McCarthy J (2013) End of the stag party. The Courier Mail, Brisbane (July 6-7)

McShea WJ, Underwood HB, Rappole JH (1997) The science and politics of managing deer within a protected area. Wildlife Society Bulletin 25:443-446

Migli D (2006) Behaviour and Ecology of an isolated population of fallow deer (*Dama dama* L.) on the island of Lemnos, northern Aegean, Greece. MSc, Aristotle University of Thessaloniki, Greece

Milchunas DG, Noy Meir I (2002) Grazing refuges, external avoidance of herbivory and plant diversity. Oikos 99:113–130

Moriarty A (2004a) Wild deer herds in Australia's urban fringe: Issues, management, and politics. In D. Lunney, & S. Burgin (Eds.), Urban wildlife: More than meets the eye. Mosman: Royal Zoological Society of New South Wales: 179-185

Moriarty A (2004b) The liberation, distribution, abundance and management of wild deer in Australia. Wildlife Research 31:291-299

Ng WJ, Nielsen C, St Clair CC (2008) Landscape and traffic factors influencing deer-vehicle collisions in an urban environment. Human-Wildlife Conflicts 2:34-47

Nielsen C, Anderson R, Grund M (2003) Landscape influences on deer-vehicle accident areas in an urban environment. Journal of Wildlife Management 67:46-51

Nietschmann B (1977) The Bambi factor. Natural History 86:84-87

Nummi P (2000) Alien species in Finland. Helsinki: Finnish Ministry of the Environment.

Oja J, Oja S (2006) Working report 2006-53: game statistics for the island of Olkiluoto in 2005-2006. Olkiluoto: Finland

Panitsa M, Snogerup B, Snogerup S, Tzanoudakis D (2003) Floristic investigation of Lemnos island (NE Aegean area, Greece). Willdenowia 33:79-105

Pellikka, J. & Forsman, L. 2013. Metsästävien naisten määrä on kasvussa – miten tukea kehitystä? Suomen Riista 59: 34–51.

Pfister CA, Hay ME (1988) Associational plant refuges: convergent patterns in marine and terrestrial communities result from different mechanisms. Oecologia 77:118–129

Pouttu A, Lipponen K, Nevalainen S, Lindgren M, Lilja A, Poteri M, Neuvonen S, Henttonen H, Hantula J (2007) Working papers of the Finnish Forest Research Institute 45. Part 4: Results of other studies related to forest damage and long-term monitoring Joensuu Finnish Forest Research Institute: 130-135

Putman RJ, Culpin S, Thirgood SJ (1993) Dietary differences between male and female fallow deer in sympatry and in allopatry. J Zool 229:267–275

Putman RJ, Moore NP (1998) Impact of deer in lowland Britain on agriculture, forestry, and conservation habitats. Mammal Review 28:141-164

Raik DB, Lauber TB, Decker DJ, Brown TL (2005) Managing community controversy in suburban wildlife management: Adopting practices that address value differences. Human Dimensions of Wildlife 10:109-122

Ramanzin M, Bailoni L, Schiavon S (1997) Effect of forage to concentrate ratio on comparative digestion in sheep, goats and fallow deer. Anim Sci 64: 163-170

Ramp D, Caldwell J, Edwards KA, Warton D, Croft DB (2005) Modelling of wildlife fatality hotspots along the Snowy Mountain Highway in New South Wales, Australia. Biological Conservation 126:474-490

Rautio P, Kesti K, Bergvall UA, Tuomi J, Leimar O (2008) Spatial scales of foraging in fallow deer: implications for associational effects in plant defences. Elsevier Masson SAS Acta Oecol. 34:12–20

Romin LA, Bissonette JA (1996) Deer-vehicle collision: Status of state monitoring activities and mitigation efforts. Wildlife Society Bulletin, 24:276-283

Rondeau D, Conrad JM (2003) Managing urban deer. American Journal of Agricultural Economics 85:266-281

Rowden P, Steinhardt D, Sheehan M (2008) Road crashes involving animals in Australia. Accident Analysis and Prevention 40:1865-1871

Sayre RW, Decker DJ, Good GL (1992) Deer damage to landscape plants in New York State: Perceptions of nursery producers, landscape firms, and homeowners. Journal of Environmental Horticulture, 10: 46-51

Seidl I, Tisdell CA (1999) Carrying capacity reconsidered: from Malthus' population theory to cultural carrying capacity. Ecol Econ 31:395-408

Selby, Petäjistö, Koskela & Aarnio. 2005. Ikääntyminen hirvenmetsästysseurojen tulevaisuuden ongelmana? Suomen Riista 51:69-82

Sharman GAM (1978) Red deer farming. Ann. Appl. Biol. 88:347-350

SSAA (2013) SSAA launches 2013 Year of the hunter. Sporting Shooters Association of Australia. Retrieved from http://www.ssaa.org.au/fact-sheet/2013-02-12_ssaa-launches-2013-year-of-the-hunter-LR.pdf

SSAA (2014) Join the SSAA. Sporting Shooters Association of Australia. Retrieved from http://www.ssaaqld.org.au/become-a-shooter/join-the-ssaa

Stewart GH, Burrows LE (1989) The impact of white-tailed deer Odocoileus virginianus on regeneration in the coastal forests of Stewart Island, New Zealand. Biological Conservation, 49:275-293

Strahan R (1995) The Mammals of Australia. Sydney: Reed Books

Stout RJ, Knuth BA, Curtis PD (1997) Preferences of suburban landowners for deer management techniques: A step toward better communication. Wildlife Society Bulletin, 25: 348-359

Sykes N, Carden RF, Harris K (2013) Changes in the size and shape of fallow deer-evidence for the movement and management of a species. Int. J. Osteoarchaeol 23:55-68

Swedish forestry [Internet] (2012) Swedish wood, part of the Swedish forest industries federation [cited 2016 Apr 1]. Available from: http://www.svenskttra.se/MediaBinaryLoader.axd?MediaArchive_FileID=eb34da70-248d4e78-b7cf-9592aca6c0db&FileName=Forest.pdf

Tahvanainen JO, Root RB (1972) The influence of vegetational diversity on the population ecology of a specialized herbivore, Phyllotreta cruciferae (Coleoptera: Chrysomelidae). Oecologia 10:321–346

Takada M, Asada M, Miyashita T. (2003) Can spines deter deer browsing? Field experiment using shrub Damnacanthus indicus. J For Res. 8:321–323

Taylor BD, Goldingay RL (2004) Wildlife road-kills on three major roads in North-eastern New South Wales. Wildlife Research 31:83-91

The Hunting Consortium Ltd (2012) Scandinavia: Denmark, Norway, Sweden, Finland, Iceland. Retrieved from:

http://ww.huntingconsunsortum.com/europe-scandinava.htm.

Vankova D, Bartos L, Miller KV, Brandl P (1999) Behaviour of white-tailed and fallow deer during winter supplemental feeding. Folio Zoologica 48:8-92

Ward AI (2005) Expanding ranges of wild and feral deer in Great Britain. Mammal Review 35:165-173

Warren RJ (1997) The challenge of deer overabundance in the 21st Century. Wildlife Society Bulletin 25:213-214

WCC (2013) Deer fact sheet. Wollongong: Wollongong City Council

Webb E (2013) Call for cull as police fear feral deer roaming through Dandenong Ranges. Leader, June 19 Retrieved from http://www.heraldsun.com.au/leader/east/call-for-cull-as-police-fear-feral-deer-roaming-through-dandenong-ranges/story-fngnvlxu-1226665611267

Annex 1

Questionaire used for the survey conducted in Finland in 2012 as a collaboration between the Finnish Wildlife Agency (Suomen Riistakeskus), the University of Turku, and the Finnish Forest Research Institute (METLA). It addressed hunters' knowledge and opinions of the introduced white-tailed deer.

1. Gender?
2. Age?
3. Your municipality
4. Your permanent residence is
5. Have you ever seen white-tailed deer?
6. Did you know that the white-tailed deer was introduced to Finland from the USA?
7. Do you appreciate white-tailed deer in your region?
8. Have you noticed any changes in the following species' populations in the last 5 years?
9. Are white-tailed deer causing any damage in general?
10. If the answer was Yes, can you specify what the most serious kinds of damage caused by white-tailed deer are? Rank from 1-6 (1 - the most important, 6 – least important)
11. Do you hunt?
12. In which municipality do you mainly hunt?
13. How long have you been hunting?
14. Do you appreciate white-tailed deer hunting in general?
15. Do you feed white-tailed deer in winter time?
16. What would be your hunting preference list? Rank from 1-5 (1 - the most desired, 5 – least desired)
17. Do you hunt white-tailed deer?
18. If the answer was Yes, can you specify why you hunt white-tailed deer? (Meat, recreation, trophy, social duty, other)
19. Are you a land owner?
20. Your land property contains: Forest, Agriculture, Both, Other
21. Do you appreciate white-tailed deer on your land property?
22. Do you feed white-tailed deer in winter time?
23. Have you noticed any damage caused by white-tailed deer on your property?
24. If the answer was Yes, can you specify where?
25. Why do you think that those damages were caused by white-tailed deer? (I saw how white-tailed deer was browsing/bark striping etc., There are no roe deer or elk on my land, I saw white-tailed deer damaging my agricultural crops, Other)

Full questionnaire (including questions used separately by the Finnish Wildlife Agency (Suomen Riistakeskus)

<u>Valkohäntäpeurakysely</u>

1. Sukupuoli?
2. Ikäsi?
3. Kotikuntasi
4. Asuinpaikkasi?
5. Oletko koskaan nähnyt valkohäntäpeuraa?
6. Tiesitkö, että valkohäntäpeura tuotiin Suomeen Yhdysvalloista?
7. Arvostatko valkohäntäpeuraa omalla alueellasi?
8. Oletko huomannut muutosta seuraavissa eläinkannoissa viimeisen 5 aikana?
9. Aiheuttaako valkohäntäpeura yleisesti ottaen vahinkoa?
10. Jos vastasit "Kyllä", arvioi, mikä on vakavin vahinko, jonka valkohäntäpeura aiheuttaa? Listaa vaihtoehdot 1-6 (1 = vakavin vahinko, 6 = merkityksetön vahinko)
11. Metsästätkö?
12. Minkä kunnan alueella pääasiallisesti metsästät?

13. Kuinka kauan olet metsästänyt?
14. Arvostatko valkohäntäpeuranmetsästystä?
15. Ruokitko valkohäntäpeuroja talvella?
16. Mitä metsästät mieluiten? Listaa vaihtoehdot 1-5 (1=mieluisin, 5=vähiten mieluinen)
17. Metsästätkö valkohäntäpeuraa?
18. Jos vastasit edelliseen kysymykseen kyllä, minkä vuoksi metsästät valkohäntäpeuraa?
19. Oletko maanomistaja?
20. Omistatko
21. Arvostatko valkohäntäpeuraa omalla maallasi?
22. Ruokitko valkohäntäpeuroja talvella?
23. Oletko havainnut valkohäntäpeuran aiheuttamia vahinkoja maallasi?
24. Jos vastasit ”Kyllä”, missä havaitsit vahinkoja?
25. Miksi uskot valkohäntäpeuran aiheuttaneen vahingon?
26. Toimitko metsästysseuran johtotehtävissä tai jahtipäällikkönä valkohäntäpeuran metsästyksessä?
27. Edustamasi alue
28. Edustamasi riistanhoitoyhdistys
29. Metsästysseuranne metsästykseen käytettävissä oleva pinta-ala?
30. Mikä oli metsästykseen osallistuneiden metsästäjien lukumäärä metsästysseurassanne metsästyskaudella 2011-2012?
31. Arvio metsästysseuranne alueella elävien valkohäntäpeurojen lukumäärästä tällä hetkellä (kpl)?
32. Mikä on mielestänne tavoiteltava valkohäntäpeurakannan suuruus metsästysseuranne alueella (kpl)?
33. Miten valkohäntäpeurakanta on seuranne alueella kehittynyt viimeisen 5 vuoden aikana?
34. Miten tärkeä riistaeläinlaji valkohäntäpeura on seuranne toiminnassa?
35. Millä tavoin alla mainitut tekijät ovat mielestänne vaikuttaneet alueenne peurakannan kokoon viimeisen 5 vuoden aikana? (asteikkona -2: huomattava vähentävä vaikutus, -1: vähentävä vaikutus, 0: ei vaikutusta, 1: lisäävä vaikutus 2: huomattava lisäävä vaikutus)
36. Millainen alueenne valkohäntäpeurakannan sukupuolijakauma mielestänne on?
37. Millainen alueenne valkohäntäpeuraurosten ikä- /sarvirakenne mielestänne on?
38. Montako valkohäntäpeuraa seuranne alueella kaadettiin kaudella 2011-2012
39. Toivoisitteko saavanne peuroja saaliiksi
40. Mitkä ovat suurimmat ongelmat peurakannan hoidossa tällä hetkellä seurassanne tai yleisesti?
41. Miten valkohäntäpeuran metsästystä seurassanne lupamäärän puitteissa ohjataan?
42. Missä määrin seuraavia seikkoja tulisi mielestänne painottaa peurakannan hoidossa?
43. Voit perustella tähän edellä mainittuja vastauksiasi (peurakannan hoidossa painotettavat seikat):
44. Missä määrin näet seuraavat valkohäntäpeurakannan säätelyjärjestelmän kehittämissuunnat toivottavina?
45. Voit perustella tähän edellä mainittuja vastauksiasi (peurakannan säätelyjärjestelmän kehittämissuunnat):
46. Muita ajatuksia peuranmetsästykseen liittyvän lainsäädännön ja kannan säätelyjärjestelmän kehittämiseen liittyen?
47. Mikä olisi keskeisin tavoite valkohäntäpeurakannan hoidolle tulevaisuudessa? Perustelkaa, miksi haluatte kannan kehittyvän esitettyyn suuntaan.
48. Millainen vaikutus alueenne valkohäntäpeurakannalla on koirien käyttöön muussa metsästyksessä?
49. Kuinka monta peurayksilöä arvioitte suurpetojen tappaneen seuranne alueella vuoden 2011 aikana?
50. Miten tapettujen valkohäntäpeurayksilöiden määrä jakautuu eri suurpedoille?
51. Miten peurakantaa seurassanne arvioidaan?
52. Miten luotettavana pidät nykyistä peurakanta-arviota ja sen laatimisessa käytettyjä kannanarviointimenetelmiä?
53. Miten peurakannan arviointia pitäisi mielestäsi kehittää?
54. Mitä tutkimustietoa tulisi tuottaa valkohäntäpeuraa koskien?

Annex 2. Interview summary of the representatives of the major stakeholders in Myrina. The position of decision-making groups, to be used by an appointed municipality advisory group to develop deer management strategy.

Main stakeholders / Question	Lemnos Island Department of Rural Economy (n = 6)	Lemnos Island Forestry Service Department (n = 2)	Lemnos Island Police Department (n = 5)	Deer-feeder volunteers (n = 3)	Municipality of Myrina (n = 2)	Local newspaper (n = 3)
Deer damage?	Private gardens, vegetable yards, arable crops	Private gardens, vegetable yards, arable crops, 20 vineyards, no forest damage	Vehicle collisions (2008-2011, 6 deer killed, no human injuries or fatalities)	Small ornamental trees, private gardens, bushes	Private gardens, small plantations, 1 vehicle collision	Escaped deer in Myrina searching for food in garbage bins inside the city
Attitude towards deer presence in fortress area?	Positive. Good tourist attraction. But no deer outside fortress.	Positive. But need to address insufficient food supply (competition with feral goats).	Positive	Positive. But no deer outside fortress area, need additional food.	Positive. But no deer outside fortress area.	Positive. But need information for tourists, and locals .
Translocation to another fenced area?	Negative. Problems with catching and transporting deer. No food supply in new site. Addition to problem with wild rabbits (overgrazing).	Negative. Difficult to keep deer from escaping. No fenced wildlife.	Positive	Negative. No fences: Greek culture dictates free-roaming wildlife.	Negative. No deer outside fortress area So, no damage to private property and no illegal hunting.	Positive. Keep deer in open territory.
Management suggestions?	Deer farms? For protection of deer and public admiration. Environmental protection (food supply and suitable habitat).	Part of population in fortress, supported with supplemental food and water. Portion in restricted area. Granting a few shooting licenses? (300 €/deer)	Keep deer safe, as well as private property. Damage control implementation.	Management guidelines. Local Society education. Licences (300 €/deer). Deer farms. Additional trees and plants.	Improve productivity of existing vegetation (i.e. plant clover species (*Trifolium spp.*). Fence fortress area to prevent deer escaping.	No deer outside the fortress. No deer farms. Management advice for locals, media and pupils.
Additional information	Management tips for farmers on correct course of actions if deer are on their property.	Deer hunting forbidden by law (population control by hunting would require changing the law).	Police often receives reports on deer damage to vegetable gardens.	Many complaints, some unsubstantiated.	Difficult to capture and transport deer (requires animals be kept under welfare standards). Existing wild rabbit and feral dog problems.	Feral dog problems. Locals express willingness to feed deer with vegetable leftovers.