Chapter 11
Hunting in Managed Oak Woodlands: Contrasts Among Similarities

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Frontispiece Chapter 11. The California tule elk (*Cervus canadensis* ssp. *nannodes*) is a subspecies of elk once almost lost to commercial overhunting. Successful reintroduction efforts have allowed renewed sport hunting opportunities of great value to landowners. (Photograph by B. Voelker)

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Abstract Distinct cultural and legal histories governing the property rights that regulate wildlife and land tenure in California and Spain have created dissimilar hunting systems. The differences that are manifest in the methods of hunting, the economic return to landowners, the actions taken to manage game species, and the accompanying environmental effects. Private landowners in Spain retain greater control of game species, while in California, the state and federal government exerts greater authority. After providing background on the game species and systems of hunting in California and Spain, a review of the legal and cultural history illustrates how distinct systems evolved in places that are similar in many other ways. In terms of economics, hunting revenue in Spain is often greater than in California, due to higher hunter participation rates, fewer governmental restrictions that limit the commercialization of hunting, and greater liberties in hunting methods and game management practices. As such, income from hunting provides a greater incentive for Spanish landowners to maintain areas of habitat for game species. Some of the greatest contrasts between these places are illustrated in wildlife management practices, where Spanish landowners can implement far more intensive practices to manipulate populations of game species. Numerous environmental effects can result from these management practices, which include changes to vegetation, erosion, genetic impacts, invasive species introductions, and impacts to non-game species.

Keywords Hunting · California · Spain · Game · Wildlife management · Property rights · Predator control

11.1 The Basics

The oak woodlands of California and Spain share commonalities of climate, vegetation, livestock production, and biodiversity of global importance. Yet distinct cultural and legal histories governing property rights over wildlife and land tenure have created dissimilar hunting traditions. The geography, game species, hunting participation rates, land tenure, and other factors have all shaped these unique systems, and the legal and cultural history of hunting illustrates how these hunting systems evolved. This historical discussion elucidates the economic, legal,

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and social roots of present-day hunting, while the final sections dwell on wildlife management practices, and the associated environmental impacts of hunting in Spain and California oak woodlands.

11.1.1 Geography and Game Species

Three regional *autonomías,* or autonomous regions—Castilla-La Mancha, Extremadura, and Andalucía—contain a sizable part of the Spanish dehesa (Chap. 1) and include what historically and today are Spain's most productive hunting lands. Forty-two percent of all Spanish hunting areas are contained in these autonomías, where two-thirds of all big game harvests take place (Metra and Seish 1985; López Ontiveros and Verdugo 1991). The dehesa, in association with surrounding and understory shrublands, provides quality food and cover for popular game species including Iberian red deer (C*ervus elaphus hispanicus*), wild pig (*Sus scrofa*), and occasionally mouflon (*Ovis orientalis musimon*) or fallow deer (*Dama dama*) (Blas Aritio 1974). High quality hunting in the early 1900s made the Spanish dehesa a destination for big game hunters from Europe and lands farther afield (Delgado and Muñoz 1982). Iberian red deer and wild pigs make up the largest share of Spain's annual harvest, reaching averages of 100,000 Iberian red deer and 180,000 wild boar (Carranza 2010; Garrido Martín 2011) (Tables 11.1 and 11.2).

The hunting of small game in Spain is a secondary activity, although preferred by some hunting classicists because it permits solitary and contemplative travel in a natural realm (Delibes 1982). Small game species predominate in more agriculturally developed areas. Popular small game species include thrushes (*Turdus* spp.), the European rabbit (*Oryctolagus cuniculus*) and the red-legged partridge (*Alectoris rufa*). While over 3 million partridges are harvested every year, few are from natural populations, with most birds farm-raised and released onto dehesa sites before the start of each year's hunting season (Garrido Martín 2011) (Figs. 11.1 and 11.2).

The oak woodlands of California are located in foothill and coastal regions from sea level to an elevation of 1300 m in the southern Sierra Nevada. The main oak habitat is in California's Central to North Coast region and in a vast ring around the Central Valley. These offer food and cover for big game animals,

Table 11.1 Predominant game species in the oak woodlands of California and Spain

California	Spain
Predominant big game species	*Predominant big game species*
Black-tailed/Mule deer *(Odocoileus hemionus* ssp.*)*	Iberian red deer *(Cervus elaphus hispanicus)*
Wild pig *(Sus scrofa)*	Wild pig *(Sus scrofa)*
Predominant small game/upland game	*Predominant small game/upland game*
Turkey *(Meleagris gallopavo)*	European rabbit *(Oryctolagus cuniculus)*
Quail *(Callipepla californica)*	Red-legged partridge *(Alectoris rufa)*

Table 11.2 2005–2009 averaged annual harvest of game species in Spain (Garrido Martín 2011)

Species	Average harvest
Big game	
Wild boar (*Sus scrofa*)	183,739
Red deer (*Cervus elaphus*)	102,220
Roe deer (*Capreolus capreolus*)	22,591
Fallow deer (*Dama dama*)	8,805
Mouflon (*Ovis musimon*)	6,150
Spanish ibex (*Capra pyrenaica*)	2,722
Barbary sheep (*Ammotragus lervia*)	601
Chamois (*Rupicapra rupicapra*)	485
Iberian wolf (*Canis lupus signatus*)	80
Small game	
Thrush (*Turdus* spp.)	6,120,587
European rabbit (*Oryctolagus cuniculus*)	5,628,208
Red-legged partridge (*Alectoris rufa*)	3,803,460
Common quail (*Coturnix coturnix*)	1,287,014
Granada hare (*Lepus granatensis*)	1,202,869
European turtle dove (*Streptopelia turtur*)	840,888
Eurasian woodcock (*Scolopax rusticola*)	75,611

especially in terms of acorns that yield significant nutrition for wildlife in the fall when herbaceous forage is desiccated and of minimal value. Migratory deer in many parts of California descend in the fall from montane environments to lower elevation oak woodlands where they over-winter. Big game species commonly hunted include the native mule deer (*Odocoileus hemionus*, classified into as many as six subspecies) and non-native wild pigs. California quail, mourning dove, wild turkey, pheasant, rabbit, jackrabbit, and squirrels are the small game and upland game commonly hunted in oak woodlands and on adjoining cropland (Figs. 11.3 and 11.4) (Table 11.3).

Fig. 11.1 Game birds: Spain's red-legged partridge (*Alectoris rufa*).

Fig. 11.2 Changes in legislation, including the hunting law of 1970, means that an overwhelming proportion of Spanish woodland properties are posted as some form of reserved-access land (*cotos*). (Photograph by P. F. Starrs)

Fig. 11.3 Game birds: the wild turkey (*Meleagris gallopavo*) in California. (Photograph by L. T. Macaulay)

While waterfowl is hunted on water impoundments or rivers in the oak woodlands of California and Spain, most duck and goose hunting occurs in wetland habitats or flooded agricultural fields, areas outside the focus of this chapter.

Fig. 11.4 Game birds: the California quail (*Callipepla californica*). (Photograph by L. T. Macaulay)

Table 11.3 2004–2008 averaged annual harvest of game species in California (CDFG)

Species	Average harvest
Big game	
Mule deer (*Odocoileus hemionus*)	40,470
Wild boar (*Sus scrofa*)	19,864
Small game	
Dove (*Columbidae* spp.)	1,759,337
Quail (*Callipepla* and *Oreortyx* spp.)	626,970
Farmed ring-necked pheasant (*Phasianus colchicus*)	342,710
Wild ring-necked pheasant (*Phasianus colchicus*)	107,082
Black-tailed jackrabbit (*Lepus californicus*)	63,137
Cottontail rabbit (*Sylvilagus* spp.)	55,977
Western gray squirrel (*Sciurus griseus*)	50,310
Wild turkey (*Meleagris gallopavo*)	26,202

11.1.2 Hunting Seasons

California deer hunting seasons close prior to the breeding season or rut. The seasons open at varying times across the state, with archery-only hunting commencing in August–September, and general gun hunting from September to early November (CDFG 2012b). Wild pigs, a non-native and invasive species in California, are hunted year-round. Bears are occasionally found in California's oak woodlands, and the bear season often coincides with the deer season (Fig. 11.5).

In Spain, the general season for hunting runs from early October to late February, closing just before the onset of spring breeding for most game species. Hunting after February may adversely impact pregnant ungulate females, since they are easily captured by hunting dogs even when not a target of the hunt. Red deer are hunted in the Spanish *montería*—an organized hunt with dogs driving big

Fig. 11.5 Wild pigs harvested in California. (Photograph from the collection of R. Barrett)

game toward waiting hunters—within the general hunting period from early October to mid-February, and by stalking during the rutting season (from September to opening of the general season in October) (Aguayo 1986). One notable exception is the roe deer season, which generally runs from mid-April to the end of July with additional hunting periods in September and October.

11.1.3 Structural Organization of Hunting Operations

In Spain, two main hunting venues exist, the *coto social* (or *coto deportivo*) and the *coto privado* (Barbosa et al. 2004). The coto social is organized by a community and maintained for recreational use. Hunts historically occur on community hunting grounds and are generally oriented towards small game without a profit motive (Chap. 2). In modern times, these clubs may secure the use of a private property, or in some cases, a community actually owns a dehesa where a productive use of the land is hunting. The coto privado involves hunts on private lands oftentimes for profit. Viability and profitability of these properties has increased since 1970 due to four significant changes: (1) landowners can enclose wildlife behind high game fences, which makes wildlife management much easier; (2) there is more interest in big game hunting in Spain; (3) small game is increasingly scarce on community lands due to disease outbreaks that have significantly reduced European rabbit populations; and (4) the Hunting Law of 1970 has made it easier for associations to own an estate, lowered taxation on hunting lands, and allowed landowners to prevent trespassing on marked hunting reserves (López Ontiveros and Verdugo 1991; Barbosa et al. 2004; Martínez Garrido 2009).

Significant areas of public land (most of which is owned by the U.S. Forest Service) in California are open to free hunting without any reservation or membership. Some public lands require reservations or special tags drawn by lottery to hunt. Hunting operations on private lands in California generally fall into two main types: (1) year-long leases, where hunters pay for access to the property year-round with restrictions on game taken, and (2) day hunts, where hunters pay for access to a property for a given number of days with a specified amount of game to be taken. Although there is a wide array of hunting styles in California, there is no significant cultural and historical distinction between the social hunt and private hunting as in Spain; however, there are social and cultural differences between what one researcher deems "sport hunters," "meat hunters," and "ecologistic hunters," with varying priorities and motivations among the types (Kellert 1980). Small game hunting is often practiced by youth or as a secondary quarry for many hunters in California (Shaw 2008).

11.1.4 Trends in Hunting Participation

A feature shared by hunters in California and Spain is their enthusiasm for the rhythms and associations of hunting. Nonetheless, a demographic shift in hunters appears to be underway, with hunting license sales decreasing in California and Spain. As one California journalist reported in 2003, after discussions with Department of Fish and Wildlife legislative analysts, "the growing urban populations in California are 'less supportive of hunting'" (Stienstra 2003). Yet the overall populations of California and of Spain are increasing, if only gradually since 2008, so while the total count of licensed hunters decreases, the percentage of hunters with licenses in the population drops still more (Fig. 11.6). Of late the pace of decline in hunter interest has slowed slightly, with increasing sales of tags to hunt wild pigs and bear. In California, a decreasing overall percentage of hunting license holders tracks with a general decline in the state's most popular game species, the mule deer and black-tailed deer, which are particularly effected by increasing numbers of predators and a decrease in readily available habitat.

Curiously, while urbanized populations may be less familiar with hunting's traditions, schedules, and attractions, there is rising interest in hunting from a new

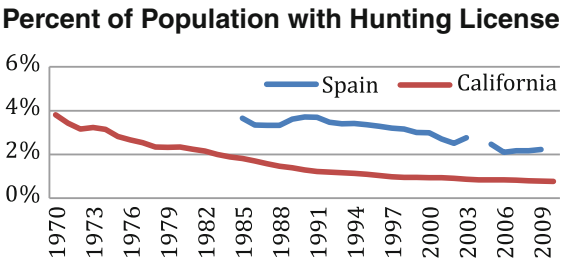

Fig. 11.6 In both Spain and California the percentage of population that hunts is decreasing. (CDFG 2012c; MARM 2012)

generation seeking to reconnect with food sources (Marris 2012). In the U.S., the most recent national survey on hunting participation has revealed an increase in the number of hunters of 9 % from 2006 to 2011, which could be indicative of a renewed desire to learn how to hunt, clean, and cook one's food from sources in the wild (Pollan 2006; Goldstein 2010; Shaw 2011; USDOI and USDOC 2011; Heyser 2012).

11.1.5 Land Ownership

The majority of dehesa habitat in Spain is under private ownership and that is not government-owned. The properties where hunting occurs reflect three distinct histories of land ownership: one in aristocratic proprietorship; another with Church, or ecclesiastical, control of property; and finally, an ownership by village communities of land that is hunted. This history has opened up a variety of ways in which hunters and landowners access and manage game species (Gómez Mendoza 1992; López Ontiveros 1993).

Approximately 50 % of California is public land, and much of that is open to free hunting access. However, more than 80 % of oak woodlands in California are privately owned (CDF-FRAP 2003). Hunter success rates on private holdings are generally much higher than on public lands because private lands generally contain higher quality habitat, food, and water resources and because private landowners can regulate hunting pressure (Scott et al. 2001; CDFG 2012a).

11.2 Brief History of Hunting

11.2.1 Spain

As Upper Paleolithic and Magdalenian cave art bears witness, interest in the taking of game in Spain was widespread even in prehistoric and ancient times. Hunters in more recent years derive from two main types, the first of aristocratic background who traditionally sought game on the properties of friends or relations, and the other residents of towns and of communities owning land suitable for hunting (Chap. 2). Wealthy landowners would hunt big game or small game, maintaining the right to exclude others, and sustaining a privileged land use with the force of law by employing hired gamekeepers or guards. Hunting by rural residents often focused on small game, taken by snare, shotgun, rifle, or net. Historically, these village hunters—almost exclusively male—hunted for recreation and for food.

During the nineteenth and first half of the twentieth century, hunting in Spain was a popular activity, though one restricted in practice. The divide between the wealthy landowning gentry, who hunted socially with friends, and the rural village

Fig. 11.7 From 1940s issues of *Caza y Pesca,* a monthly Spanish sports magazine, came two visions of "hunters" in the Spanish countryside: at *right*, a group of loden-garbed gentry; at *left*, a poacher, whose work has been discovered by horse-mounted Guardia Civil, the Spanish national police force that was especially vigilant in rural areas. (Photographs composited by P.F. Starrs)

residents and poachers who hunted for food or recreation was distinctive and large. This is much-studied for parts of Andalucía, with enduring accounts issuing especially from researchers and historians working in Córdoba (Chap. 2). Hunting and the *montes* of Spain are remarkably linked, in topics laced with political and social significance (Gómez Mendoza and López Ontiveros 2001) (Fig. 11.7).

Beyond historical accounts, there is a vast literature on twentieth-century hunting in Spain that extends even into cinema, and unease about invidious distinctions of class and access are a feature of many narratives (Almazán 1934). While residents of villages might hunt community properties, some hunted game illegally, trespassing onto the private land of others. These hunters were *furtivos,* whose actions were, as the name suggests, furtive in their pursuits. Poaching was not only an act of villager disregard and disdain for upper class norms, it was an act of defiance toward any ruling authority, including the long-lived Franco government, as depicted in literature and films such as Carlos Saura's *La caza* (1965), Borau's *Furtivos* (1975), Berlanga's *La escopeta nacional* (1977), and Brasó's *El mundo de Juan Lobón* (1989; TV miniseries). In latter-day Spain, however, fenced properties enclose valuable game animals and exclude rural hunters who once regarded taking game by poaching as an adventurous sport and a birthright. Little wonder that many properties now managed principally for game hire gamekeepers who reside on the property to protect against illicit access.

Well into the 1970s, two distinct groups participated in a montería. The shooters were one group and the *rehaleros* or *podenqueros,* dog fanciers and handlers, made up the other. In today's commercially-organized hunts, however, the rehaleros are itinerant professionals hired for wages by hunt organizers—a marked departure from older montería traditions, and a change spoken of with regret by long-time "monteros." Hunting dog owners until the last 30 years or so were prized and fully-fledged members of the hunting party. Traditionally, demonstrating the prowess of a *rehala* (the dog pack) earned the rehalero prestige at least equal to any vested in the successful shooter (Gibert Buch 1975).

11.2.2 California

California's history of hunting exploitation began at the arrival of Native Americans approximately 14,000 years ago, with early arrivals practicing subsistence hunting, which continued among some Native American groups into the early 1900s. While Spanish missions marked the first European settlements in California, their impact on wildlife resources was relatively minor compared to the influx of immigrants during the Gold Rush of 1849, when the population ballooned from 15,000 non-Native Americans to hundreds of thousands (Starr and Orsi 2000).

The immense wildlife resources present at the time of European arrival made it seem impossible that hunting could be a threat to their sustainability, but with settlers increasing in numbers, market hunting, and improved firearm technology many species began to decline and reach extinction levels. Wildlife were harvested as a source of food without any limit or regulation (CDFG 2002). Grizzly bears and wolves were extirpated from California in 1922 and 1924, respectively, and once-immense numbers of tule elk, a California subspecies of *Cervus canadensis*, were reduced to a herd of 28 animals protected by a single rancher near Bakersfield (McCullough et al. 1996). Populations of many wildlife species declined precipitously in the late 1800s, some due to overhunting, others because of habitat loss and human encroachment. Federal and state regulations were enacted in the early 1900s to create hunting seasons and bag limits, with the support of sportsmen hunters, and against the protests of some market hunters. These regulations have led to the recovery of many game species and are the foundation of the current system of state regulation of wildlife in North America—known as the North American Model of Wildlife Conservation (Tober 1981; Geist 1988) (Fig. 11.8).

Fig. 11.8 Animals taken, whether in Spain and California, are always an object of hunter pride, as here at a property in California. (Photograph from the collection of L.T. Macaulay)

Table 11.4 Wildlife practices in Spain and California

Wildlife practice	California	Spain
Shrub management	X	X
Predator control	X	X
Food planting	X	X
Wildlife fencing (2 m+)		X
Sale of meat from hunting		X
Supplemental feeding		X
Restocking and transporting native big game		X
Both sex harvest on native deer		X
Landowners set bag limit for big game		X
Hunting over bait		X
Hunting at night		X
Driving wildlife with dogs		X

X denotes commonly and legally practiced

11.3 Economics of Hunting

11.3.1 Governance, Property Rights, and Wildlife Management

Although a number of Spanish and Mexican legal principles were borrowed in the early state history of California, divergent legal histories governing wildlife since colonial times have resulted in distinct property rights over wildlife that have led

to readily apparent differences in the wildlife management regimes of each place (Table 11.4). In Spain, landowners have much greater ability to manipulate and control the movement and management of wildlife, while in California regulations prohibit landowners from fencing, relocating, and feeding wildlife. If wildlife is nominally considered *res nullius*[1] in both locations, Spanish landowners have much greater rights to control and prevent the escape of game animals, capturing *de facto* ownership, even if not *de jure* ownership. Although game species are managed in the public interest by the state and federal government in California, private landowners do control access to property where the game resides, and can charge a fee for hunters to hunt on their property.

In the United States there have been three major historical influences on the development of wildlife governance (Huffman and Wallace 2011). The first was rebellion against oppressive English policies, including the restriction of hunting to those with sufficient wealth or status. The second was the need of colonists to hunt for food and clothing. The third was the belief that given the huge expanse of America and abundant wildlife, restrictions on hunting would hinder economic growth. Eventually, laws and policies developed granting states and the federal government some aspects of managing wildlife in the public interest. There remains a strong sentiment among hunters in the United States that hunting is a time to experience nature, share adventure with friends and family, and to acquire food, and that it should be open to all regardless of wealth or status (IAFWA 2002). There is a tension between this widespread view of the role of hunting and the practice of trophy hunting for high fees, which is often seen as the domain of wealthier individuals. While there is historic opposition to paying for access to hunting opportunities, in California the deer herd has been in decline for the past several decades and the success rate of public land hunting has dropped significantly. As a result, individuals may stop hunting, or become willing to pay for access to higher quality hunting opportunities that occur on private lands.

In many rural areas, it was once and to some extent still is a common courtesy to allow friends and community members, or even polite visitors, to hunt on one's land for free or in exchange for other favors. One study found that even in 2004 nearly two-thirds of ranches on oak woodlands had hunting on their property, but fewer than ten percent charged fees for hunting access (Huntsinger et al. 1997).

The most visible manifestation of the differences between the two countries in property rights over wildlife is the enclosure of game species behind $\sim$2 m high game-fencing (Spanish: *malla* or *valla cinegética*), a common practice in Spain but illegal in California.

An extensive literature discusses the intricacies of property rights of fugitive resources, which Ostrom (1990) terms "common-pool resources" (Ostrom 1990; Lueck 1995). An essential quandary for these resources is that they are often

[1] *Res nullius* is a Latin term borrowed from Roman law. It holds that when an object (which conspicuously includes wildlife) is unowned by any particular person or entity it is ownerless property and free to be owned by anyone. When such an object is found, however, it may in some circumstances belong to the first person who takes it (as in beachcombing).

Fig. 11.9 The preparation, cooking and consumption of meat after a hunt in California is an important part of the California hunting experience: here a wild boar is barbecued. (Photograph from the collection of R. Barrett)

jointly produced by more than one person's property, yet these resources, when harvested, are generally not jointly used. For example, deer may live on, reproduce on, and utilize the habitat on several properties that are owned by different individuals, but when a deer is hunted and harvested, it is usually harvested and consumed by one person and is no longer available for someone else to harvest.

The lack of game-fencing in California and in most areas of Spain means game animals are a fugitive resource because they can easily move off a landowner's property and are a type of common-pool resource. Organizing the harvest of common-pool resources is "usually an uncertain and complex undertaking" and if the right conditions are not present, many of these resources may be utilized in a way that reduces the productivity and quality of the resource (Ostrom 1990). The limitations of institutional management and challenges to cooperative efforts such as the presence of free riders can result in difficulties in managing the fugitive resource. For example, male deer in many areas of California are often harvested at two years of age—the first opportunity that they may be legally harvested—due to the possibility that one's neighbor may harvest it first. As such, deer in California and in unfenced areas of Spain often exhibit an age structure that is skewed to younger males and very low proportion of male animals, which can lead to diminished overall harvest and biological problems (Ostrom 1990; Clark 2010; McCullough 2001; CDFG 2002; Milner et al. 2007; Pérez-Gonzalez and Carranza 2009). Game-fencing in Spain, while a costly investment, allows those landowners in Spain to control the fugitive wildlife resource and thereby avoid having to cooperate with others in management and harvest the resource—though not without creating distinct management problems and biological quandaries (Díaz et al. 2009).

Other important property rights differences between California and Spain is the ability of Spanish landowners to provide supplemental feed to wildlife, set bag limits on big game, and sell live game animals to other landowners. Feeding allows landowners to maintain larger game populations, and owners of Spanish hunting dehesa properties can retain meat from the animals taken in a hunt, which yields an additional income source. The situation is significantly different in California, where wildlife may not be fed, sold (dead or alive), or transported, and bag limits are largely state-controlled. While hunters may self-consume or donate meat from the hunt, they may not sell it on the open market. Of note, California law requires possession of the meat, prohibiting hunters from allowing an animal's meat to go "needlessly to waste" (CFGC 2012) (Fig. 11.9).

11.3.2 Commercialization

Hunting in California is far less commercialized than in Spain due to four main factors: (1) cultural opposition to charging fees for hunting, (2) fewer hunters in California as a percentage of the population (Fig. 11.6); (3) the extensive public lands that are open to free hunting, and (4) the vastly different regulatory structures and property rights regimes that govern wildlife. The more state-oriented property rights regime in California and the rest of the U.S. developed in large part as a reaction to overexploitation of wildlife by profit-motivated market hunting (Stine 1980; Tober 1981). As such, there is deep-seated suspicion and long-standing opposition to programs that would allow landowners to profit from wildlife (Fitzhugh 1989).

Greater freedoms to manipulate and control wildlife in Spain makes for a more intensively managed and significantly commercialized hunting industry. A significant shift has occurred in the role of hunting in Spain from 1970 to today. Before 1970, hunting was in the main a leisure activity for socializing, and lacked an overt focus on generating cash income, whether in the realm of large landholders or village hunting associations of small means. The Hunting Law of 1970 modernized the previous Hunting Law from 1902, and made possible the expansion of commercialized hunting and intensified management as discussed above (Structural Organization of Hunting Operations). Since the incorporation of the law in 1970, hunting increasingly is managed as a for-profit commercialized business, because hunting resource rent can surpass returns from grazing or field crops (López Ontiveros and Verdugo 1991; Vargas et al. 1995; Martínez Garrido 2009). While this increases motivations to maintain better habitat for game species, increased fencing and feeding in Spain has yielded high ungulate densities on hunting properties and can lead to deleterious environmental effects as discussed below (Olea and San Miguel-Ayanz 2006; Díaz et al. 2009).

California has developed a pair of programs to help landowners earn income from recreational hunting of wildlife on their land in exchange for habitat improvement or expanded public access. The Private Lands Management program

in California has a contentious history but mimics a Texas program that provides landowners greater harvest flexibility over game species in exchange for improving habitat. Landowners must submit a lengthy wildlife management plan to the California Department of Fish and Wildlife and must obey requirements such as informing neighbors of their intent to enroll in the program. The SHARE program provides private landowners with a liability waiver and a cash payment in exchange for allowing public access to a property for hunting or other forms of outdoor recreation (CDFG 2012d).

11.3.3 Costs, Revenue, and Net Profit

Costs and revenues are known to be highly variable between woodland properties and from year to year (Loomis and Fitzhugh 1989; Peiró and Seva 1996). This chapter draws on data from a 1987 survey of 55 ranches with hunting in California and from three case studies in Spain on properties of 658, 4000, and 7000 ha (Loomis and Fitzhugh 1989; Campos et al. 1995; Lenzano and Zamora 1999). Cost and revenue data for hunting properties is relatively limited, but new economic research on hunting is underway in each location to better understand profitability in this industry (Macaulay in prep, RECAMAN in Chap. 13). In general the economic activity, in terms of average costs, revenues, and profit per hectare, is several times greater in Spain than in California. All cost and revenue figures from this section have been converted to 2011 US dollars.

11.3.3.1 Costs

Tables 11.5 and 11.6 illustrate a sample of the differences in costs between a case study of a fenced Spanish hunting property and an average of a subset of 41 ranches in California with >10 % oak cover. These tables should only be compared generally and with caution as different accounting methods were used.

Personnel wages and vegetation management expenses account for a significant portion of total costs on fenced Spanish properties, while administrative and infrastructure costs are significantly higher in California. Economic data from unfenced properties in Spain is unavailable, but would presumably be considerably lower, especially in personnel costs, as there is less need for hired hands to census and cull the red deer population and less need of a guard to protect game animals, as there are fewer valuable trophies present (Campos et al. 1995) (Tables 11.5 and 11.6).

11.3.3.2 Revenue

Lenzano and Zamora (1999) estimate income from the sale of 76 positions at about $700 per person on an unfenced montería hunt, yielding $53,200 in revenue for a

Table 11.5 Costs of managing a hunting property in Spain. The Lenzano and Zamora case study of a 658 ha dehesa is one of the few in Spain that includes specific costs of operating a hunting estate, summarized in the table below; dollars normalized to 2011 (Lenzano and Zamora 1999; BLS 2012)

Costs	2011 dollars/ha	Percent of total (%)
Guard	26.5	50.3
Dog packs—Rehalas	6.5	12.4
Bidders	1.4	2.8
Food	1.4	2.6
Horses/Mules/Oxen	1.3	2.5
Vehicles	1.0	1.9
Veterinarian	0.9	1.7
Guides	0.6	1.1
Personnel cost subtotal	39.6	75.3
Brush clearing	8.3	15.7
Pruning trees	0.4	0.7
Enhancing oak stands	0.2	0.3
Vegetation management cost subtotal	8.8	16.7
Housing (each year)	1.4	2.8
Roads	0.8	1.4
Ponds	0.5	1.0
Water wells (each year)	0.3	0.5
Fences (each year)	0.2	0.3
Infrastructure costs subtotal	3.2	6.1
Taxes on Luxuries	0.6	1.1
Renewal of Registration	0.4	0.8
Montería Hunting Permit	0.0	0.1
Administrative costs subtotal	1.0	1.9
Total Costs/ha	52.6	100.0

red deer montería. Added income of $5,000 can come from on-site wild boar, with $5,000 from the sale of venison and boar meat after the hunt (Lenzano and Zamora 1999). This leads to a total revenue stream of $63,200 resulting in approximately $96/ha in revenue (income before costs). The value of a montería position can vary from $500 to $6,000, with most montería positions costing $800–1,200 (Campos et al. 1995). The sale of live deer for restocking dehesa properties can offer an additional source of income. If the value of live animals exceeds the meat value, landowners may find it more profitable to capture and sell live animals instead of culling their deer herd (Vargas et al. 1995).

In California, research has shown that hunter success rate, percentage of trophies, and the wealth of hunting participants added to revenues (Loomis and Fitzhugh 1989). Additional analysis of the data shows that proportion of a ranch with oak habitat significantly improved revenue in California hunting operations. Ranches in the study on average earned $19.54/ha, while those with 10 % or more

Table 11.6 Average costs of 41 Ranches in California with hunting and ≥ 10 % oak woodland cover [adapted from data from (Loomis and Fitzhugh 1989; Standiford 1989)]

Cost	2011 dollars/ha (BLS)	Percent of total (%)
Non-professional wages: cooks, operators, etc.	1.5	22.7
Guides	0.7	9.7
Accountants	0.1	1.9
Attorney and consultants	0.1	1.5
Personnel wages subtotal	2.4	35.8
Vegetation management	0.1	2.0
Vegetation management cost subtotal	0.1	2.0
Vehicles: maintenance	0.3	4.5
Vehicles: depreciation	0.3	4.5
Irrigation water	0.2	2.9
Improvements (roads fences and water): maintenance	0.2	2.6
Phone	0.2	2.4
Road construction	0.1	2.0
Ranch equipment: depreciation	0.1	1.8
Other annual costs	0.1	1.7
Ranch equipment: maintenance	0.1	1.2
Supplemental feeding	0.1	1.0
Improvements (roads fences and water): depreciation	0.1	1.0
Predator control	0.0	0.7
Other costs (gas, electric, structure maintenance)	0.4	5.3
Infrastructure/Maintenance costs subtotal	2.3	32.3
Liability insurance	1.0	15.0
Lease of hunting rights on other lands	0.5	7.0
Advertising	0.5	6.9
License, permit, and legal fees	0.1	1.7
Administrative costs subtotal	2.1	30.5
Total costs	6.8	100

oak woodland cover received $21.09, and those with 15 % cover or more earned $22.47/ha on average (calculated from data in Standiford 1989).

11.3.3.3 Net Profit

A significant issue to consider is how costs factor into final profitability calculations. Some costs, as with water provisioning, are undertaken for livestock, yet benefit wildlife. Comparisons of net profit among hunting operations is difficult. While accounting differences make a detailed comparison impossible, the

profitability of Spanish dehesa hunting properties appears significantly higher than an equivalent California site.

Spanish studies show net profit (owner hunting net operating margin) of $23.80–72.47/ha (Campos Palacín et al. 2001), while other studies tally net losses when costs such as capital depreciation are incorporated. Lenzano and Zamora (1999) suggested that by using a third party intermediary a landowner could receive a return of $6/ha, but under self-management, profitability increased to $37/ha in an unfenced property, with increases up to $42–63/ha for fenced properties while amortizing fencing investments. Net profit in California is estimated at $5.68–7.31/ha. There is significant variation in profitability levels, with 30 out of 41 ranches operating profitably, and 11 ranches taking losses (calculated from data in Standiford 1989).

While data suggests Spanish dehesas may earn 10 times as much from hunting than California ranches, these figures should be compared with caution given differences in accounting for costs and revenues (Standiford and Howitt 1993).

11.4 Wildlife Management

Wildlife management can generally be divided into two major types:

1. Top-down population regulation: actions taken by humans that directly impact the movement and population composition of game species and predators, such as harvest, culling, fencing, predator control and restocking; and
2. Bottom-up management practices: actions taken by humans that influence or improve resources needed by wildlife. These are generally improvements to food, cover, and water resources for the benefit of wildlife species.

11.4.1 Top-Down Population Regulation: Harvest, Fencing, Restocking, and Predator Control

11.4.1.1 Harvest Methods and Regulations

A major component of any wildlife management program is managing the harvest of animals by hunting. Harvest rates are impacted by the method of hunting, bag limits, and the age and sex of animals harvested. Distinct regulations in Spain and California govern each of these aspects of hunting. California's hunting methods are far more restrictive (Table 11.7).

Table 11.7 Hunting methods in Spain and California

Hunting method	Spain	California
Big game		
Spot and stalk, i.e. rececho	X	X
Stand hunting, i.e. aguardo, espera	X	X
Montería	X	
Gancho	X	
Hunting over bait	X	
Hunting at night	X	
Small game		
Opportunistic, i.e. la caza al salto	X	X
Walking lines, i.e. ojeo	X	X
Driven shooting	X	
Live decoy hunting	X	
Use of sighthounds (galgos)	X	

Big Game

Common to Spain and California are the spot and stalk (*rececho*) and stand-hunting methods. In spot and stalk hunting, hunters use binoculars to spot game animals from a vantage point where a large area of terrain can be surveyed. They then stalk the animal to get close enough to take a shot. In Spain, rececho is the most expensive hunting method for a hunter to undertake, and is usually used to harvest a single trophy animal. In California it is one of the primary ways to hunt, and generally costs no more than hunting from a blind or stand. Stand hunting involves placing hunters in a concealed or elevated position (the stand) where they wait for an animal to approach. Stand hunting (*aguardo* or *espera*) is often done over bait in Spain, may be performed at night, and is generally used for selective wild boar hunting. In California, stand hunting is used by hunters who wait in stations above locations frequented by game, or they may wait over grain fields, since hunting over bait is illegal.

Unique to Spain is the montería, where 50–75 hunters take up shooting positions in fixed locations on a property for a single day of the year. The *rehaleros* or beaters move into the lower reaches of the property with one or more *rehalas* or *recovas*, a group of 20–25 hounds, and chase animals from hiding in the often-dense brush and into the open where hunters shoot the game, often on the move. The gancho is a small-scale montería, usually focused on wild boar. In California dogs can be used to hunt non-native wild pigs, but the method usually involves following dogs to the game rather than dogs driving animals to hunters waiting in designated locations.

Small Game

Small game methods of hunting are generally similar in Spain and California, although Spanish hunters may use packs of dogs, as in big game hunting, to drive

Fig. 11.10 Dogs are an essential element in the drive hunt, or montería, of Spain. (Photograph by P. F. Starrs)

Fig. 11.11 Dogs await transport and release with eager anticipation before a hunt in the Sierra Morena. (Photograph by L. T. Macaulay)

small game toward hunters (Vargas et al. 2006). With rabbits, hunters can utilize methods of "la caza al salto," which roughly translates as "hunting on the jump," where a solitary hunter with or without dogs walks an area and flushes rabbits. Additionally, rabbit hunting can be performed with sighthounds that rely on vision and speed to hunt. Spanish hunters usually use the *galgo*, a breed similar in appearance to the greyhound (Figs. 11.10 (at left) and 11.11).

California considers rabbits, jackrabbits, and squirrels as small game, and generally classifies game birds including quail, dove, and wild turkey as upland game. In California, small game mammal hunting is practiced with and without dogs, but lacks the widespread popularity and cultural significance of hunting rabbits and hares in Spain. Blogger Hank Shaw describes a prevalent attitude toward jackrabbits: "Most "normal" hunters wouldn't waste a shell on hares…. [T]hese folks view jackrabbits as beneath them" (Shaw 2008). Small game mammal hunting is generally practiced by youth or opportunistically as a secondary quarry, when hunting for other game.

Upland game bird hunting of quail and turkey generates more hunter interest than small mammal hunting (Table 11.3). Live decoys are illegal in upland game bird hunting in California, although artificial decoys are utilized, particularly for turkey hunting. Quail in California are generally hunted by individuals or small groups of hunters. The practice of walking lines is less productive in California quail hunting, given the prey's preference for thicker habitat cover and the pattern in which they flush. Hunters will use dogs to locate and retrieve birds, but rarely to drive the animals. Smaller bag limits for wild turkey result in lower harvest numbers, which belie the significant interest in wild turkey hunting in California, particularly during the spring mating season, when male turkeys are lured within shotgun range by mimicking the call of a female hen.

Bag Limits and Antlerless Harvest

California's Department of Fish and Wildlife generally imposes a bag limit of two deer, and various limits on small game. Because wild pigs are nonnative in California and have high fecundity, there is neither a closed season or bag limit. In Spain, each regional government, or autonomía, sets its hunting regulations. Generally, there is no limit on the big game species, but small game species have various limits.

While Spanish landowners generally control the age and sex of harvest on big game on their properties, the California Department of Fish and Wildlife retains control over bag limits and the age and sex of harvests. Due to political controversy dating back to the state's first antlerless harvest in 1956, regulatory authorities prohibit female and juvenile male harvest of deer in most parts of the state (Fitzhugh 1989). This has led to high hunting pressure on male deer and sex ratios that, while variable, are oftentimes far less than 0.5 bucks-to-doe ratio, with some estimates as low as 0.05 bucks per doe (CDFG 2012e). Despite research that shows density-dependent responses in California deer and increased buck harvests as a result of removing female deer, political opposition persists, and today the California Department of Fish and Wildlife (prior to 2013, the California Department of Fish and Game, or CDFG) describes California as having the

"dubious distinction" of being the only state in the United States where doe hunts cannot be carried out even when such hunts are biologically justified (McCullough 2001; CDFG 2002).

A similar tradition of not harvesting female red deer historically existed in Spain. This was rooted in a belief that hunting females would drive populations to local extinction, which was occurring just after the Civil War in the late 1930s and 1940s. However, after the hunting law in 1970 with populations increasing for most Spanish big game species, management policies embraced the need to regulate population size and the ratio of males to females to improve game animal condition, increase the value of trophies, and reduce the impact on vegetation and the risk of traffic collisions (Carranza 2010).

11.4.1.2 Fencing

The most significant wildlife management consideration on Spanish hunting lands is whether a property is fenced. On unfenced (open) properties, traditional agricultural practices and livestock are usually the main productive activities and big game hunting is of secondary importance (Vargas et al. 1995). Given a propensity of wildlife to stray onto adjacent properties, unfenced lands generally have low intensity management, since only very large properties or those in cooperative agreements with neighbors can reap the benefits of targeted harvest and habitat improvement strategies. These smaller unfenced properties tend to manage for a greater number of wildlife than for high quality trophies. Unfenced hunting lands have been documented to have a 0.25 male-to-female sex ratio, and an age structure where over 45 % of the males are juveniles (Pérez-González and Carranza 2009; Torres-Porras et al. 2009).

Fenced properties require significantly different management practices than open properties because the wildlife cannot escape the property, allowing managers to more accurately census the population of game species and control the harvest. This includes knowing the sex ratio and age structure of the population, which allows a landowner to practice much more effective population management through selective hunting, allowing for more stags to mature to trophy quality and increasing the overall number of valuable males in the population.

Although fenced properties may entail significant benefits for a landowner in terms of quality and quantity of trophies, and can result in a wildlife population with more natural characteristics and age structure, their management requires resources to maintain healthy wildlife populations and habitats. This is particularly true in the Spanish Mediterranean ecosystem known for high variability in rainfall and in resource production. A landowner must maintain the fence itself, ensure a water supply within the fence, and provide adequate forage for the animals within the property to prevent excessive grazing and habitat degradation in times of drought. Many fenced properties cull to reduce population size, particularly of females and of smaller, non-trophy males to counteract selective pressures of trophy hunting for large males (Martínez et al. 2005; Mysterud and Bischof 2010).

Fig. 11.12 Game fences represent a significant act of landowner control over a dehesa property. Fences allow game species containment and increased profits by intensified management. The problems associated with fenced properties made this particularly controversial when game fences first arrived, but the fences are now very common. (Photograph by P. F. Starrs)

Dehesa properties may also need to provide supplemental summer feed, especially in times of drought, to maintain a wildlife population that cannot migrate off the property to find food. Furthermore, gamekeepers and guards are required to police a property and prevent poaching of valuable trophy animals.

As with other aspects of Spanish hunting management, fencing regulations are controlled by regional governments. Most set a minimum size and enforce permeability restrictions on fencing. In southwestern Spain a big game hunting operation has a minimum area requirement of 700 ha—also the minimum size for a fenced estate. The tendency, however, is to enclose larger areas. Experts in Andalucía recommend that properties smaller than 2,000 ha obtain a certificate of quality as a prerequisite for fencing (Carranza and Vargas 2007; AAMAA 2008). Fences must have regular openings to allow the movement of non-game species such as the protected Iberian lynx (*Lynx pardina*). Fences retain deer species better than wild boar, which easily burrow under a fence. Enclosures for wild boar (*cercones*) are in general prohibited for their association with unnatural, high-density management, which is linked to an increase of diseases. However, these do occur and their numbers are increasing (Fig. 11.12).

11.4.1.3 Restocking and Farmed Game Species

Restocking and farming of game species plays a major role in both small and big game hunting in Spain (Barbosa et al. 2004), but in California the practice is utilized almost exclusively with exotic game birds, notably the ring-necked pheasant. In Spain, red deer, red-legged partridges, rabbits, roe deer and wild boar may be restocked, with red-legged partridges the most common among farmed game species. Vargas et al. (2006) estimated that one-third of red-legged partridges harvested in Andalucía were farmed birds, usually released into the field prior to a hunt. For other species, restocking is less common, but can involve animals from game farms, or from live captures in other areas, which are generally used to re-establish or reinforce natural populations.

For stocking game species in Spain, a permit is needed to move game animals and the approval depends on regional policy. Generally, only native species or subspecies can be transported, although enforcement of this regulation varies. There is no current regulation against the release of animals from game farms, provided that they belong to native varieties of the region where they are going to be released, although effective enforcement is not common. There is a growing tendency toward limiting import, export, transfer, or release of live game.

In California, three-quarters of exotic ring-necked pheasant harvested are from stocked game bird farms (CDFG). For native big game species, restocking is illegal unless undertaken by California Department of Fish and Wildlife to re-establish game species (CFGC). The state does license a number of game bird farms that exclusively utilize farmed birds.

11.4.1.4 Predator Control

California permits predator control on a number of species. Steel-jaw leg traps and poison have been banned, but box traps, padded leg traps, and snares are legal subject to their being checked every 24 h. Mountain lions (*Puma concolor*) are legally protected by a statewide voter referendum in 1979, and predator control of these populations is illegal, except when lions are killed for public safety concerns or with depredation permits granted by the state. Many landowners and hunters blame this law for a decline in deer populations in California, although research suggests that a combination of factors, including habitat change, is affecting deer populations (Longhurst et al. 1976; Kucera and Mayer 1999). Bobcats (*Lynx rufus*) can be harvested with the purchase of a special tag and a hunting license. There is no legal season on red foxes (*Vulpes vulpes*). Gray foxes (*Urocyon cinereoargenteus*) are considered a furbearer species with a separate season (Fig. 11.13).

In Spain, landowners practice predator control most intensively for predators of small game such as the red fox and the common magpie (*Pica pica*). While there is intensive effort to control red fox populations, studies have found that red fox populations are rarely controlled by these measures, and that oftentimes other non-target predator species may be most greatly impacted (Virgós and Travaini 2005).

Fig. 11.13 Not all hunters are older, or male. This wild boar eventually gained the young huntress an award for taking a silver medal specimen, in a hunt north of Córdoba. It was not her first hunt. (Photograph by P. F. Starrs)

The Iberian wolf (*Canis lupus signatus*) is the only predator that can significantly impact red deer populations. Wolf populations are increasing in central and northern Spain, while in southern Spain they appear to be declining. In Extremadura, wolves disappeared in the early 1990s (Rico et al. 2000), and in Andalucía there is only a small breeding population in the Sierra Morena. Authors describe an antagonistic relationship of rural landowners with wolves and some illegal killing may occur, but disease and traffic fatalities likely account for more deaths than illegal hunting or predator control (Rico et al. 2000). Ultimately, the wolf's range is so limited today that wolves are rarely encountered on dehesas (Blanco and Cortés 2002).

11.4.2 Bottom-Up Practices: Shrub Management, Food Plots, Supplemental Feed, and Water

In California and Spain, landowners practice a variety of habitat management actions to improve the food, cover and water needs for game species, which we will refer to as bottom-up management practices. In both California and Spanish oak woodlands this generally involves clearing understory brush, planting food plots, and providing water sources. In Spain, supplemental feeding is common (Fig. 11.14).

Fig. 11.14 Much of the dehesa is given to occupation by brush, if not regularly cleared of its aromatic understory vegetation. Sometimes, however, to give access to hunters, strips (or *manchas*) will be cut into the understory, as in this aerial photograph near Hornachuelos, Córdoba. Oaks were carefully left behind, in keeping with legal strictures. (Photograph by P. F. Starrs)

11.4.2.1 Shrub Management

While the level of shrub, or brush, presence and growth in a given area is dependent on a multitude of factors such as grazing, soil characteristics, topography, fire history, and climate, many landowners will clear brush to improve herbaceous production or to stimulate fresh and more palatable brush growth. While some brush species provide important cover and forage for ungulates and other wildlife, others provide little nutritional value for game species and can reduce the overall forage production for game and livestock. California deer prefer foraging on brush during the spring when new growth appears (Evans et al. 1976). Palatable species include manzanita (*Arctostaphylos* spp.), chamise (*Adenostoma fasciculatum),* ceanothus (*Ceanothus* spp.), and oaks (*Quercus* spp.*)* (Sampson 1963). A less palatable species rarely eaten by deer in California is coyote brush (*Baccharis* spp.). Palatable brush species in Spain include species of phyllirea (*Phyllirea* spp.*)*, madrone (*Arbutus* spp.) and mytle (*Myrtus* spp.*)*, while less palatable species include rockrose (*Cistus* spp.*)*, heather (*Erica* spp.*)*, and mastic (*Pistacia lentiscus)* (Rodríguez Berrocal 1993; Bugalho and Milne 2003). Many of these brush species are highly resilient and persistent in oak woodlands, and often return at various time intervals after clearing. Rockrose, *Jara pringosa* (*Cistus ladanifer*), will return aggressively 5–8 years after it is cleared. Even brush species that provide important forage for wildlife grow into tall thickets beyond the reach

of deer, so some managers clear brush to encourage herbaceous production and new brush growth (Sampson 1963). After clearing, California landowners may retain brush piles as habitat, in particular for quail and a variety of other game and nongame wildlife (Gorenzel et al. 1995). In Spain, brush piles may shelter partridges and rabbits, but creating brush piles is not a widespread practice.

In California, ranchers will sometimes use tracked vehicles to drag a large chain with 60-pound links across brush areas to remove brush and enhance habitat for deer. Brush-clearing costs can be substantial. One study in Andalucía found that 17 % of expenses on a hunting property were devoted to clearing brush (Lenzano and Zamora 1999), while marginal expenses were devoted to pruning and enhancing oak cover. Discing every 4–6 years is the most commonly used practice to limit brush encroachment with hand-grubbing of brush and grazing utilized to reduce the frequency of follow-up discing treatments (Huntsinger et al. 1991).

Traditional management of the dehesa involves clearing all brush species, leaving older oaks interspersed with herbaceous vegetation. While this improves livestock feed and some agricultural returns, recent research suggests that maintaining a mosaic of brush species in dehesa habitat is ideal for game species (Carranza 2010). Leaving a mosaic of brush in the dehesa contributes to natural regeneration of oak trees (Chaps. 5, 8), adds to biodiversity and provides an increasingly important component of the diet of big game species during the summer drought period (Bugalho and Milne 2003; Plieninger et al. 2003; Díaz 2009; Carranza 2010).

While controlled burning can produce similar benefits, it is rarely used in Spain because escaped fires could harm valuable cork oak bark, and because arson historically was a means of expressing dissent with political authority by vandalizing the property of landowners who fence land (Huntsinger et al. 1991). In California prescribed burns are made difficult by air pollution regulations, which limit the days that a rancher can conduct a burn, and it is logistically difficult to coordinate fire-fighting personnel on short notice to reduce the liability risk of the fire escaping a property.

11.4.2.2 Food Plots

Ranchers in both Spain and California plant improved pastures for wildlife. In some places in California, this includes planting fields of barley or other grains to attract wild pigs. In Spain, land managers will sometimes sow fields to supplement the dietary needs of wildlife on the property, especially in closed or fenced properties.

11.4.2.3 Supplemental Feeding

Direct feeding of wildlife is generally illegal in California, although difficult to enforce. Several decades ago in Spain, supplemental feeding was a practice seen as

beneficial to game and wildlife. Today, ecological knowledge and management policy generally discourages interfering with natural processes, although feeding threatened species is often justified and practiced. Recent decreases in population sizes of rabbits, for example, has resulted in supplementary feeding, although feeding to promote concentration of animals for hunting purposes is discouraged. For big game, supplementary food and making salt available is only allowed during extreme drought months in late summer. Many private land managers nonetheless provide food without control by authorities. For example, a wildlife study in Spain describes 23 t of feed being placed out for pig hunting on a 920 ha property (Braga et al. 2010).

11.4.2.4 Water Provisioning

Spanish and California landowners provide wildlife with supplemental water sources. While this historically was to serve livestock, wildlife species benefit. Water sources can range from stock ponds that collect and store surface water runoff to troughs that are filled with groundwater pumped from aquifers. Ranchers in California equip "wildlife friendly" water troughs with ramps to allow the escape of birds, bats, and other animals that may fall into the trough. Water troughs may be inset at near ground level for ease of access of game species. Ranchers in drier areas of California's oak woodlands may construct "guzzlers" designed to provide water for small or big game species (Bleich et al. 2005). In Spain, the most common and traditional practice is to build stock ponds that fill with water pumped from a shallow aquifer or from surface runoff. These are designed to maintain water storage until the end of the summer dry period.

11.5 Environmental Effects

There are many positive environmental effects from management for hunting. Most notably, wildlife habitat is conserved in a relatively undisturbed state, especially when compared to conversion of oak woodlands to intensive agriculture or residential development. Because habitat loss is the greatest threat to biodiversity worldwide, this conservation of open areas provides critical habitat for many species in biodiversity hotspots (Brooks et al. 2002). Standiford and Howitt (1992, 1993) have demonstrated that incorporation of hunting revenue provides an incentive to retain oaks on woodland properties. The economic return from hunting ventures reduces the economic incentive to use the oak woodlands in less sustainable ways, resulting in greater habitat conservation and increased provisioning of ecosystem services including the following:

- Habitat conservation
- Reduce opportunity cost for habitat conservation

Table 11.8 A generalized overview of the complex mix of environmental effects of wildlife management actions

Environmental Effect	Wildlife Management Action
Animal Density	Fencing
Overgrazing and Vegetation Impacts	Feeding
Disease Impacts	Game Farming/Translocations/Harvest
Fragmentation	Fencing
Genetic Impacts	Fencing
Domestication	Feeding
Changed mating behaviors	Harvest
Hybridization	Game Farming/Translocations
Inbreeding	
Genetic drift	
Artificial selection and breeding	
Loss of local genetic adaptations by introgression	
Population Structure	Harvest
Age structure	
Sex ratios	
Altered dispersal patterns	
Erosion and water quality	Fencing
	Feeding
	Brush management
Invasive species	Brush management
	Discing
	Food plots
	Game farming/Translocations
Impacts on protected or non-target species	Predator control

- Nutrient cycling
- Provisioning of food (game, livestock, crops)
- Water filtration
- Air filtration
- Carbon sequestration
- Aesthetic value
- Recreational experiences
- Cultural significance
- Spiritual inspiration

Management actions for hunting have particular impacts on the environment, and our focus in this section will evaluate those effects. The impacts can be described by two mechanisms: (1) the effects of people on an environment through wildlife management actions, and (2) the effects of game animals on their habitat, which is largely determined by the species present and animal density. These are inextricably linked and will be discussed in an integrated way.

A brief and generalized overview of environmental impacts of management actions is classed by management action and environmental effect in Table 11.8.

Much of the discussion will focus on environmental effects in Spain due to the greater range of wildlife management practices legally available.

11.5.1 Animal Density: Overgrazing and Disease/Parasite Concerns

Management actions of fencing, feeding, game farming/restocking, under-harvest and excessive predator control can lead to high animal densities and increased risks of vegetation degradation and disease outbreak. Overgrazing can result in vegetation community simplification with a loss of palatable species, detrimental effects on biodiversity and ecosystem function, and erosion (Murden and Risenhoover 1993; Mysterud 2006; Acevedo et al. 2008). Risks of disease and parasitic outbreaks also increase with high animal density (Andrews 2002; Vicente et al. 2007; Castillo et al. 2011)

Disease emergence or increased disease risk is a frequent consequence of ungulate overabundance (Acevedo et al. 2008). Several studies show a prevalence of tuberculosis-like lesions in southern Spain, which is noted for its intensively managed and fenced hunting properties (Vicente et al. 2007). Recent research increasingly posits that although overabundance plays a significant role in disease and parasite transmission, management practices that promote the clumping of animals, even of different species, at water sites or supplementary feeding sites can exacerbate disease even at low animal densities (Vicente et al. 2007; Castillo et al. 2011).

11.5.2 Erosion and Water Quality

Erosion is a concern on oak woodlands because the loss of fertile topsoil can reduce the vegetative capacity of a property. High animal density resulting from fencing or feeding can lead to over-grazing, and loss of many plants that anchor soils into the ground increasing erosion risks and reducing water quality (Kauffman and Krueger 1984). Brush clearing practices can leave large areas of land without vegetative cover, increasing erosion risks and impacting water quality in riparian zones (Sampson 1963).

11.5.3 Fragmentation

Fences increase fragmentation of a landscape. While fences generally are designed only to prevent the movement of certain game species, they can make migration of other species more difficult and produce unwanted genetic impacts by separating

animal populations. Furthermore, fences can increase predation at crossing points, increase mortality of birds and other animals that get caught in the fence, and can lead to animals exceeding carrying capacity of a landscape (Andrews 2002; Hayward and Kerley 2009).

11.5.4 Genetic Impacts of Fencing, Feeding, Harvest, and Restocking

Genetic impacts that result from management activities can include the domestication of wild species, changed mating behaviors, inbreeding, genetic drift, hybridization, artificial selection, and loss of local genetic adaptations.

Fencing isolates populations, encouraging both genetic drift and inbreeding. For red deer populations in southwestern Spain, fences encourage genetic differentiation between neighboring properties, accounting for some level of inbreeding (Martinez et al. 2002). But the full role of fences on inbreeding is complex. In the dehesa, fenced lands are some of the only areas that sustain a natural age structure of red deer populations. In unfenced areas, overhunting of males leads to female-biased populations with mostly young males (Pérez-González and Carranza 2009). Research has shown that transmission of genetic variability is compromised in the paternal lineage in open lands compared to fenced ones (Pérez-González and Carranza 2009). The result is that inbreeding does not differ on average between open and fenced properties (Martinez et al. 2002) and cases of extreme inbreeding are found even more easily in open lands (Pérez-González et al. 2010a, b). Inbreeding can lead to decreased survival, increased vulnerability to disease, reduced fitness, and decreased lifetime breeding success. Biologists recommend prioritizing strategies to minimize the effects of inbreeding (Mysterud and Bischof 2010).

Feeding tends to increase the gathering of animals and have potential effects on natural mating behaviors. In Spanish hunting properties with supplemental feeding, the placement of feed can be more important in female red deer aggregation during the breeding season than the distribution of natural resources (Pérez-González et al. 2010a, b). Males then shift their strategy from harem defense to territoriality around the presence of supplemental feed (Carranza et al. 1995). Supplemental feeding also tends to increase harem size, but brings a reduction in sexual harassment of females by males (Sánchez-Prieto et al. 2004). The evolutionary consequence benefits males who control the larger female harem groups (Carranza et al. 1995). In red deer populations with mature males (mostly fenced populations), supplementary feeding may further increase the degree of polygyny and affect male mating success (Pérez-González and Carranza 2011).

Harvest has a major impact on population density, age structure, and sex ratio, leading to selective pressures that influence the genetic makeup of game animals. Several studies discuss how harvesting trophy-quality game selects for smaller and potentially less fit animals (Martínez et al. 2005; Mysterud 2010). Compensatory

culling targeting low-quality yearlings may successfully counter the selective effects of trophy hunting, although combinations of human mediated management practices may lead to semi-domestication (Torres-Porras et al. 2009; Mysterud 2010; Mysterud and Bischof 2010).

Game farming and restocking practices mix genetic lines and leads to hybridizing among game animals that used to be separated by significant geographic distance. These practices increase the risk of losing local adaptations due to genetic introgression from non-local populations. Indiscriminate translocation practices throughout Europe introduced genetic matrilines of Scottish red deer and Eastern European red deer in some Spanish red deer populations (Martinez et al. 2002; Fernández-García et al. 2006). Recent regulations have attempted to reduce this practice, requiring genetic tests of trophies prior to their entry into Spanish records to ensure they are not hybrids. Some regions of Spain have begun to require these genetic tests prior to authorizing translocations, and some landowners utilize these genetic tests to purge hybridization from their herds (Carranza et al. 2003; Carranza 2010).

Genetic impacts are not limited to big game species. The red-legged partridge faces threats from farm-raised animals, including parasite and disease transmission, and genetic dilution through introgression of farmed bird genes (Vargas et al. 2006; Blanco-Aguiar et al. 2008).

11.5.5 Population Structure

In California, buck-only harvest regulations result in female-biased sex ratios and the selection for smaller-antlered deer because larger-antlered males are often preferentially removed from the population. California has not implemented any compensatory culling scheme to reduce this effect. Bucks that lack forked antlers (with at least two points on each side) are illegal to harvest. While this is designed to prevent the harvest of one-year-old males, there are examples of 2–3 year old bucks that do not grow branched antlers being selectively protected and presumably allowed to breed. This artificially selects for deer whose antlers never mature beyond the size of a one-year-old buck, which runs counter to expected breeding fitness characteristics.

Harvest practices can impact the age structure and sex ratios of game species, leading to altered dispersal patterns (Pérez-González and Carranza 2009). The phenomenon of artificially skewed age and sex ratios is captured effectively by Pérez-González and Carranza (2009) who found that red deer sex ratios in fenced properties was approximately 0.79 males to females, while unfenced populations exhibited a 0.25 male to female ratio. They also found lower percentages of adult males in unfenced properties than fenced ones, at 54 versus 74 %.

The population characteristics of the unfenced properties described above are often the result of overharvest of adult males, which leads to reduced male mating competition. This altered population structure can affect genetic exchange between

populations in unfenced areas. Pérez-González and Carranza (2009) found that low male mating competition changed natural dispersal patterns to female-biased dispersal instead of the expected male-biased dispersal for polygynous species such as the red deer.

A study comparing two harvest methods of wild boars, espera (stand hunting) vs. montería (driven hunts by dogs), showed that the montería was much less selective, yielding harvest of animals across all age classes and genders, while espera hunting was much more selective for mature males (Braga et al. 2010).

11.5.6 Invasive Species

Management actions that clear vegetation can create openings for invasive species. In California, perennial native grasslands are usually extirpated from an area after plowing, discing, or planting of food plots. Invasive weeds, such as yellow star thistle (*Centaurea solstitialis*), and non-native grasses are usually the dominant species that re-vegetate plowed areas.

Translocations of non-native game animals can lead to invasions by the game animals that outcompete native species or disrupt ecosystem function. This can spread exotic diseases or parasites to native species. Wild boars have spread throughout many oak woodlands in California, causing changes in the ecosystem (Wilcox and Van Vuren 2009). In Spain, the Barbary Sheep (*Ammotragus laervia*) has expanded in certain areas and can compete with native ungulates, in particular the Spanish ibex (*Capra pyrenaica*) (Carranza 2010). Translocation of rabbits has been implicated to some extent in the spread of both myxamatosis and rabbit hemorrhagic disease (RHD), which have decimated rabbit populations throughout

Fig. 11.15 So significant is hunter success in wild boar hunting in Spain that proud landowners will often create a trophy plaque showing the "defenses" of the boar, especially for a mature animal, as seen here at a dehesa in northern Córdoba. (Photograph by A. Caparrós)

Spain (Delibes-Mateos et al. 2008). Since the rabbit is the primary prey species for at least 29 top predators in Spain, its decline has led to declines in predator species, including the Spanish imperial eagle (*Aquila adalberti*) and the Iberian lynx, which are highly dependent on rabbits (Delibes-Mateos et al. 2008) (Fig. 11.15).

11.5.7 Protected and Non-Target Species

Predator control in California's oak woodlands does not currently threaten any endangered species, although historical hunting and culling of predators such as the gray wolf (C*anis lupus*) and the grizzly bear (*Ursus arctos horribilis*) extirpated those species from the state. While intensive predator control was historically a part of California's management for hunting and livestock, recent regulations banning poisons and limiting methods of trapping have decreased the impact of predator control. Mountain lions are protected, and while ranchers can obtain a permit to kill a mountain lion that has preyed on livestock, the administrative process may take several days, during which time the mountain lion often moves far from a kill site.

Spain's predator control practices appear somewhat detrimental to non-target species. While the target of predator control tends to be the red fox or the common magpie, many other species are affected by illegal or non-selective predator control. Studies have found declines in populations of the common kestrel (*Falco tinnunculus*) and the common genet (*Genetta genetta*) on hunting properties where intensive predator control is practiced (Beja et al. 2009). Additional research shows that non-selective control measures of box traps, snares, and illegal poison that is intended for red foxes may not significantly impact fox populations, but in fact adversely affect species such as the badger (*Meles meles*), wildcat (*Felis silvestris*), and stone marten (*Martes foina*), which are unable to cope with intensive predator control (Virgós and Travaini 2005).

11.6 Conclusions

The oak woodlands of Spain and California are ecologically similar, but significant disparities in history and governance yield dramatically different hunting systems on the two sites. These distinctions are manifest in the methods of hunting, the economic return to landowners, game management practices, and the environmental impacts of such management.

Income from hunting can provide an economic incentive to maintain areas of relatively undisturbed wildlife habitat. Properties that earn revenue from hunting are more common in Spain and often earn more than those in California. Current law and economic conditions in Spain make it favorable for landowners to continue to utilize areas of dehesa for recreational hunting, and reinforces a trend

away from traditional livestock operations, brush clearing, and agricultural use that were the norm even a decade or two ago. However, while properties managed for income as hunting reserves may be profitable (Chap. 13), they are not lucrative enough to entirely replace the traditional multiple uses of dehesa habitat. In California, historical precedent, widespread public lands, lower hunting participation rates, limitations on commercialization of wildlife, and increasing restrictions on hunting and wildlife management practices all serve to reduce the amount ranch owners earn from hunting. Nonetheless, the local food movement and the current interest in wilderness experiences are shaping a new narrative about hunting as an ecologically sound way to connect to one's food source while also obtaining organic meat. Even though hunting can provide sustainable economic return on dehesas and wooded oak ranchlands, uninformed wildlife management practices that are too narrowly focused on game animals can cause environmental degradation (Díaz et al. 2009). However, thoughtful management practices that seek to improve habitat for a variety of species can not only maintain but improve environmental values on these properties.

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