

Environmental benefits of extensive livestock farming: wildfire prevention and beyond

Mirazo-Ruiz J.

in

Bernués A. (ed.), Boutonnet J.P. (ed.), Casasús I. (ed.), Chentouf M. (ed.), Gabiña D. (ed.), Joy M. (ed.), López-Francos A. (ed.), Morand-Fehr P. (ed.), Pacheco F. (ed.).
Economic, social and environmental sustainability in sheep and goat production systems

Zaragoza : CIHEAM / FAO / CITA-DGA

Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 100

2011

pages 75-82

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=801486>

To cite this article / Pour citer cet article

Mirazo-Ruiz J. **Environmental benefits of extensive livestock farming: wildfire prevention and beyond.** In : Bernués A. (ed.), Boutonnet J.P. (ed.), Casasús I. (ed.), Chentouf M. (ed.), Gabiña D. (ed.), Joy M. (ed.), López-Francos A. (ed.), Morand-Fehr P. (ed.), Pacheco F. (ed.). *Economic, social and environmental sustainability in sheep and goat production systems.* Zaragoza : CIHEAM / FAO / CITA-DGA, 2011. p. 75-82 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 100)



<http://www.ciheam.org/>
<http://om.ciheam.org/>

Environmental benefits of extensive livestock farming: wildfire prevention and beyond

J. Ruiz-Mirazo

CSIC - Estación Experimental del Zaidín, Mediterranean Pastures and
Silvopastoral Systems Research Group
c/ Profesor Albareda 1, E-18008 Granada (Spain)
jruizmirazo@gmail.com

Abstract. Livestock production systems are progressively shifting towards an industrialized model that is outcompeting extensive livestock farms in regions such as Mediterranean Europe. The objective of this paper is to contribute to the ongoing debate on the environmental sustainability of these changing livestock systems by focusing on two linked environmental issues (wildfires and climate change) and on Spain as a representative study case. In recent decades, wildfires have dramatically increased in Spain. This process is mainly attributed to the decline of traditional rural activities such as livestock grazing, which used to reduce fuel loads and fire risk. To offset this trend, several Spanish wildfire prevention programmes are currently remunerating livestock farmers for fuelbreak grazing services. Meanwhile, the Spanish food chain is increasingly furnished by market-driven industrialized livestock production systems, which are large contributors to climate change. These systems require many external inputs, such as abundant feedstuff, are poorly integrated with crop production and are, therefore, very demanding in terms of fossil energy and other non-renewable resources. From this perspective, it is concluded that environmental sustainability in livestock production systems is closely linked to basing animal intake on pastures and other locally produced resources. This approach constitutes an effective climate change mitigation strategy and can improve forest conservation.

Keywords. Industrialization – Climate change – Sustainability – Food sovereignty – Mediterranean.

Les avantages environnementaux de l'élevage extensif: plus que la prévention des incendies

Résumé. Les systèmes de production animale tendent progressivement vers un modèle industrialisé qui est plus compétitif que l'élevage extensif dans des régions comme l'Europe méditerranéenne. L'objectif de cet article est de contribuer au débat en cours sur la durabilité environnementale de ces systèmes d'élevage en transformation en se concentrant sur deux problèmes environnementaux (les incendies de forêt et le changement climatique) et sur l'Espagne comme un cas d'étude représentatif. Dans les dernières décennies, les incendies ont considérablement augmenté en Espagne. Ce processus est principalement attribuable au déclin des activités rurales traditionnelles telles que le pâturage du bétail, qui réduisait les charges de combustible et les risques d'incendie. Pour compenser cette tendance, actuellement plusieurs programmes espagnols de prévention des incendies rémunèrent les éleveurs pour les services de pâturage des coupures de combustible. Au même temps, la chaîne alimentaire espagnole est de plus en plus approvisionnée par des systèmes industrialisés de production animale, qui sont d'importants contributeurs au changement climatique. Ces systèmes d'élevage nécessitent de nombreux intrants externes, tels que d'abondants aliments, sont mal intégrés dans la production agricole et sont donc très exigeants en termes d'énergie fossile et d'autres ressources non-renouvelables. Dans cette perspective, il est conclu que la durabilité environnementale des systèmes de production animale est étroitement liée à que l'alimentation du bétail soit basé sur des pâtures et d'autres ressources produites localement. Cette approche constitue une stratégie efficace d'atténuation du changement climatique et peut améliorer la conservation des forêts.

Mots-clés. Industrialisation – Changement climatique – Durabilité – Souveraineté alimentaire – Méditerranée.

I – Introduction

Even if extensive grazing still occupies much land, the livestock sector has undergone a complex process of change in recent decades. An increasing trend towards the intensification and industrialization of livestock systems has been observed, which is a process made possible by using more agricultural feedstuff instead of natural pastures (LEAD and FAO, 2006). In many countries, intensive production is outcompeting extensive livestock systems, and this is contributing to a severe reduction in the use of land by grazing livestock. In Mediterranean Europe, this process is one piece of the generalized decline in rural economic activities, which is accelerated by the unprofitability of the forest resources and of the marginal arable lands, which are frequently destined to reforestation according to the European Common Agricultural Policy (CAP).

At first sight, the release of the local and regional natural resources from human impacts such as livestock production could be regarded as positive for nature conservation (e.g., more wildlife and biodiversity). Nevertheless, the drastic rural abandonment is producing new and severe problems for management. The simplification of the typically Mediterranean diverse rural landscapes (Lasanta *et al.*, 2006) is causing the local loss of the high levels of biodiversity and of the cultural heritage associated to them (Izquierdo, 2006). Moreover, abandoned land is known to quickly lose its potential to produce food and other commodities (Emanuelsson, 2009), while the local intensification of agriculture is making this sector rely more heavily on external inputs, which may be environmentally questionable. Besides, abandonment renders landscapes more vulnerable to perturbations such as wildfires, which can enhance carbon emissions and facilitate land erosion (Vélez, 2009). Undesirable side effects like these are unveiling the misconception that equals nature conservation to the exclusion of human activities. In fact, the maintenance of certain farming practices such as extensive livestock grazing in Mediterranean ecosystems is believed to be ecologically sound (Perevolotsky and Seligman, 1998) and technically appropriate to achieve current management goals such as forest protection and restoration (Ruiz-Mirazo *et al.*, 2009).

Undoubtedly, livestock farming systems and the changes they undergo are producing multifaceted environmental impacts on our environment at the local, regional, and global scales (LEAD and FAO, 2006). Their complexity and their multiple connexions with other elements (e.g., the global food system or the forest sector) call for the integration of livestock sector analyses in a more comprehensive picture.

The objective of this paper is to contribute to drawing this picture and to the ongoing debate on the environmental sustainability of livestock production by focusing on wildfires and climate change, two linked environmental issues that are socially perceived as of foremost importance (IESA/CSIC, 2008). The references and examples provided to illustrate this analysis come mostly from Spain, but may be considered representative of the trends observed and the policies applied in Mediterranean Europe.

II – Wildfires

Wildfire events and their associated impact have dramatically increased in Spain in recent decades, a trend shared by most countries of the northern Mediterranean rim. The augmented wildfire incidence is mainly attributed to the recent land-use changes derived from socioeconomic development, although climate change could have also been influential (Pausas, 2004). Development has caused the decline of many traditional rural activities, such as extensive livestock production systems, and homogeneous fire-prone forests and shrublands with increased fuel loads have expanded (Moreira *et al.*, 2001, Lasanta *et al.*, 2006).

1. Wildfire prevention strategies

In some Mediterranean countries, costly governmental fire suppression programmes have been successful in reducing the impact of the pervasive wildfires (Vélez, 2009). Nevertheless, natural areas remain very vulnerable, as described above, so improving the wildfire prevention strategies seems mandatory if a further reduction in the mean yearly burnt area is pursued. In this context, incorporating stock grazing into prevention programmes has frequently been proposed (e.g., Franca, 2001, Launchbaugh *et al.*, 2008). The capacity of livestock to effectively control shrub growth is supported by scientific evidence (Magadela *et al.*, 1995, Torrano and Valderrabano, 2005, Jauregui *et al.*, 2007) so targeted grazing, particularly if intensified along strategically located fuelbreaks, could be expected to successfully reduce fuel loads. Moreover, this approach is less costly than other alternative treatments that are regularly used to offset vegetation growth in fuelbreaks (Varela-Redondo *et al.*, 2008).

When adequately managed, most types of grazing livestock can produce excellent results for wildfire prevention (Dopazo *et al.*, 2009, Thavaud, 2009), but sheep and goat systems have some features that make them particularly adequate for this goal. In the Mediterranean, many sheep and goat breeds are native and well adapted to the pasture resources available, which is a valuable heritage when animals have to graze in forest areas where the quality and quantity of fodder may be limited. Besides, these livestock are usually guided by a shepherd, who can ensure that high stocking rates are maintained on the fuelbreaks without the need to use fences and to supply the water or feed that may be required in fenced areas. Involving shepherds in forest protection can have further benefits for wildfire prevention, as their sole presence in the forest area may discourage arsonists and ensures an early alert in the event of wildfire.

The silvopastoral management of fuelbreaks has been widely applied in south-eastern France over the past 25 years (Thavaud, 2006), which constitutes the most important reference in the region. Other Mediterranean countries have also run tests (Franca, 2001), but only a few of them have developed into permanent management programmes. This is the case of several regions of Spain, where the governmental forest services and local livestock farmers collaborate in wildfire prevention programmes, albeit in somewhat different formats.

2. Fuelbreak grazing in Spain

Habitually, farmers that take part in wildfire prevention programmes make their livestock graze intensively in the fuelbreak areas defined by forest services and, thus, vegetation fuel loads are reduced. In the event of wildfire, this would facilitate that fire brigades gained control of the wildfire. In exchange for this service, livestock farmers receive money and/or in-kind remuneration, which can consist on animal housing, fences or water troughs. In Comunitat Valenciana (eastern Spain), for instance, a programme which started in 1996 establishes a payment of €22 ha⁻¹ yr⁻¹ to farmers who concentrate their livestock in fuelbreaks for a minimum of 130 days yr⁻¹ (DOCV, 2009). Along that period, a minimum stocking rate of one cow, three goats or five sheep per hectare must be maintained. If setting up fences or bringing water for animals is necessary, the payment can be increased by some €20-40 ha⁻¹ yr⁻¹ (DOCV, 2009). Under this system, 3,680 ha of fuelbreaks were grazed in 2009 with the collaboration of 62 farmers.

In Aragón, a northern Spanish region where only in-kind remuneration is offered, 42 farmers undertook in 2010 the maintenance of approximately 3,500 ha of fuelbreaks. This programme started in 2008 with the objective of managing as many as 5,000 ha in the region. In Andalucía, located in southern Spain, livestock grazing of fuelbreaks started being tested in 2003 and widely promoted in 2005, while remuneration for farmers was implemented in 2007 (Ruiz-Mirazo *et al.*, 2007, Ruiz-Mirazo *et al.*, 2009). The payments per hectare currently range from €42 to €90, depending on the grazing difficulty (steepness, type of vegetation and distance to animal housing) associated to the fuelbreaks. However, the work of each farmer is evaluated every year, and the amount of money they finally receive can be lowered (or even cancelled) if

the grazing objectives are not accomplished. In some occasions, a complementary in-kind remuneration is also provided to facilitate grazing in public estates. By 2009, the grazed fuelbreak network of Andalusia had reached a total surface area of 2,350 ha, which were grazed with the collaboration of 69 farmers.

The coupling between farming practices and environmental protection constitutes a primary objective of the European CAP, particularly since the first Agri-environmental measures were implemented in 1992. The grazing management of fuelbreaks being a good example of this, it has long been funded by this European programme in south-eastern France (Thavaud, 2006). Currently, the region of Catalunya (north-eastern Spain) is also using an Agri-environmental measure to promote livestock grazing within the Priority Protection Perimeters, which are large forest areas with high fire risk.

In all of these cases, the livestock grazing of fuelbreaks is mostly funded by the forest services of the regional governments. This can be considered an indication of the importance given by Spanish forest managers to maintaining some livestock grazing in forest areas. Now that extensive livestock systems and the associated grazing pressure have declined, efforts are being made to offset this process and achieve better forest protection.

III – Climate change

Climate change is the global environmental issue that has concentrated more attention in recent years. The Intergovernmental Panel on Climate Change (IPCC) has received worldwide recognition, notably after the 2007 Nobel Peace Prize, and its reports constitute a solid reference for policy makers and the general public. The scientific evidence gathered (IPCC, 2007) has left little room for climate-change sceptics, and the adaptation and mitigation strategies are starting to be included in regional policies and international agreements.

1. Livestock, climate change and the global food system

The agriculture sector is held directly responsible for 13.5% of the 2004 greenhouse gas (GHG) emissions (IPCC, 2007), most of which come from livestock farming activities. The enteric fermentation by ruminants produces 37% of the anthropogenic methane, while the management of manure is behind 65% of the anthropogenic nitrous oxide (LEAD and FAO, 2006). Besides, part of the emissions related to forestry and deforestation (17.4%), industry (19.4%), transport (13.1%) and energy supply (25.9%) (IPCC, 2007) are also linked to certain models of agricultural production, product processing, packaging and distribution. Rural social movements such as Via Campesina claim that industrial agriculture and the industrialized food system should be largely held accountable for climate change, as they produce almost half of the global GHG emissions (Grain, 2009a). However, these farms should be sufficiently productive: otherwise, GHG emissions per kg of product would be higher than desirable.

As part of the global food system, intensive livestock production systems demand large quantities of soya, maize and other agricultural products as feedstuff. These inputs are produced mostly by industrial agriculture in a few countries (primarily the USA, Brazil, Argentina, China and India), exported worldwide and consumed in livestock farms and feedlots. Even if economically successful, such an industrial livestock production system is poorly integrated with crop production and is very demanding in terms of fossil energy and other non-renewable resources. Besides, it is believed to cause other undesirable environmental problems (e.g., manure concentration, abuse of herbicides and pesticides), and to be detrimental for the livelihood of small sustainable farmers, who are a key element of food sovereignty (Grain, 2009b).

The generalization of this system is powered by markets that demand cheap and abundant animal products, and contributes to raising GHG emissions, which has very relevant

consequences for climate change. Some calculations indicate that up to 9% of current global emissions could be avoided if we opted out of the intensive livestock production systems and aimed for improved local or regional livestock farming systems that were well integrated with crop production (Grain, 2009b). The following example aims to illustrate these global figures with a detailed analysis on the shift observed in the Spanish agricultural model in the second half of the 20th century.

2. Evolution of the energy balance in Spanish agriculture, 1950-2000

This section reports on a publication by Carpintero and Naredo (2006), who compiled several case studies on the energy balance of Spanish agricultural systems. The energetic efficiency of these systems was systematically calculated as the ratio between outputs (e.g., cereals, meat or milk) and inputs (e.g., fertilizers, seeds or machinery), both measured in energetic terms. Previous studies on agricultural systems of other industrialized countries had concluded that energetic efficiency was frequently below the unit (i.e., more energy was employed as input than obtained as output), which was attributed mostly to the inefficient energetic conversion rates of livestock production systems.

Between the years 1950 and 2000, drastic changes took place in Spanish Agriculture. The Gross Value Added of this sector lost relevance in the Gross Domestic Product, falling from almost 50% to only 4%. Meanwhile, the cost of human labour increased 10 times more than that of other equivalent energetic inputs in agriculture. The industrialization or "modernization" process transformed an almost closed-circuit agriculture (where most byproducts were being reemployed) into an activity that is highly dependant on external inputs and machinery. As a result, the energetic efficiency of the Spanish agricultural production dropped from 6.1 to 1.4 in this 50-year period. In regions such as Galicia, where livestock production is particularly important, this indicator dropped from 1.5 to 0.3 between 1955 and 1975.

These tendencies have continued in recent years. Between 1994 and 2000, crop and livestock production increased by 8% while inputs grew by 18%, both in energetic terms. Some inputs, such as fertilizers and electricity (necessary to pump water from ever deeper sources) have grown by 30% in this period. Overall, these results highlighted the contrast between the high-speed consumption of non-renewable resources by industrialized agriculture and the much slower natural production rates observed in Spanish agricultural systems.

It may be argued that some energetic cost must be assumed in order to produce sufficient proteins for the human diet. However, according to LEAD and FAO (2006), livestock systems are also inefficient for this purpose: worldwide, livestock produce 58 million tonnes of protein (contained in food products they provide) using 77 million tonnes of protein (contained in the feedstuff they consume). The latter type of protein has a poorer nutritive value than the former, but it could potentially be used for human nutrition. These figures are driven by intensive livestock systems, where the current trend is to use a concentrate-base diet to produce monogastric species (pigs and poultry, mainly), which have dietary requirements that are closer to humans than to ruminants (LEAD and FAO, 2006).

IV – The search for environmental sustainability

Livestock systems are undergoing important changes that are affecting how land is grazed, what resources are used and what environmental impact is generated in the production processes. The details provided focusing on Spain and on two specific environmental issues illustrate some of the consequences linked to the generalization of an industrialized livestock production system in a developed Mediterranean country.

At a regional or country scale, the decline of extensive livestock systems and other traditional agrarian activities (e.g., the collection of firewood or mountain agriculture), is having undesired

consequences such as more wildfires, the simplification of the diverse agrarian landscape, or the loss of an important cultural heritage and the potential to produce food. Meanwhile, at the global scale, market-driven industrialized livestock systems are causing important GHG emissions due to their high demand of inputs and to the processing and transport their production requires as part of the global food system.

Observing these processes from a physical point of view, we may affirm that we are neglecting the primary production, i.e. the energy captured in crop, range and woodlands of our territory. Instead of transforming it into food using the capacity of ruminant livestock, the energy of this underutilized pastures is accumulated in the form of biomass until, as it happens with increased frequency, it burns in a large wildfire. Meanwhile, we are making an abusive use of fossil energy and other non-renewable resources, as well as of the land of other countries, to furnish our tables with food that contains a high proportion of animal products.

Ever since the climate change is in the political agenda, mainly technological improvements (e.g., the production of biogas as a way to manage manure in livestock systems) have been proposed to mitigate the impact of human activities on the climate. These advances may be valid, but their effect will probably be negligible if the global food system, which is driven by worldwide markets and causes major impacts on our environment, remains basically the same. Markets cannot be expected to assign the resources in an environmentally sustainable way, as the prices of many of them (e.g., water, energy or feedstuff) do not reflect their scarcity and the environmental impact their production generates (LEAD and FAO, 2006). Sharp political action could correct for this by forcing the internalization of the environmental costs associated to each step of the chain of production. Unfortunately, not even under the urgent need for action that the climate change dictates are steps being taken in this direction.

V – Conclusion

A comprehensive assessment of the environmental sustainability of livestock production systems will require taking into account multiple aspects and impacts that take place at different scales and affect other sectors. Considering the scenario described for Spain, which may well be generalized to other countries of Mediterranean Europe, the environmental sustainability of livestock production systems is found to be closely linked to basing animal intake on pastures and other locally produced resources. This approach can constitute an effective climate change mitigation strategy and can improve forest conservation.

Effective policies need to be implemented to make this approach viable. Currently, the overall sustainability of extensive farming systems is frequently very low, as shown by Mena *et al.* in another paper presented at this Seminar. Fortunately, some externalities and services linked to grazing, such as the illustrated wildfire prevention, are starting to be recognized and economically supported. This can promote grazing even in remote pastures, which can contribute to making the best use of all the resources available.

It goes without saying that pastures have to be correctly managed to ensure sustainability. Nevertheless, if all ruminant livestock currently reared in Spain were fed again on pastures, many areas would probably become overgrazed. We may need to consider this as a warning about the food system and diet we have adopted, its dependency on external and non-renewable inputs, its high environmental impact and its deficiencies regarding the preservation of our natural resources and our food sovereignty.

Acknowledgments

The author was sponsored by a European Social Fund co-funded I3P grant from the *Consejo Superior de Investigaciones Científicas* (CSIC), and by the project "Grazed fuelbreaks as a fire-preventive silvicultural tool in Mediterranean forestlands", funded by *Egmasa (Junta de*

Andalucía). Andere Ruiz and an anonymous reviewer made useful suggestions on a previous version of this paper.

References

- Carpintero Ó. and Naredo J.M., 2006.** Sobre la evolución de los balances energéticos de la agricultura española, 1950-2000. In: *Historia Agraria*, 40, p. 531-554.
- DOCV, 2009.** Orden de 11 de mayo de 2009, de la Conselleria de Medio Ambiente, Agua, Urbanismo y Vivienda, por la que se convocan y se aprueban las bases reguladoras de las ayudas gestionadas por la Dirección General de Gestión del Medio Natural, en materia de prevención de incendios forestales, para el ejercicio 2009. Diari oficial de la Comunitat Valenciana, 6018 / 21.05.2009.
- Dopazo C., Robles A.B., Ruiz García R. and San Miguel A., 2009.** Efecto del pastoreo en el mantenimiento de cortafuegos en la Comunidad Valenciana. 5º Congreso Forestal Español. Ávila, Spain: SECF. [Accessed online in October 2010]: <http://www.congresoforestal.es/fichero.php?t=41725&i=208&m=2185>.
- Emanuelsson U., 2009.** *The rural landscapes of Europe - How man has shaped European nature*. Stockholm, Sweden: Forskningsradet Formas. 384 pp.
- Franca A. (ed.), 2001.** *The future of the Green Mediterranean*. Alghero, Italy: Environmental Defence Office of the Autonomous Region of Sardinia. 208 pp.
- Grain, 2009a.** The international food system and the climate crisis. In: *Seedling*, October 2009. p. 2-8.
- Grain, 2009b.** *Small scale sustainable farmers are cooling down the earth*. Barcelona, Spain: Grain. 24 pp. [Accessed online in October 2010]: www.grain.org/o_files/Sustainable-farmers2.pdf.
- IESA/CSIC, 2008.** *Ecobarómetro de Andalucía 2008*. Sevilla, Spain: Consejería de Medio Ambiente, Junta de Andalucía. 84 pp.
- IPCC, 2007.** *Climate Change 2007: synthesis report*. Geneva, Switzerland. 52 pp. [Accessed online in October 2010]: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.
- Izquierdo J., 2006.** *Desarrollo rural, conservación cultural de la naturaleza y biodiversidad: nuevas ideas para una reforma pendiente*. VIII Congreso Nacional de Medio Ambiente. Madrid, Spain. [Accessed online in October 2010]: <http://www.rimisp.org/FCKeditor/UserFiles/File/documentos/docs/pdf/0486-006677-conamatextoparapublica.pdf>.
- Jauregui B.M., Celaya R., Garcia U. and Osoro K., 2007.** Vegetation dynamics in burnt heather-gorse shrublands under different grazing management with sheep and goats. In: *Agroforest. Syst.*, 70. p. 103-111.
- Lasanta T., González-Hidalgo J.C., Vicente-Serrano S.M. and Sferi E., 2006.** Using landscape ecology to evaluate an alternative management scenario in abandoned Mediterranean mountain areas. In: *Landscape Urban Plan.*, 78. p. 101-114.
- Launchbaugh K., Brammer B., Brooks M.L., Bunting S., Clark P., Davison J., Fleming M., Kay R., Pellant M., Pyke D.A. and Wylie B., 2008.** *Interactions among livestock grazing, vegetation type, and fire behavior in the Murphy Wildland Fire Complex in Idaho and Nevada, July 2007*. Washington, USA: U.S. Geological Survey. 42 pp. [Accessed online in October 2010]: <http://pubs.usgs.gov/of/2008/1214/>.
- LEAD and FAO, 2006.** *Livestock's long shadow: environmental issues and options*. Rome, Italy: FAO. 390 pp. [Accessed online in October 2010]: <http://www.fao.org/docrep/010/a0701e/a0701e00.HTM>.
- Magadela A.M., Dabaan M.E., Bryan W.B., Prigge E.C., Skousen J.G., Dsouza G.E., Arbogast B.L. and Flores G., 1995.** Brush clearing on hill land pasture with sheep and goats. In: *J. Agron. Crop Sci.*, 174. p. 1-8.
- Moreira F., Rego F.C. and Ferreira P.G., 2001.** Temporal (1958-1995) pattern of change in a cultural landscape of northwestern Portugal: implications for fire occurrence. In: *Landscape Ecol.*, 16. p. 557-567.
- Pausas J.G., 2004.** Changes in fire and climate in the eastern Iberian Peninsula (Mediterranean basin). In: *Climatic Change*, 63. p. 337-350.
- Perevolotsky A. and Seligman N.G., 1998.** Role of grazing in Mediterranean rangeland ecosystems. In: *BioScience*, 48. p. 1007-1017.
- Ruiz-Mirazo J., Robles A.B. and González-Rebollar J.L., 2009.** Pastoralism in natural parks of Andalucía (Spain): a tool for fire prevention and the naturalization of ecosystems. In: F. Pacheco and P. Morand-Fehr, (editors). Changes in sheep and goat farming systems at the beginning of the 21st century. Zaragoza, Spain: CIHEAM-IAMZ. *Options Méditerranéennes*, Series A, 91, pp. 141-144.
- Ruiz-Mirazo J., Robles A.B., Jiménez R., Martínez-Moya J.L., López-Quintanilla J. and González-Rebollar J.L., 2007.** *La prevención de incendios forestales mediante pastoreo controlado: el estado del arte en Andalucía*. Wildfire 2007. Sevilla, Spain. [Accessed online in October 2010]: http://www.fire.uni-freiburg.de/sevilla-2007/contributions/html/in/autor_R.html.

- Thavaud P. (editor), 2006.** *Dispositif agroenvironnemental appliqué à la prévention des incendies de forêt en région méditerranéenne. Résultats de 20 ans de réalisations et propositions pour l'avenir. Document de synthèse.* Laudun, France: Éditions La Cardère - l'Éphémère. 52 pp.
- Thavaud P. (editor), 2009.** *Guide pratique pour l'entretien des coupures de combustible par le pastoralisme.* Laudun, France: Éditions La Cardère - l'Éphémère. 70 pp.
- Torrano L. and Valderrábano J., 2005.** Grazing ability of European black pine understorey vegetation by goats. In: *Small Ruminant Res.*, 58. p. 253-263.
- Varela-Redondo E., Calatrava-Requena J., Ruiz-Mirazo J., Jiménez-Piano R. and González-Rebollar J.L., 2008.** El pastoreo en la prevención de incendios forestales: análisis comparado de costes evitados frente a medios mecánicos de desbroce de la vegetación. In: *Pequeños Rumiantes*, 9. p. 12-20.
- Vélez R. (editor), 2009.** *La defensa contra incendios forestales. Fundamentos y experiencias.* 2nd Edition. Aravaca, Spain: McGraw-Hill.