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Economic losses to Iberian swine production from forest fires

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ABSTRACT

Most forestry property in Andalusia is privately held. One of the most important possibilities for economic development of rural areas is the use of pasture lands (*dehesa* in Spanish). During the spring–summer season, swine grazing takes advantage of grasses between the trees, and during winter (harsher times), they use *Quercus* tree fruit. Swine production has a direct economic impact on the rural areas' activities. Wildfires are the most significant disturbance in the Mediterranean ecosystems therefore; it is important to study the potential negative impact of wildfires on the swine resource. The public sector is responsible for the application and valuation of policies or activities creating wealth in forest areas while protecting the environment and preventing greater impacts and damages.

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1. Introduction

The origin of the Spanish *dehesa* dates back at least to the Middle Ages, and possibly over 1000 years ago (Martín and Fernández-Alés, 2006). Its present condition is the result of the combined action of cultural, ecological, economic, geographic, historical, landscape, and social factors (Campos et al., 2004). Two basic strata make the *dehesa* system: a grazing productive stratum, and a dispersed trees stratum with productive and stabilizing functions (San Miguel, 2006). Therefore, this is an agro-silvopastoral system dedicated to herding activities (Joffre et al., 1988; Montero et al., 1998). Economic studies about the *dehesa* have shown that their profitability is due not only to direct production, but also to their created goodwill (Campos, 1999; Plieninger and Wilbrand, 2001; Campos, 2004).

Pasture lands associated with *dehesas* are not permanent but represent regressive stages of forests. Their origins are usually related to a disturbance such as wildfire, grazing, or agriculture (Bernet, 1995). These pasture lands are characterized by low production in winter months and no production at all during the summer months (Ferrer et al., 2001). Animals depend on other resources like farm products or acorns because of the discontinuous grazing production (Bellido et al., 1986). *Quercus* (generally associated with *dehesas*) acorns mature and fall off during the fall and winter seasons (Martín et al., 1998). Therefore, the winter acorn production helps ease feeding problems (Montoya, 1989).

The Iberian pig breed is the animal that best uses the *Quercus* tree fruit (Nieto et al., 2002). Pasture lands are central to the production of Iberian pigs (Parsons, 1962), particularly because pigs consume acorns during the winter months of November through January (Goodrum et al., 1971). Iberian pig production guarantees present and future profitability of the *dehesa* (López, 1998; Campos, 2001). Protection and planning of *dehesa* swine production are of utmost importance for rural development because of the often depressed socioeconomic rural conditions of the *comarcas* (equivalent to counties) (Johnson, 1994; Bengston et al., 1998).

Planning of the fruit resource use depends on the quantity of acorns available to livestock (Ortuño and Jovellar, 1996; Porras, 2002; Ogaya and Peñuelas, 2007). One of the main problems in planning the use of *dehesas* is the variability in fruit production, caused principally by climatic variability (Sharp and Spnague, 1967; Koening et al., 1994; Cecich and Sullivan, 1999; Healy et al., 1999; Siscart et al., 1999; Greenberg, 2000; Abrahamson and Layne, 2003). Acorn production per tree depends on many factors including species, age, size, genetic variability, management regime, site index, and phytosanitary condition (pest infestation and illness) (Gysel, 1958). However, it has been determined that the best predictor of fruit production by tree and by hectare is tree density corrected by site index and phytosanitary condition (Martín et al., 1998). Generally, a bumper crop is followed by smaller crops for a few years (Cañellas et al., 2007). It is difficult to estimate a mean acorn production because of the large variation in mass production among years (Gea-Izquierdo et al., 2006; Olea and Miguel Ayanz, 2006). In general, acorn production increases

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exponentially with tree age and size (Cierjacks and Hensen, 2004). In addition, there is a good correlation between fruit production per tree and crown diameter (Martín et al., 1998). It is hypothesized that there is a tendency to a reduction in acorn production because of a degradation of the *dehesa* conditions caused in part by droughts, abandonment of traditional harvesting practices, and overgrazing (Navarro, 2004; Bellocq et al., 2005).

Humans have used fire since the Neolithic Era, and this has been not only a natural factor but an important agricultural tool (Abrams, 1992). Rural migration is a major contributing factor to large wildfires because of the large accumulation of fuel from vegetation that retakes abandoned agricultural lands (Pérez, 1990; González Bernáldez, 1991). Wildfires are becoming a threat to the landscape and biodiversity partly because of climate change and anthropogenic actions (Pinto, 1993). However, although low-intensity wildfires could be beneficial for natural regeneration (Arthur et al., 1998; Abrahamson and Layne, 2003), most wildfires pose a significant environmental risk with potential serious consequences for the environment and society (Martínez Ruiz, 2000). The explosiveness of wildfires can cause serious economic problems for cattle ranchers (Plieninger and Wilbrand, 2001). Fire prevention programs in rural areas play a crucial role in reducing the problem by reminding people of the damages and losses caused by wildfires to life and property and also to cattle ranching operations (Vélez, 2009).

This work presents the results of an economic appraisal of Iberian swine production in *dehesa* feeding grounds. We use a substitute price system to estimate the economic value of pasture lands and the economic value of acorn production based on the nutritional needs of the Iberian swine livestock. Wildfires are the most important disturbance in the Mediterranean area causing damages to tangible assets, environmental services and landscape goods. In this sense, the protection of the environment is one of the greatest roles of forest managers. Economic impacts depend on fire intensity and vegetation resilience. The economic valuation of swine production and the vulnerability of livestock to wildfires must be incorporated in suppression management activities to assure economic development of depressed rural areas. The main objective of this paper is to develop a simple economic valuation methodology based on the fire intensity level (FIL) to determine the economic value of Iberian swine production in *dehesa* systems. A sample application provides information on the utility of the system for fire management planning for protection of *dehesa's system*. In addition, the economic information developed for valuing the swine production was incorporated into a geographic information system (GIS) for the Autonomous Region of Andalusia that shows the economic losses to the Region *dehesa's* system (on a 10 km^2 grid) as consequence of wildfires. In preparing the spatial analysis outputs we used the same fire simulation model and fire economic analysis model as used in the development of the economic value for the Iberian swine production. A detailed description of the fire economics simulation model is found in Rodríguez y Silva and González-Cabán, (2010).

2. Methodology

2.1. Study area

The study area is located in the easternmost edge of the *Sierra Morena* mountain range to the north of Huelva Province, known as *La Sierra* territory (Fig. 1). This territory has 300,080 ha of alternating valleys and mountain ranges. Annual precipitation in the area ranges between 700 and 1000 mm; most of it falling during the winter season, and rarely occurring during the summer months. The presence of several mountain ranges of medium height (160 to 1040 m) creates a beautiful landscape. Thickets of *Cistus* spp. dominate the higher slope zones, whereas valleys and lower slope areas are dominated by *dehesas* systems. The study area contains a protected natural area named *Parque Natural de Areacena y Picos de Aroche*. The main characteristic of this natural area is that 64% of its territory is composed of oak (*Quercus* spp.) *dehesas* along with grasslands and thickets.

The study area landscape is mostly the result of human activities because of forest exploitation. The main forest use is for livestock husbandry, particularly swine. As of 2004 the number of swine was estimated at 56,000 for the *Parque Natural de Aracena y Picos de Aroche* and at 344,643 for the whole Huelva Province (Consejería de Medio Ambiente, 2004).

2.2. Pastoral valuation

Pasture is an important asset because it is the main source of food for animals. The term “grass” is a generic term referring to any forest resource used to feed livestock as forage or grazing. Characterization of the grass requires information on the available production, nutritional value of the grass, and the amount the animal is capable of eating.

The amount of dry material available for animal consumption was determined through sampling of the area. We used a geographic information system (GIS) to establish the location of the sampling plots based on the different pasture lands and accessibility. The sample plots were 40 × 40 cm and located in a random transect along the *Sierra Morena* mountain range. The information collected was composition, height, total wet weight, and pasture type (legume-type or grass-type). The dry weight was determined by oven drying the collected material for 48 h at 70 °C (Mannetje and Haydock, 1963). We determined the carrying capacity of the *dehesas* area knowing the nutritional needs of the livestock. The grass consumption is a function of the capacity of the animal to eat dry material, and it is directly proportional to the animal live weight, ranging around 3% of live weight daily (San Miguel, 2006).

The amount of dry material available and its quality were used to determine the carrying capacity of the area. Two methods were used to determine the carrying capacity based principally on the quality of the grassland. The first was application of the Hobbs et al. (1982) model to the protein and energetic components of the Mediterranean habitat. The second was determining fodder unit (FU) based on the amount of legumes and grass species present and their pastoral values. The FU is given by the following equations:

$$FU / ha = \left(60G_{per} / 12\right) P_v \tag{1}$$

$$P_v = 0.2 \sum C_s Q_s \tag{2}$$

where, FU/ha is the fodder units per hectare (supply of useable energy), G_{per} is the duration of the growing period (months), P_v is the pastoral value (ranges between 1 and 100), C_s is the contribution by each grass species (%), and Q_s is the quality index for each species. It takes the value zero (0) when animals don't eat it and 5 when most desired by animals (Daget and Poissonet, 1972).

There is a difficulty when trying to select the assessment method to value a product without a direct market price (Iberian pig breed). The most commonly used include (1) indirect valuation methods that use an assigned value based on the live weight (kg) per animal on forest lands, (2) the residual of derived price system, (3) the avoided or substitute price system, (4) the hedonic prices system, or (5) the contingent valuation method.

The avoided or substitute price system uses the price of substitute market goods (cereal, hay, straw), that pigs could eat. In this sense, the value of the resource (€/ha) is determined based on the fiber and protein needs of the animals and the price and quality of the substitute product. Following is the economic evaluation of the fodder

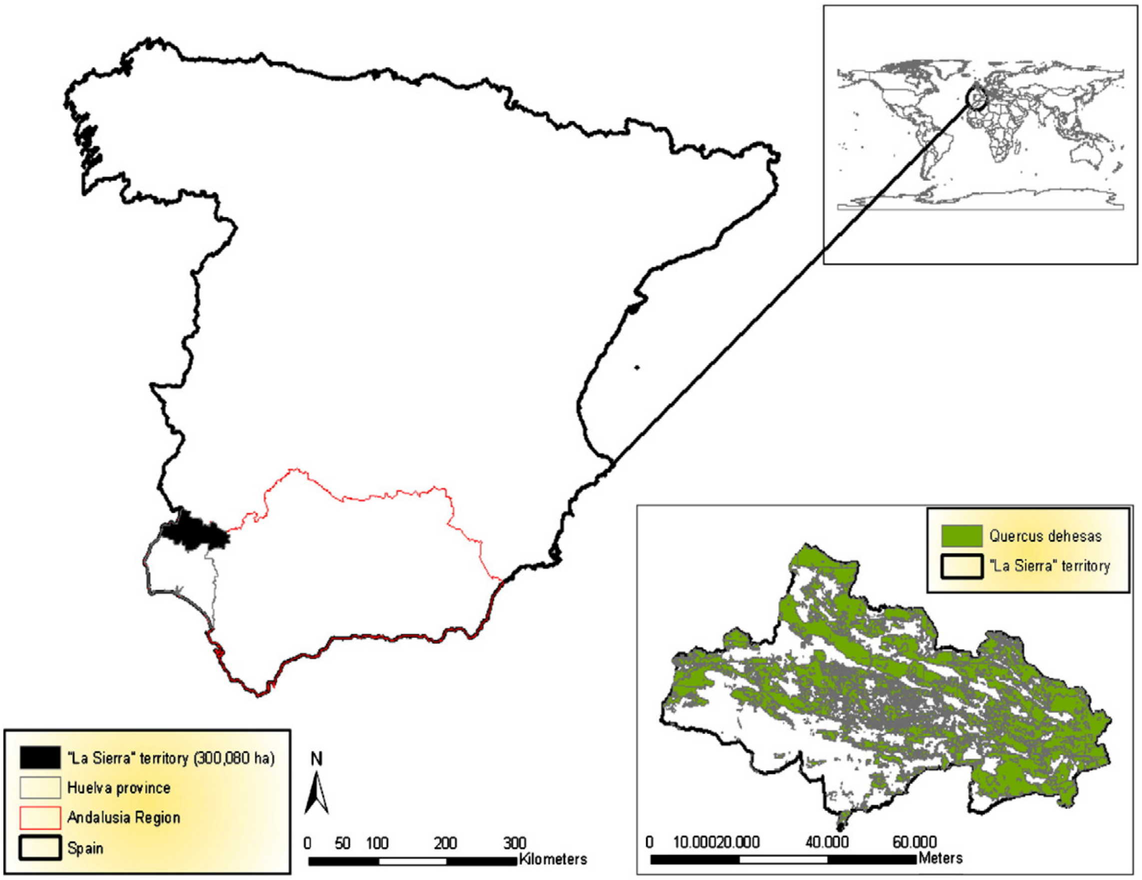

Fig. 1. Study area location.

units per hectare and the acorn production that sustains the Iberian swine in the *dehesa* systems.

2.3. Valuation of acorn production

Historical records of the use of the *dehesa* for swine production allow us to estimate the number of swine that can be fed in a *dehesa* system by comparing the historical acorn production and phytosanitary condition with current production and conditions. Likewise, we can extrapolate the physical carrying capacity from a swine-producing *dehesa* to nearby areas with similar ecological and physiographic characteristics such as topography, species, and canopy closure.

We used a previously developed method to estimate the acorn production (Espárrago et al., 1993) that counts 50 times the number of fruits present in a 20-by-20 cm square in the lower third of the *dehesa* slope. Based on this work, the Government of Extremadura Department of Pastures and Forest Production, Research and Technological Services, developed a methodology to measure the *dehesas*, from sample number and method to calculation of the number of swine that could be fed in a hectare of land (Vázquez et al., 2002).

Forestry parameters (National Forestry Inventory) and geostatistical techniques (GIS) are used to determine mean acorn production per hectare to estimate the *dehesa's* value. The fruit production per hectare is given by the tree production (kg/ha) and the canopy closure adjusted for site index and phytosanitary condition (Vázquez et al., 2002). Table 1 shows an estimate of the total acorn production per hectare based on the fruit production per "typical" tree and stand density. In this case, we can observe that the acorn production rate is decreasing rather quickly when tree density is increasing because of greater tree competition. As can be seen in the table the productivity of the site with 80 trees/ha is only 24% of what it is for the site with only 20 trees/ha.[1] This represents a productivity loss of 76% per tree (from 11 kg/tree to only 2.6 kg/tree). As an example, the procedure was computed for three areas with potential for swine production. Table 2 shows an estimation of the carrying capacity of the sites given their annual production and stand density.

The Iberian pig breed has developed the unique ability to peel the fruit, deriving large quantities of dry material from it. For each 8 to 10 kg of fruit, the Iberian swine can gain 1 kg of weight (García et al., 2003). Economic valuation of the acorn production by oaks (*Quercus* spp.) is difficult because of its lack of a direct market (tangible asset). The value estimates depend on whether or not the fruit is used for swine production. However, a shadow price for the fruit can be

Table 1
Estimation of acorn production per hectare by "typical" tree.

Acorns production of "typical" tree	Trees per hectare			
(Kg/tree)	20	40	60	80
11	220	352	345	209
14	280	448	438	266
21	420	672	658	399

Note: Acorn estimates are obtained from multiplying the typical tree acorn production by the number of trees/ha (e.g. $20 \times 11 = 220$). Note that the fruit production per ha decreases as the number of trees increases because of greater tree competition.

[1] Under the most favorable conditions, only 20 trees/ha, the acorn production is 220 kg/ha (11 kg/tree × 20 trees/ha) or 100% productivity. If the same productivity per tree were maintained per hectare production for the 80 trees/ha site would have been 880 kg/ha, but as shown in the table is only 209 kg. This represents a productivity of only 2.6 kg of acorns per tree. When compared to the 11 kg/tree in the 20 trees/ha site this is a reduction in productivity of 76%.

Table 2
Total carrying capacity estimates per hectare by "typical" tree given annual acorn production.

Production	Trees per hectare			
Kg/tree	20	40	60	80
	Swine per hectare			
11	0.319	0.510	0.449	0.303
14	0.046	0.649	0.635	0.385
21	0.609	0.974	0.953	0.578

Table 3
Relationship between flame length and fire intensity level.

Flame length	FIL
Meters	
<2	I
2–3	II
3–6	III
6–9	IV
9–12	V
>12	VI

associated with the products resulting from the Iberian swine feed and how representative they are within the La Sierra territory. For example, a swine weight gain of 11.5 kg associated with the consumption of this fruit is valued at €23[2] (published in Agriculture Official Bulletin in Andalusia region in 2006 and 2007).

2.4. Potential effects of wildland fires

The potential effect of wildland fires on livestock production will depend greatly on fire severity. One purpose of this work is to develop a simple valuation based on the fire Intensity level (FIL). Flame length can be used as a good indicator of fire damage intensity (Table 3). Fire simulators such as Farsite© (Finney, 1998), FlamMap© (Finney, 2003) and Visual Cardin© (Rodriguez y Silva, 1999) could be used to estimate this parameter, using weather information from local weather stations and GIS information to analyze physiographic and fuel model conditions.

Generally, a wildland fire implies consumption of all annual grasses by the fire in the area and having to wait until next spring for its recovery. This recovery could be longer for areas needing a break from grazing for grass regrowth or for tree growing. Although the total acorn production is almost always lost during the year of a fire, losses in a *dehesa* system will depend on fire intensity. A wildfire causes annual losses in fruit production because of the dead trees and partial fruit production losses in the surviving trees. Tree death is not always immediate but can take place later because of damage to the root system or weakening effects of sprouting.

2.5. Economic valuation of wildfires caused losses

Losses should be calculated depending on the generated annual income from pasture production. A problem exists because of the number of years without pasture production. This period is variable in the *dehesa* or forest systems. The utilization period depends not only on the grass recovery but also in allowing the area to rest from use to permit the regeneration or recovery of the forest. Normally, the rest/recovery period after wildfires is between 5 and 10 years (Martínez Ruiz, 2000). Most of the land in the study area is private for which the rest/recovery period is usually shorter: about 5 years to avoid erosion problems and to recover tree and wildlife vitality. Grasslands without trees do not usually need a rest/recovery period, and losses are computed annually. All case studies are computed as follows (see Martínez Ruiz, 2000):

$$L = \left[V(1 + 0.06)^n - 1\right] / 0.06(1 + 0.06)^n \quad (3)$$

where L is the pasture loss (€/ha), V is the annual income given the carrying capacity of the site (€/ha), n is the estimated number of calendar years until recovery (vegetation resilience), and 0.06 is the annual interest rate.

[2] At a rate of 8–10 kg of fruit per 1 kg gain in swine weight gain it would take from 88 to 99 kg of fruit for a weight gain of 11.5 kg. Valuing the weight gain at €23 it means a shadow price of 0.26–0.23 €/kg of fruit.

The valuation of the *dehesa* should be computed starting with the annual loss since the reference fire until stand senescence. In the case of acorn production, about 80% of *Quercus* spp. trees surviving a medium- or high-severity wildfire will not produce fruit the year after the fire; the following years' improvement in acorn availability will depend on fire severity (Abrahamson and Layne, 2002).

Mean age of the stand is obtained from the national forestry inventory as a function of the average diameter at breast height. The following equation was used to compute the damages to fruit production:

$$L = A_p P\left[(1 + r)^n - 1\right] / r(1 + r)^n \quad (4)$$

where L is the fruit loss (€/ha), A_p is the annual production (kg/ha),[3] P is the estimated price in €/kg,[4] r is the annual interest rate, and n is the number of years between the time of the fire and senescence.

3. Results

3.1. Pastoral valuation

Grazing capacity of the area was computed as the ratio of grass production by surface area to the amount of grass an animal can eat during the harshest conditions. A field survey was used to estimate the amount of pasture available. To protect the soil from erosion processes, only 50% of all primary grass production is assigned for feeding. The grass characterization permitted estimation of the livestock carrying capacity per hectare, making possible the estimation of the cost assumed by the rancher if that source of feed were not available. In the Mediterranean ecosystems, it is estimated that 1 cattle unit per hectare (CU) is equivalent of 200 units of pastoral value (P_V) (Consejería de Medio Ambiente, 2004).

We inventoried in two calendar years in the Sierra Morena farms, 1995–1996 and 2006–2007, because the estimation of grass quantity depends greatly on rainfall conditions. A valid measurement of grass production requires estimation of the dry mass (DM) under years with different rainfall patterns: a high rainfall year, and a low rainfall year (Fig. 2). The value of dry mass was estimated as the mean value between a low rainfall year (1995–1996) and a high rainfall year (2006–2007).

Computation of the carrying capacity for each pastoral type took into account three parameters: the amount of dry material, the pastoral value, and both the energy and protein need requirements of the animals. When estimating the carrying capacity using the dry material parameter the assumption is that an animal consumes 3% of its live weight daily. The pastoral value for each pastoral type was computed based on the species and their coverage (area occupied in the territory) according to the equations discussed in the Methodology section. To compute carrying capacity based on the animals' energy and protein requirements we used the worst characteristics

[3] This information is obtained from the stand density, site index, phytosanitary condition and official annual production references produced by the Department of Agriculture of Andalusia.
[4] This is an official estimate from the Department of Agriculture of Andalusia.

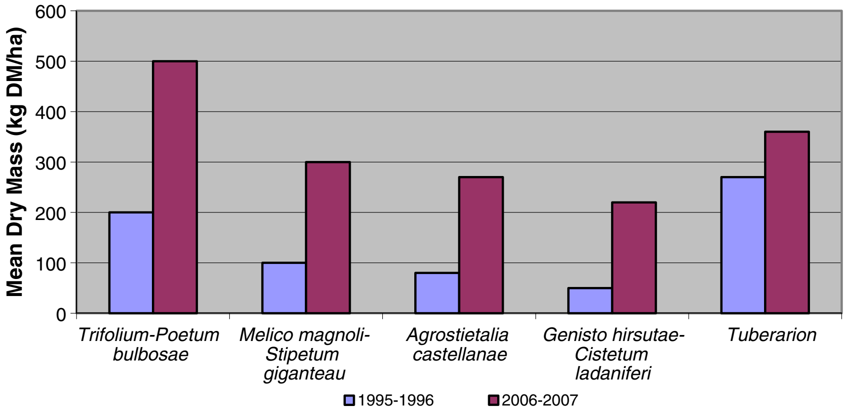

Fig. 2. Differences in dry mass on a Sierra Morena farm during a wet (2006–2007) and a dry year (1995–1996).

Table 4
Carrying capacity for the first pasture unit measured (*Trifolium-Poetum bulbosae*) by different methods.

Estimation method	Carrying capacity (cattle units/ha)
Dry mass	0.32
FU availability	0.343
Energy requirement	0.29
Nitrogen requirement	0.23

for a 90 kilo live animal: a lactating female. Such an animal requires 6706 kcal/day (4032 kcal/day for sustenance and 2674 kcal/day for lactation), and 56.7 g N/day (22.74 g N/day for maintenance and 33.96 g N/day for milk production) (Hobbs et al., 1982). As an example, analysis of the mean dry mass for the first pasture unit studied (*Trifolium-Poetum bulbosae*) showed a mean value of 350 kg DM/ha. This value took into account both the retention of grass for protection purposes and the reduction in number of animals to account for pasture greenness. Identification of each pastoral species coverage led to a pastoral value estimate of 17.14 and of 771.3 forage units (FU) for *Trifolium-Poetum bulbosae*. There were not much differences between the carrying capacity estimates based on dry mass, pastoral value, and energy and protein requirements (maximum difference of 0.11 CU/ha) (Table 4). The lowest value was for the nitrogen requirements (0.23 CU/ha); the highest value was the one using the Pastoral Value technique (0.34 CU/ha). We established the *Trifolium-Poetum bulbosae* carrying capacity at 0.29 CU/ha, a little higher than that recommended by San Miguel (1994).

3.2. Valuation of acorn production

Although the carrying capacity method is simple, its design can be costly because of the large number of factors to consider. We used mean values to make the method application more general (at landscape level), although this could increase the error of the estimates by 5 to 10%. However, we felt the gains in applicability compensated for the increase in estimates error. Once the individual production was known, we added site index and phytosanitary condition of the stand. Those two factors gave the total acorn production per unit of area (corrected production), together with the reduction in production from immature individuals. Lastly, the fruit quality was introduced; taking into account that the highest quality fruit is from *Quercus ilex*. It was estimated that 9 kg from this species is equivalent to 14 kg from *Quercus suber* fruit (San Miguel, 1994).

Acorn production estimates ranged from 161.5 to 400 kg/ha; carrying capacity per area ranged from 0.23 to 0.55 CU/ha (Table 5). Estimates for the first management unit were in the same range as those computed by the pastoral method based on the nitrogen needs (0.23 CU/ha). For the other two management units, the limiting factor will be the grasses itself. As expected, the highest value was for unit 2, with 40 *Q. ilex* trees per hectare. As observed, there were significant final production differences per area given the same initial densities in the second and third management units. The reason for this is that all results were expressed in terms of kg of *Q. ilex* fruit production. This procedure will also be used for any new species evaluated.

The *dehesa* productivity was calculated with the assumption that an Iberian swine gains approximately 1 kg of weight for 9 kg of *Q. ilex* fruit consumed. Therefore, a weight gain of 11.5 kg corresponds to the consumption of 103.5 kg of *Q. ilex* fruit (San Miguel, 1994). Once this relationship was established, we proceeded to make the conversion into monetary units. Given the weight gain value (Consejería de Medio Ambiente, 2004) and relationship with acorn production, the conversion price of the fruit is 0.22 €/kg.

3.3. Estimation of wildfire caused damages

The reduction in pasture resource and acorn production from fire was shown in terms of the fire intensity level (FIL). Pasture resource

Table 5
Sustainable carrying capacity estimated for some management units with acorn production.

Management unit species	Stand density (trees/ha)	Acorn production (kg/tree)	Production (kg/ha)	Carrying capacity (CU/ha)
1— *Quercus ilex*	94.22	8.5	161.5	0.23
2— *Quercus ilex**	39.68	12.5	400	0.55
3— *Quercus suber*/*Quercus ilex*	37.58	10	336	0.46

Note: CU = cattle unit; *The only difference between the first and the second site is the stand density. Notice that a 42% reduction in stand density from the first to the second entry results in a 47% in acorn production per tree.

Table 6
Mean damages to the *dehesa* by fire intensity level.

Fire intensity	Pasture loss 1994–2006	Acorn loss 1994–2006	Acorn losses 2007
		Percent	
I	45	5	5
II	65	10	
III	85	20	14
IV	100	45	
V	100	65	67
VI	100	75	

losses were valued based on the history of pasture usage. Fires with an intensity level of VI are expected to result in loss of all forage for that year. The fruit losses were expressed in terms of a percentage value using the experience of three large wildfires in Andalusia occurring between 1994 and 2006 (Table 6). In addition, for fruit damages, the percentages for three of the six FIL were validated on a large wildfire in 2007. As can be seen in the table the percentage of fruit damage for 2007 is similar to that occurring in the years between 1994 and 2006.

The final step in the process, once the losses were determined and the FIL map was completed, was preparation of a GIS-based data layer portraying the potential damages to swine livestock production and the economic losses to Andalusia Autonomous Region *dehesa's* system (on a 10 km^2 grid) as consequence of wildfires (Fig. 3). This data layer is an integration of the units' land cover and Fire Danger Rating System fuel models (Anderson, 1982). The equations presented before are applied to these layers to calculate potential damages to

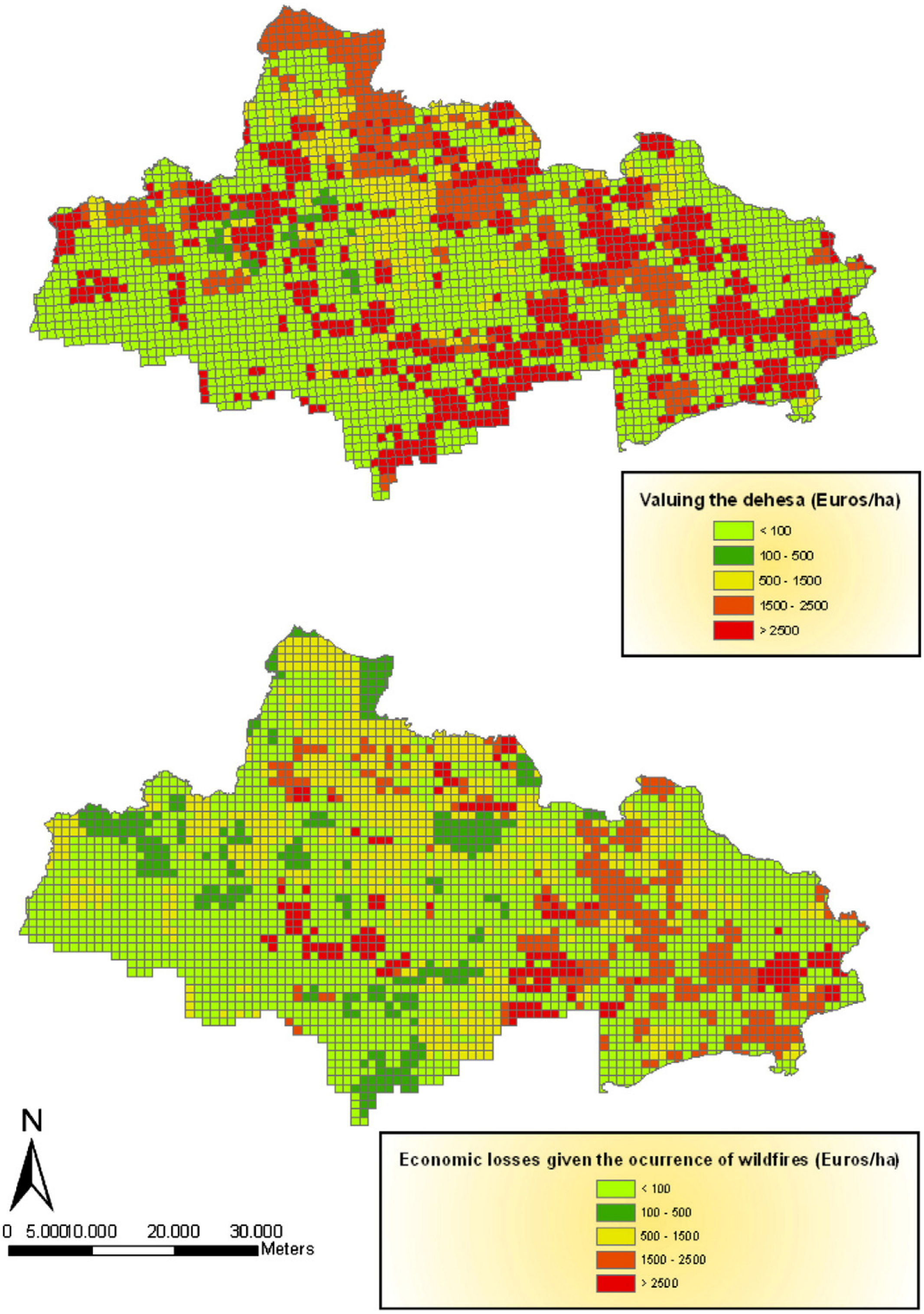

Fig. 3. Economic vulnerability of swine livestock production given the occurrence of wildfires.

the site swine livestock production. In preparing the spatial analysis outputs we used the same fire simulation model and fire economic analysis model (see Rodríguez y Silva and González-Cabán, 2010) as used in the development of the economic value for the Iberian swine production.

The damages were estimated using the biggest loss in carrying capacity for the ecosystem in terms of pasture and acorn production (see Table 5). As an example, in the case of about 90 *Q. ilex* trees, the computation was done using the carrying capacity of 0.23 CU/ha (Table 5), which was considered to impose the greatest reduction in the *dehesa* sustainable carrying capacity.

4. Conclusions

Development of a multidiscipline forestry policy is not possible without considering livestock production, because of the importance of potential areas for production. For decisionmaking the economic valuation of Iberian swine production is useful and important, because it provides managers information necessary to evaluate potential tradeoffs when proposing fuel reduction programs for maintaining the *dehesa's* system. Areas shown to have high economic values would justify greater investments in fire protection programs. The sustainability of the *dehesa* system is challenged by violent wildfires that cause potential serious damages that go uncompensated. It is necessary to create fire prevention programs and prioritize response actions to reduce damages to rural areas at risk.

Comparison of pasture lands is the most commonly used method for estimating the carrying capacity of an area for livestock production. The pastoral valuation method using the avoided or substitute costs does not include the nonnutritional benefits to the livestock of an agrosilvopastural ecosystem. However, it is important to add a safety factor that permits the use of the pasture land while providing for the area's soil protection. In this study, the livestock production levels used do not surpass the carrying capacity of the ecosystem.

The acorn production estimation presented here for the valuation of the *dehesas* has been presented previously, although here it is based on mean production values of the *Q. ilex* or *Q. suber* trees and for a specific period. Therefore, although the precision of the estimates is lower, this method's operational applicability is greater, making it a useful technique for wider situations.

The use of GIS in economic estimation methods provides flexibility when doing spatial ordination of the territory and increases the dynamisms of planning and systems protection tools in the case of disturbances. In addition, it is an unbiased tool when distributing local, regional, or national assistance budgets. The combination of livestock values and potential economic losses from wildfires in a GIS map of the Andalusia region is novel. This approach provides decision makers a relatively easy tool to evaluate where to invest the limited fire protection resources available. It could also help them analyze the potential economic consequences of fire policy changes. Inclusion of monetary units for livestock values is in response not only to economic criteria but also to development and social criteria for rural areas in regression or neglect. Inclusion of wildfires, one of the most significant disturbances in the Mediterranean ecosystems, in the analysis-responds to a planning and forest management need identified by technicians. One of the main causes of wildfires in rural areas is the abandonment of traditional forestry activities. Incorporating potential fire behavior parameters in the analysis provides a tool for retaining traditional forestry activities in the area. Sustainability of livestock production areas can provide the necessary protection for each territory. The methodology provided here permits the application of this simple and flexible technique to any territory and type of livestock by small changes in the nutritional requirements of each animal species.

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