https://doi.org/10.15302/J-LAF-1-020060 RECEIVED DATE | 2021-08-31

Shepherding for Wildfire Adaptation: A Case Study of Two Grazing Management Techniques in the Mediterranean Basin

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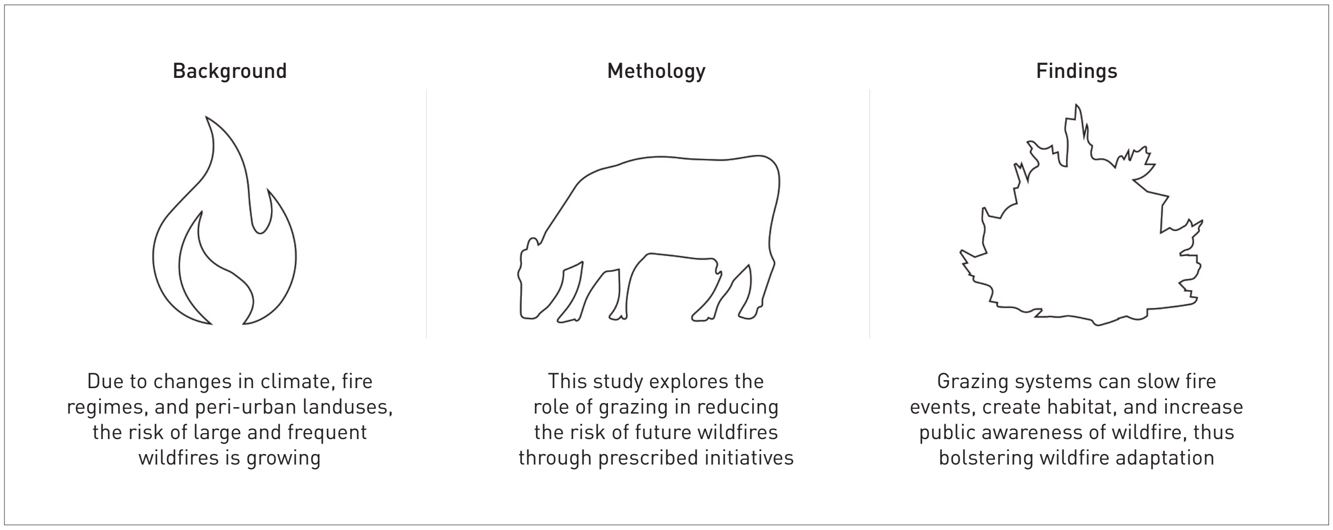
GRAPHICAL ABSTRACT



HIGHLIGHTS

- Grazing systems can be effective in bolstering wildfire adaptation
- Strategically-designed grazing systems can slow or reduce the intensity of wildfire
- Grazing systems can be cost effective when compared to conventional fuel treatments
- Grazing systems can raise public awareness on wildfire
- Grazing systems can create and diversify habitats by developing landscape mosaics

ABSTRACT

The risk of larger, more intense, and more frequent wildfires is growing across the world, especially in the Mediterranean Basin and regions of the world characterized by dry, hot summers, fire-prone and fire-adapted vegetation, and a build-up of fire fuels. These increased wildfire risks point toward a need for more effective and multi-beneficial management techniques. This paper explores two techniques aimed at reducing wildfire risk and bolstering wildfire adaptation through the act of shepherding: 1) "Fire Flocking," a technique that employs the rotational grazing of animals in overgrown forests to reduce fuel loads and create a bio-based economy, and 2) "Infrastructure Shadowing," a technique that develops a grazing program under high voltage power lines to reduce the risk of ignition. The study employs a descriptive case study methodology that combines a comprehensive literature review, stakeholder interviews, and spatial analysis; and evaluates the two cases to ascertain technical successes and challenges. While grazing systems are complex and have many variables needing to be considered, findings from the study suggest that creative and strategically designed grazing practices can slow the spread and decrease the intensity of wildfire events in a cost-effective manner, create desired habitats by developing mosaic-like landscape patches, and increase wildfire awareness. While it is clear that more experimentation should be done to explore how grazing can reduce wildfire risk, this study reveals the potential of multifunctional land stewardship practices to foster regenerative, evolutionary pathways with wildfire.

KEYWORDS

Wildfire; Climate Change; Wildfire Management; Land Stewardship; Landscape Adaptation; Grazing System

EDITED BY ZHOU Jiayi, Tina TIAN

1 Introduction

Globally, the risk of large, intense and more frequent wildfires is growing[1]. Wildfires are now impacting communities across the world, from catastrophic bushfires in Australia to ravaging forest fires in France, to fynbos fires in South Africa. Pyrogeography now touches every continent except for Antarctica and, as historian Stephen Pyne has claimed, we are living in the age of fire, the Pyrocene. According to Pyne, this geological epoch is not new; rather, it began when humans started harnessing fire to shape the land. Today, the Pyrocene is experienced in extreme forms with mega-wildfires, transformations in ecosystem types (such as forests and chaparral morphing into grasslands), and the colossal burning of fossil fuels overwhelming a planet that is warming at unprecedented rates[2]. In this deepening era, fire begets more fire.

These feral wildfires happen for three primary reasons. The first is climate change. The global climate is getting hotter and drier, which is exacerbating risk for areas that are already fire-prone, especially those characterized by a Mediterranean-type climate[3]. Mediterranean regions have a wet winter season when most of the landscape receives moisture, and a dry, hot summer season when the vegetation dries out and becomes kindling. With climate change, these regions are experiencing longer periods of drought, lower levels of humidity, and longer fire seasons which are changing regional plant phenology[3]. All of these climate change factors increase the risk of more intense and more frequent fires[4]. The second reason relates to how humans have specifically influenced fire regimes (the frequency, intensity, and overall pattern of how fires occur) across the world. For example, in some places, fire suppression has led to a build-up of vegetation and biomass that would otherwise burn at more regular intervals, thus increasing the risk of larger fire events. Lastly, wildfires are changing in character because of land use changes in the wildland-urban interface (WUI), the liminal space between wildland and the built environment where the presence of humans disrupts the ecological and structural processes that define these environments. WUI landscapes are incredibly diverse in form and structure based on urbanization character and regional conditions, and nearly always include a hybridized combination of introduced vegetation (such as highly flammable weedy annual grasses and horticultural specimens) combined with relic native plant communities. In the WUI, it is not just a motley ensemble of vegetation that can provide fuel for fires, but also houses, structures and a variety of other constructed materials that can significantly increase burn intensity. The WUI is also characterized by elevated rates of human caused ignitions, further increasing fire risk and frequency[5].

In the Mediterranean Basin, large, frequent, and higher intensity wildfires are now common due to the reasons outlined above—the effects of a changing climate, fire regimes, and peri-urban land use[6]. In this region, rural retreat (people leaving and depopulating the WUI) has led to land abandonment and the reforestation of former agricultural lands, increasing the amount of fuel available for wildfire[7]. Given the many detrimental effects of human influences on fire behavior—degraded air quality, extensive infrastructure and property damage, undesirable ecological change, etc.—there is a pressing need for more effective ways of managing wildfire, which will require adapting to a changing world. We are no longer designing for stable climates and landscapes. Rather, we are learning to work with ever-accelerating changing environmental conditions, particularly those of wildfire. Thus, there is a great need to experiment and develop a range of techniques for dealing with wildfire. Grazing, and the shepherding needed to steward it, is one of them.

2 Grazing for Fuel Reduction

Managing landscape fuel loads (primarily vegetation, dead or alive) is a wildfire adaptation strategy that includes techniques such as pruning, thinning, masticating, mowing, burning, herbicide application, and grazing. The primary goal of fuel treatment is to create spatial variation in vegetation so that the landscape being treated functions as a patchwork of plants[8]. When conducting fuel treatments, it is helpful to think about modifying the vertical arrangement of vegetation to reduce fuel ladders that drive crown fires and the horizontal arrangement of vegetation to reduce continuous surface fuels that help spread fires across the landscape. The mosaic that results from these activities help slow or stop wildfires from expanding vertically and horizontally[9].

Grazing for fuel reduction is a technique that is gaining momentum and popularity in fire-prone regions of the world. In the United States, for instance, the Healthy Forests Restoration Act of 2003 helped promote herbivore grazing as a viable way to reduce wildfire risk[10]. In the Mediterranean Basin, there has been more hesitancy to adopt the technique due to the regional historical instances of overgrazing and the potential for deforestation and desertification[8]. In recent years, though, grazing has emerged as a common wildfire risk reduction practice, with many projects scattered across countries including Portugal, Spain, France, Italy, and Greece[11].

Grazing relies on herbivores (typically domesticated, such as

1. An example of grazing to reduce landscape fuel in the Catalonia region of Spain in 2021.

cattle, goats, sheep, and horses) to modify the vegetative structure of a landscape (Fig. 1). It is sometimes referred as "preventative silviculture" or "strategic" grazing, where herbivores either forage plants for feed or trample plants into the ground to help change wildfire behavior. Grazing herbivores tend to remove smaller diameter plants which often contribute to wildfire events, helping slow the spread of fire, reduce flame length, and decrease intensity[12]. Furthermore, grazing is a technique that is often supported by the general public: it can be used on steep slopes and is more cost-effective than other fuel reduction strategies[13].

Grazing is a complex management tool with many variables that need to be considered. Currently, there is still limited knowledge about the potential benefits and limitations of various approaches including grazing for wildfire risk reduction[13]. Thus, well-crafted pilot projects that incorporate an adaptive management learning approach can significantly advance knowledge now and into the future.

There are common variables to consider when developing or assessing grazing systems for wildfire risk reduction purposes:

1) Spatial composition—whether the area being treated is linear in shape and serves as a fuel break, or a patch within a larger landscape;

2) Pre-grazing treatment—whether herbivores graze in an undisturbed landscape or whether a preliminary treatment should be done to the landscape prior to grazing;

3) Species selection—foraging preferences, diet compositions, and nutrient recycling in excrement differ from one herbivore to another;

4) Developmental stage—different life stages of herbivores selected for grazing often have different nutrient requirements;

5) Grazing time—whether herbivores graze during the growing season;

6) Stocking rate—depending on the number of herbivores used for the treatment;

7) Size—paddock (or treatment area) size can also impact the grazing intensity;

8) Maintenance—whether the treatment is intended to be a short-term or long-term endeavor;

9) Ecological benefits—how the treatment is creating new habitats and connecting to existing patches and corridors;

And 10) rural connectivity—whether the activity is fairly isolated or integrated into larger regional initiatives.

This paper unpacks two wildfire management techniques, "Fire Flocking" and "Infrastructure Shadowing," which aim to increase landscape adaptation through fuel reduction activities that decrease the amount of vegetation in the landscape. Our case study interest in these particular techniques over others are manifold, but reflect our focus on integrative, multi-benefit landscape-based approaches and the exploration and adaptation of historic and embodied/physical forms of land stewardship as landscape architects. In this paper, the two initiatives are analyzed and compared with one another to better interpret their benefits, challenges, potential in application, and further exploration in the field of landscape architecture.

3 Methods and Results

The case study employs a methodology that includes a literature review, stakeholder interviews, and spatial analysis. The literature review covers materials related to both techniques, including historical accounts of regional landscapes and fire regimes, organizational interview records, implementation plans, best practice documents, product catalogs, public-facing brochures, and operator manuals. Interviews were held with representative key stakeholders for each initiative. Interviewees included co-founders of both initiatives, a local shepherd, and a transmission service operator. Lastly, both techniques were spatialized and analyzed through a series of maps, sections, perspectives, and plans.

Based on the above research, the two cases were evaluated using criteria to ascertain technique successes and challenges. Criteria included background information on the regional landscape, an overview of the techniques and process involved, and the current direction of the initiative.

3.1 Fire Flocking Case Study

Fire Flocking is a management technique that employs the rotational grazing of herbivores in overgrown forests to reduce fuel and create a bio-based economy (Table 1)[14].

3.1.1 Background

The Catalonia region of Spain has a long and rich history of herbivore grazing and silvopastoral traditions. It is also an area that is fire-adapted and increasingly fire prone. Historically, it was common for small to medium fires (those that generally burn under 5,000 kw/m), both naturally- and human-ignited, to be found in Mediterranean pine-oak ecosystems; these fires typically burned surface fuels and were allowed to rove the landscape[15][16]. But over the past 100 years, this regional landscape has undergone significant changes that have left it vulnerable to the effects of larger, more intense wildfires. To begin, the pastoral practices of shepherding and forestry, which tend to be low paid and marginalized, have lost much of skilled labor pool[15], resulting in an exodus of people from the countryside and an abandonment of the rural fringe[16].

Following this rural exodus came a natural colonization of former agricultural lands by opportunistic vegetation and, in just a few decades, forest land use significantly grew in the region[15]. This trend was compounded by a complicated patchwork of private land ownership and a lack of mandating management legislation. Today, many of the forests in Catalonia are young, structurally similar[14], and very dense. The canopy is primarily composed of Aleppo pine (*Pinus halepensis*), which allows light to penetrate to the ground[15], promoting the growth of understory species like mastic oak (*Pistacia lentiscus*) and kermes oak (*Quercus coccifera*)[16].

Young Mediterranean forests in Catalonia are at a high risk of wildfire. The oak understory serves as vertical ladder fuel for fires, and many of the species that comprise this forest are pyrophytic—containing oils, resins, and waxes that are highly volatile. Furthermore, this landscape is under additional stress due to the effects of climate change—from droughts to insect infestations—making them even more vulnerable to dieback and fuel for future fires. Across Europe, wildfire has increasingly impacted forests, a trend which is estimated to escalate in the future[17].

Table 1: Fire flocking case study overview

Case feature	Description
Location	Catalonia region, Spain
Status	Implemented (pilot) + ongoing
Potential scale	Regional
Size	48.11 hm^2 (pilot), 500 hm^2 (current estimate)
Dominant vegetation species	*Pinus halepensis*, *Quercus ilex*, and *Pistacia lentiscus*
Grazing herbivores	Cattle, goats, and sheep
Implementation cost	≈ 1,200 EUR/hm^2
Primary implementer	Pau Costa Foundation

3.1.2 Technique Overview

In an effort to create a more fire-resistant landscape in Catalonia, Pau Costa Foundation is leading a project called Fire Flocks (Ramats de Foc)[18]. The project has five primary goals: 1) manage overgrown vegetation in former agricultural areas to reduce the amount of fuel in the landscape; 2) bring back the culture and function of silvopastoralism to the landscape by reintroducing cattle, goats, and sheep as grazers; 3) increase biodiversity by creating strategic openings in the forest cover and a mosaic-like pattern across the landscape; 4) create a unique brand of value-added agricultural products from the effort; and 5) educate the public about the project, the landscape changes facing the region, and how they can personally contribute[16].

3.1.3 Technique Process

The Fire Flocks initiative started in 2016, with four years of funding from the Fundación Daniel y Nina Carasso. To initiate zones for grazing, local firefighters consult with Pau Costa Foundation on the identification of regional "Strategic Management Points" (SMP), critical zones that could change the behavior of wildfire or help firefighters with staging and operation efforts during a wildfire event[19] (Fig. 2). Identified SMPs first undergo a mechanical fuel reduction process as pre-grazing treatment, and then local shepherds are assigned. Ideally, these shepherds own land in the SMPs, otherwise, they can sign a five-year lease with private landowners to use their land for grazing.

The fuel reduction goal of this grazing is to create both vertical and horizontal breaks in the forests. To achieve this, the shepherds work with Pau Costa Foundation to design a grazing plan that details the grazing sub-areas and flock size, rotational schedule, feed supplements, and infrastructural needs[16]. Throughout this

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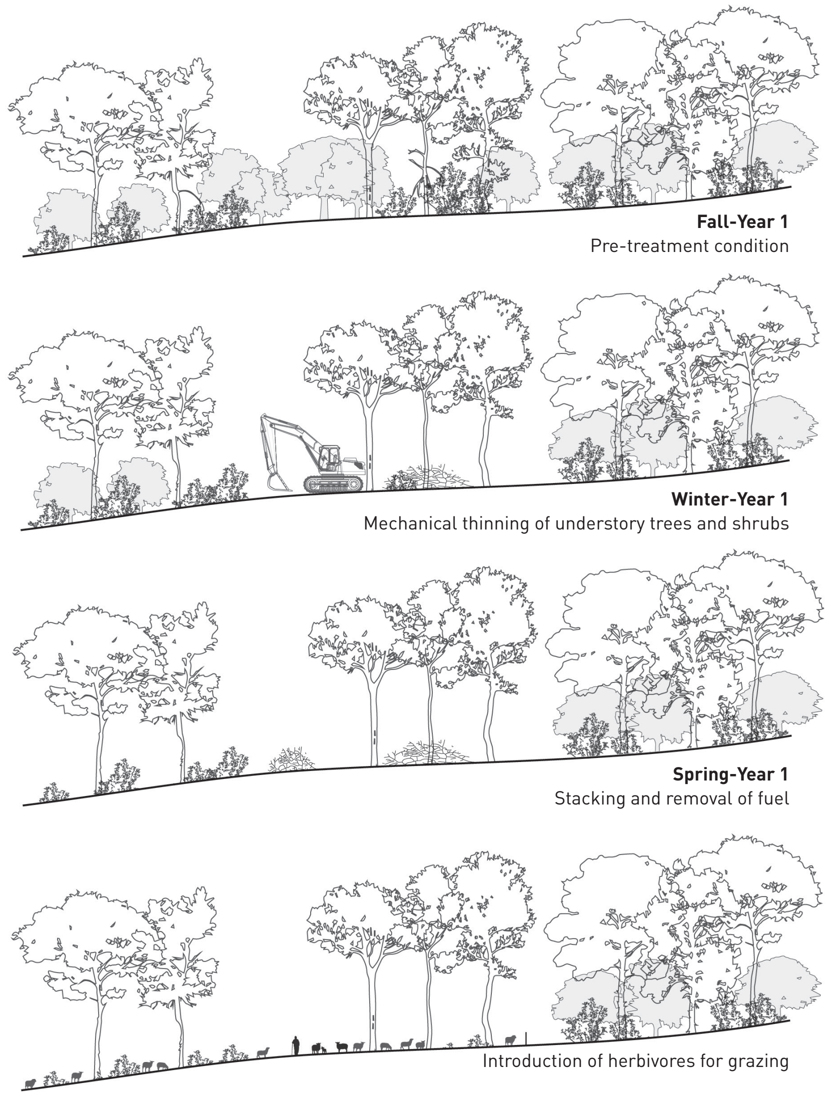
2. Map of Fire Flocking on the Baussitges Estate, located in northeastern Catalonia. After fuel is reduced in the SMPs, secondary grazing happens in a patchwork-like pattern across the rest of the estate.
3. Sequential sections showing the general implementation procedure of a Fire Flocking project.
4. Over time, patches of horizontal and vertical breaks are created in the forest through grazing.



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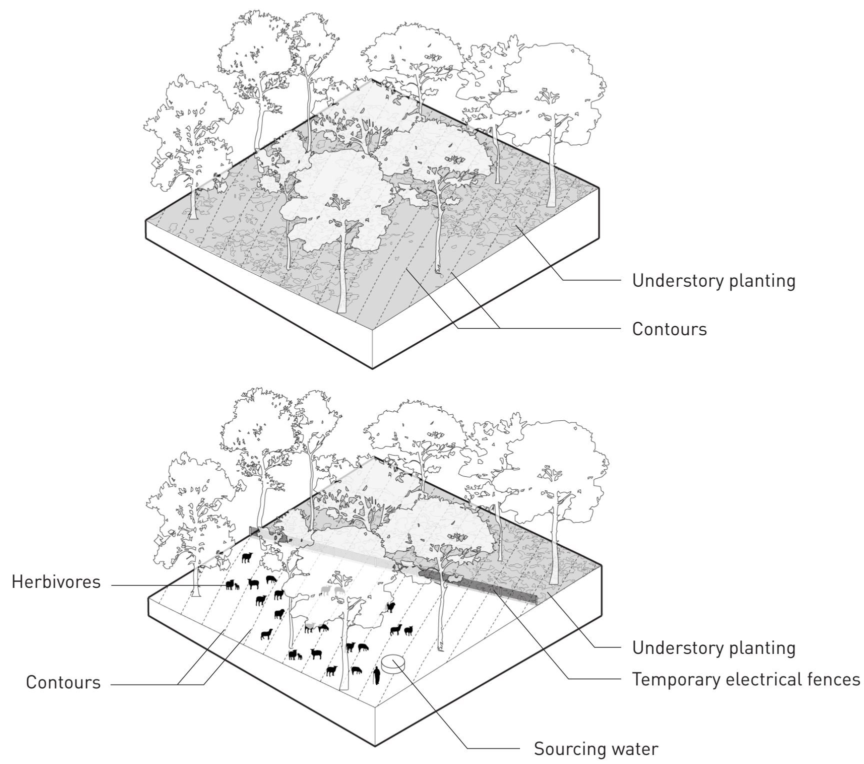
process, the shepherds are given latitude to use their own expertise to conduct the management as they see fit. Before herbivores are brought to the area, infrastructure such as paving, water points, and fencing are planned and developed to ensure a smooth operation. After a year of grazing, an inspection is done to certify a 90% reduction in annually grown herbaceous material and a 60% reduction in annually grown shrub material on the landscape. This inspection typically happens prior to the summer months when wildfires are common. Based on the success of the management process (measured by the overall reduction of fuel), shepherds could get paid up to EUR 140 per hectare per year, with the average being around EUR 100 (Figs. 3, 4)[16].

Shepherds involved in the project are allowed to use the official Fire Flocks brand, which links agricultural products to wildfire management efforts in the region. Then, based on the product type, herbivore breed, and flock size, shepherds prepare their goods over the course of the year and target butchers, shops, and restaurants appointed by Pau Costa Foundation.

3.1.4 Current Direction

Since the pilot project on the Baussitges Estate, Fire Flocks has expanded: as of 2021, the project has recruited 22 shepherds with cattle, goats, and sheep, and over 60 local restaurants, butchers, and shops. The project is now being managed by Emma Soy Massoni,



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Guillem Canaleta, and Ona Alay of Pau Costa Foundation.

With this experience, Pau Costa Foundation is also involved in a larger network of grazing organizations across Europe that contributes to knowledge-building. For example, the Fire Shepherds program seeks to educate European shepherds beyond traditional milk and meat production and toward management practices that promote biodiversity and wildfire risk reduction. In turn, the shepherds can diversify the services they offer to their clients and spread the idea of shepherding for multiple functions. The Fire Shepherds program is also creating a model for shepherding schools based on best practices to further this vision.

3.2 Infrastructure Shadowing Case Study

Infrastructure Shadowing is a management technique that develops a grazing program under high voltage (HV) power lines to increase wildfire adaptation (Table 2)[20].

3.2.1 Background

Like much of the Mediterranean Basin, Southern France is expected to experience larger and more frequent wildfire events in the near future[21].

It is well documented that fuel reduction could be an important management technique for the wildland-urban interface, especially in strategic zones that are highly vulnerable to ignition. One of these zones lies under the HV power lines that crisscross the forested and unmanaged landscapes of Southern France. Overhead HV power lines typically carry 1,000 ~ 400,000 V to transport energy across the country[22]. In the areas directly below and adjacent to this electrical network, dead or dying trees and overgrown vegetation can ignite a wildfire[23]. Additionally, issues such as line swaying due to wind and line lengthening due to heat further raise the risk of ignition. Traditionally, it is common for transmission system operators (TSOs) to develop a linear safety corridor along HV power lines—sometimes over 50 m in width—to deal with problematic vegetation[24].

TSOs typically take a conventional approach to reduce wildfire risk. They target young vegetation before it reaches the overhead lines. Their periodic maintenance process, which typically occurs every 3 ~ 12 years depending on onsite vegetative growth, usually involves a tractor equipped with a rotary cutter. If a site is too steep or has too many physical obstacles, TSOs must work manually. In both situations, mulched trees and shrubs are left onsite, typically scattered across the ground[23].

While this clear-cutting and mulching process succeeds in immediately removing fuel within the safety corridor, it poses challenges for long-term management. With access to light and soil enriched by mulched vegetation, seeds of pioneer species are able to quickly germinate and grow[23].

Table 2: Infrastructure shadowing case study overview

Case feature	Description
Location	Drôme, France
Status	Implemented
Potential scale	Regional
Size	2.5 hm^2 (pilot), 530 hm^2 (current estimate)
Dominant vegetation species	*Pinus halepensis* and *Quercus ilex*
Grazing herbivores	Horse
Implementation cost	≈ 2,100 EUR/hm^2
Primary implementer	LIFE Elia-RTE

3.2.2 Technique Overview

In an effort to find alternatives to this conventional fuel reduction process, the LIFE Elia-RTE project emerged in 2011 and continued for 6.5 years. In total, the project cost EUR 3.2 million, financed by the European Union through the LIFE program (36%), The Region of Wallonia (25%), ELIA—the Belgian TSO (24%), and RTE—the French TSO (15%). The project employed seven people and focused on 35 HV power line sites spread across both Belgium and France[22].

In general, the project had three main goals: 1) create linear corridors along HV power lines to promote habitat creation and to bolster biodiversity, 2) experiment with new fuel reduction techniques for wildfire risk reduction, and 3) educate and raise public awareness about alternative management for electrical infrastructure. To achieve these three goals, the LIFE Elia-RTE team viewed three networks that typically operate in silos as one interconnected system: the electrical network managed by the TSO; the ecological network comprised of patches, buffers, and corridors; and the social network made up of all the stakeholders with vested interest in the landscape[22].

3.2.3 Technique Process

We focused on LIFE Elia-RTE's diverse ecological habitat network designed and implemented for wildfire management, with a particular focus on grazing. This particular case sits within a larger LIFE Elia-RTE project that transformed over 530 hectares

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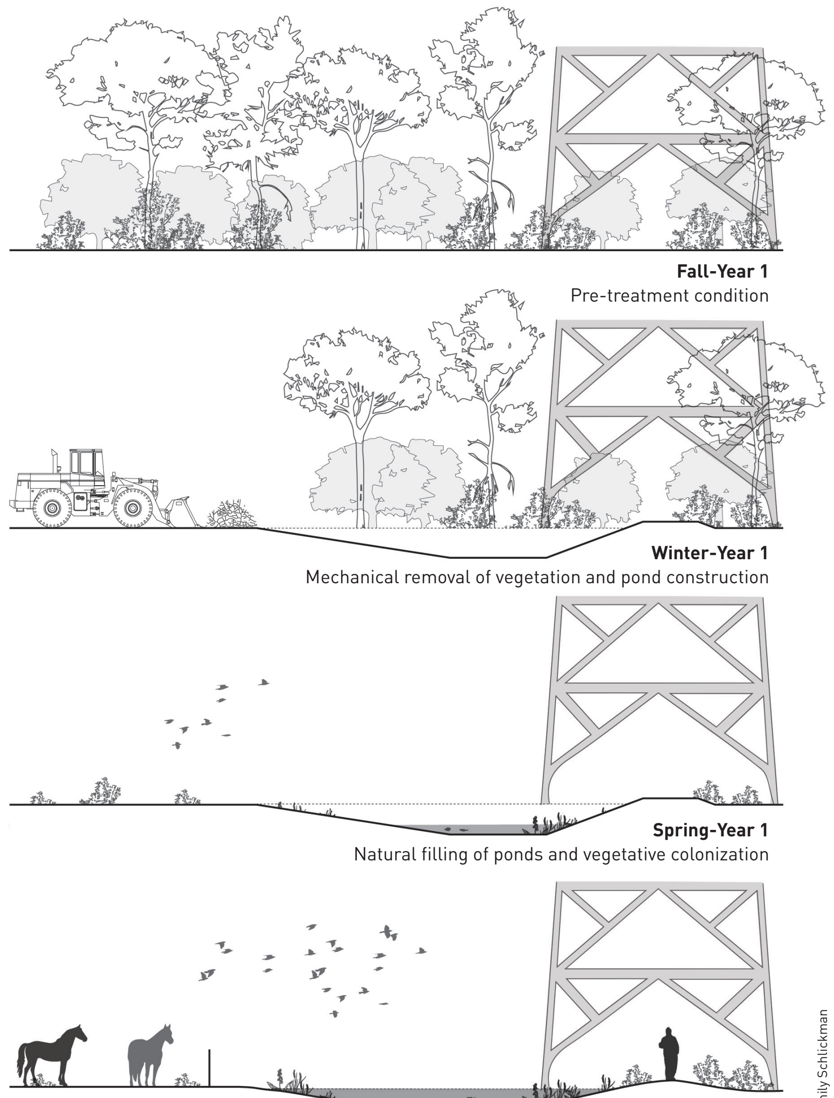
5. Map of Infrastructure Shadowing, located in Drôme.
6. Sequential sections showing the steps involved in the Infrastructure Shadowing project.
7. Over time, a linear fuel break is created along the HV power lines.



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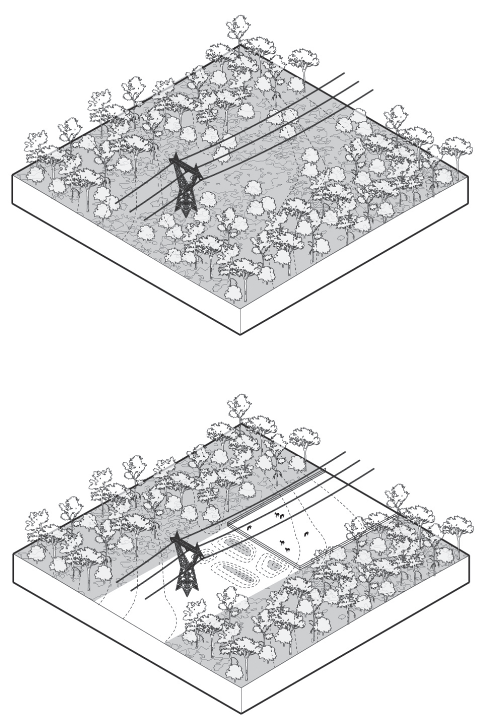
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of land under power lines into experimental plots of excavated and constructed wetlands (strategically placed near the bases of the electrical towers for maximum protection), forest edges, bogs, grasslands, meadows, orchards and pasture for grazing. Grazed areas constituted about 68 hectares, and we studied the development of a grazing program in Drôme, France. This region is primarily rural, defined by a mosaic of agricultural and forested land, and dotted with small communities. Crisscrossing the landscape are a series of HV power lines.

To test the idea of using grazing herbivores for increasing wildfire adaptation, the LIFE Elia-RTE team first selected a 2.5-hectare pilot site just north of the Drôme River and south of the small community of Allex. The site is narrow and long, with HV power lines running above (Fig. 5). In 2013, the land was purchased by the local government with an agreement between the local communities, local TSO, and representatives from the nearby National Ramières Nature Reserve. When the land was purchased, it was overgrown with woody species and invasive species like solidago goldenrod[25].

Prior to the first grazing season, the project team used heavy machinery to remove large woody plants and to prepare the landscape. The north side of the site was prepared for horse grazing and the south side of the site for wetland habitat creation. The north side was broken into two main grazing pastures. To contain the herbivores, temporary electric fences were erected around the pastures and a small shelter was built to provide protection. The electric fences prevented the herbivores from interfering with the wetland habitat to the south[26].

During the first grazing season in July and August, a number of horses owned by a local breeder were brought to the site to reduce the amount of woody vegetation within the safety corridor of HV power lines. Following the first season, the number of horses grazing the site was reduced to two[27]. This grazing pattern repeated four times until 2017, which marked the end of project funding[25] (Figs. 6, 7).

3.2.4 Current Direction

When the pilot project ended in 2017, funding was secured through a Natura 2000①[28] contract so that the National Ramières Nature Reserve could continue with the management of the site. Part of the funding was earmarked for an annual mowing of the wet meadow which was transformed through horse grazing. The other part of the funding was earmarked for continued monitoring of biological inventories on site.

With the success of the pilot project, the project team is currently working with the larger LIFE Elia-RTE effort to find ways of implementing the Infrastructure Shadowing technique in other locations beyond Southern France.

4 Discussion

4.1 Fire Flocking Case Study Discussion

4.1.1 Technique Successes

The Fire Flocks initiative has succeeded to fulfill many ecological, economic, and social goals. Studies have shown that fuel reduction activities like extensive grazing can slow the spread of and decrease the intensity of wildfire[16]. By reducing the fuel continuity both horizontally and vertically, the risk of catastrophic crown fires is reduced[19]. By developing breaks in the forest, the project has also created new habitat with a thinner understory.

Fire Flocks has also uplifted an agricultural tradition in the Catalonia region by helping to rejuvenate a rural bio-economy. By boosting shepherding and associated products, the project has supported local food production chains. In turn, shepherds in the program have received access to private property for grazing, exposure to new services and value-added products, and new management knowledge for bolstering wildfire adaptation[16].

The technique has also been considered fairly low-cost[8], especially after the initial mechanical pre-grazing treatment phase, and scalable to other fire-prone areas in Europe. Furthermore, the agricultural products branded with the Fire Flocks label have seen an increase in demand. For example, following the pilot project, there was an increase of 12% in meat sales and of 40% in the number of restaurants selling the products[16].

Lastly, the Fire Flocks initiative has helped educate people in the region about wildfire management and has invited them to get involved. The project team has found innovative ways to raise public awareness about wildfire including the development of product labels that inform end consumers of the project about how they are contributing to management with their purchase[16]. Furthermore, Fire Flocks has been an effort that involves many stakeholders, all of whom have been invested in working together to build a more fire-adapted region[29].

4.1.2 Technique Challenges

While the Fire Flocks initiative has succeeded on many fronts, it still faces a range of challenges. From a valuation standpoint, many of the stakeholders involved hold different perspectives and interests; extensive private ownership in rural areas also makes it difficult for the team to manage the landscape. For example, it is common for 20 ~ 30 landowners to own property in one SMP; thus, one rejection to grazing could reduce the impact of the management plan. Furthermore, it can be difficult to find shepherds willing to partake in the program given that traditional shepherding is a time-consuming job that requires a lot of experience and is not very profitable[19]. Creating more of a financial incentive for shepherds could help with this hurdle. Furthermore, many of the SMPs identified for the project are difficult to access and require infrastructural planning to allow for grazing to happen.

While the herbivores selected for the Fire Flocks program are already adapted to the climate and topography of Catalonian region, there is a range of productivity and efficiency in the flocks[15]. Part of this variability stems from palatability as herbivores prefer different kinds of plants. For example, sheep tend to eat grass, shoots, and other small understory plants whereas goats tend to eat brush and broadleaf vegetation. Another reason for this range in productivity is associated with access and terrain. For example, due to their size, cattle may have difficulty accessing certain areas of the SMPs due to steep slopes and natural obstacles[15].

① Natura 2000 is the largest coordinated network of protected areas in the world. It offers a haven to Europe's most valuable and threatened species and habitats (Ref. [28]).

While grazing is considered a cost-effective method for reducing fuel and while the products associated with the Fire Flocks initiative are increasing in demand, an in-depth cost-efficiency analysis might be helpful to assess financially-sustainable models for implementing Fire Flocking and how to develop pathways to get there[19].

Another challenge with Fire Flocking stems from the annual evaluation process to determine the effectiveness of the grazing regimes on the landscape. The current evaluation model uses simplified indicators that do not fully address the complexity of the management process. The timing of the annual inspections is also problematic given that the Mediterranean fire season is no longer confined to summer months. Additionally, due to the late start of the pilot in 2016 and a lack of historical data of grazing in the SMPs[16], it is difficult to make assessments of the long-term wildfire adaptation performance on the landscape.

Finding the right venues to sell the Fire Flocks products is challenging and might require the help of an external consultant. There is also a need to refine the target audience for the products beyond the typical urban, middle-aged consumers. There is also a desire to develop an everyday product that is more present on the consumer side and can appeal to a wide range of shops and restaurants.

The last challenge relates to scalability. The pilot project impacted an area of approximately 48 hm^2 in Catalonian region and the current initiatives are impacting around 500 hm^2. Moving forward, it might be helpful to better understand how SMP sizes and distribution across the landscape relates to wildfire management at a regional scale.

4.2 Infrastructure Shadowing Case Study Discussion

4.2.1 Technique Successes

Infrastructure Shadowing has succeeded on many ecological, social, and economic fronts. Through the primary act of horse grazing within the safety corridor of the HV power lines, the landscape transformed from an overgrown parcel full of woody plants toward a meadow-like landscape with fewer invasive species. This lower-profile vegetation is in an area that is highly vulnerable to ignition, helping reduce the risk of wildfire events. Furthermore, by maintaining large swaths of landscape below the power lines, linear fuel breaks are created; these can help firefighters slow wildfires that are moving perpendicular to the corridor.

Compared with conventional management techniques, the techniques employed by the LIFE Elia-RTE program, including Infrastructure Shadowing, are estimated to be 1.4 to 3.9 times less costly in the first 30 years after implementation, despite a fairly significant initial investment. Furthermore, this estimate does not take non-monetary benefits like ecosystem services into account[22].

Infrastructure Shadowing also supports local shepherds, farmers, and breeders by providing new pasture space for their herbivores. It is also a great way to raise public awareness about habitat loss and wildfire risk[22]. The technique is very visible to the public and often transferable to other linear infrastructural networks such as railways, roads, and gas lines[22].

Lastly, by creating and supporting new meadow and wetland habitat, this technique strengthens ecological connectivity by creating corridors that connect core habitat zones and boost biodiversity. These corridors are critical for facilitating the movement of species from one habitat zone to the other for feeding and reproduction. In a heavily forested region, open environments—like what can be found under HV power lines—is inviting for many species. Furthermore, for many species, these zones are stepping stones or springboards when exploring new terrain.

4.2.2 Technique Challenges

One challenge of Infrastructure Shadowing is that the safety corridor of the HV power lines may be owned by a number of people, resulting in a large number of project stakeholders. Thus, more communication and negotiation may be required to reach consensus[19].

Another challenge is that unconventional management techniques, like the one outlined in this case study, can pose a threat for TSOs to safely maintain the pylons, HV power lines, and other electrical equipment. With active grazing areas and designated habitat zones, the number of access points and service roads to this infrastructure may be limited[24]. Additionally, while there are long-term cost savings associated with Infrastructure Shadowing implemented by LIFE Elia-RTE, there is often a significant initial investment that TSOs must overcome[23].

The last challenge relates to long-term planning and how to adaptively manage these new landscapes within the safety corridors of the linear infrastructural networks. In the case of Drôme, funding was secured to ensure maintenance and monitoring efforts. But this is a relatively small site. With future projects, especially those with large sites, a long-term management plan for annual efforts will need to be prioritized.

4.3 Wildfire Adaptation Discussion

Considering the variables used for assessing grazing for wildfire adaptation purposes, the two cases outlined in this paper differ from one another in a number of ways. First is the spatial composition of the treatments. In the Fire Flocking case, wildfire adaptation is built over a large area to create a patchy, mosaic-like landscape. For the Infrastructure Shadowing case, wildfire adaptation is built through a linear fuel break—a 200-foot-wide (about 61 m) band along the HV power lines. While this linear fuel break strategy may be more manageable to implement and it may serve as a staging ground for firefighters to slow down approaching wildfires, its limited size and geographic constraints may not significantly reduce the risk of future wildfire events in the way that a more distributed, patchy treatment, like Fire Flocking, would.

The two cases also vary in terms of herbivore selection. The Fire Flocking case relies more heavily on goats and sheep for grazing whereas the Infrastructure Shadowing case relies on horses. Goats, as facultative browsers, can eat a wider range of plants, including woody and poisonous plants; they are also strong climbers and are able to reach higher vegetation. Sheep are pickier and they typically clear herbaceous materials before foraging woody plants; they are also less mobile. Due to their size, both goats and sheep are susceptible to predation and require supervision and protective fencing. Horses, on the other hand, can be more independent grazers. Yet, while they may trample more plant materials than goats and sheep, they tend to forage primarily on herbaceous material.

Another way the two cases vary is the impact of the projects on rural development and the potential to spread awareness about wildfires and potential adaptation techniques. The Fire Flocking case engages a number of shepherds, butchers, and restaurants in the Catalonia region, and contributes to a new bio-based economy with value-added products. This reach could mean more people would learn about wildfire issues and the benefits of grazing. The Infrastructure Shadowing case, on the other hand, is more limited in its reach of providing new pastures for local shepherds.

5 Conclusions

Fire Flocking and Infrastructure Shadowing share three primary facets of success. When compared with conventional long-term wildfire management practices, these techniques are more cost-effective. Additionally, both initiatives have succeeded in raising public awareness about habitat loss and other potential impacts of wildfire on the landscape. Lastly, they have created and diversified ecological habitats by developing a mosaic-like patterning on the landscape.

Yet, both Fire Flocking and Infrastructure Shadowing face three common challenges. First, with distributed land ownership, especially in small parcels involving many landowners, it can take months or even years to reach all landowners and agree on a path forward. Second, stakeholders rarely agree on long-term management planning that will ensure the continuation of the techniques. Third, neither technique has a comprehensive performance evaluation process. This is complicated by the fact that neither technique has been tested by a wildfire event.

Many of the other challenges serve as fodder for further design speculation and testing. For example, how to creatively expand and maintain both financial and emotive support from stakeholders in projects building wildfire adaptation? Are there additional ways they might be engaged? How to build and promote integrative wildfire management? Similarly, there are also many opportunities and questions regarding how grazing can be more strategically integrated into multifunctional landscape designs. Particularly for the infrastructure shadowing case, we noticed that strategically grazed areas only constituted a small portion of the overall design, and these areas were rigidly and statically defined by habitat type and by fences. As we come to better understand the finer details and potential affordances of different grazing practices, it is likely that they can be shepherded more fluidly and more broadly across a range of landscape types and uses.

There is no simple or single solution for the increasing threat of wildfires in the age of fire. We hope that this paper might inspire more landscape architects to engage in professional and pioneering work to test and evolve multi-functional landscape approaches to bolster wildfire adaptation.

ACKNOWLEDGMENTS

The authors would like to thank the following individuals for their contributions to this article: Virginia Morgan, Liao Aiyuan, Jay Deisman, Emma Soy Massoni, Marta Carola, and Gérard Jadoul. The authors would also like to thank Routledge for supporting a forthcoming book on the larger topic of landscape management techniques for wildfire adaptation.

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https://doi.org/10.15302/J-LAF-1-020060 收稿时间 | 2021-08-31 中图分类号 | TU986.3, S762 文献标识码 | A

野火适应性放牧管理
——以地中海盆地放牧管理技术实践应用为例

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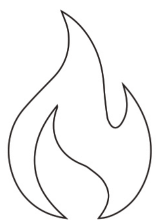
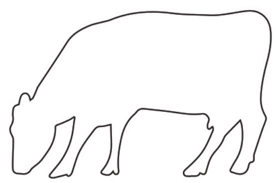
图文摘要

背景介绍



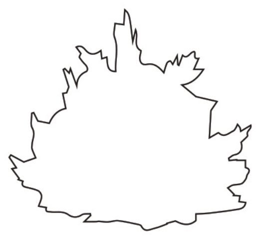
气候、起火条件和城市边缘用地情况的变化引发了更大规模、更频繁的野火灾害，应对形势日益严峻

研究方法



本研究基于实践应用，探讨了放牧管理对减少未来野火风险的作用

研究结果



放牧系统可以缓减野火灾情，创造栖息地，提高公众对野火的认识，从而增强场地野火适应性

文章亮点

- 放牧管理途径能有效增强场地的野火适应性
- 策略性放牧管理途径可以降低并减缓火势蔓延速度
- 放牧比惯常的燃料管理方式成本更低
- 放牧管理有助于建立并提升公众对野火的认知
- 放牧管理可以通过将场地划分为若干景观斑块的方式创造和丰富栖息地

摘要

全球环境变化不断加速，气候和起火条件，以及城市边缘用地情况的变化引发了更大规模、更猛烈、更频繁的野火灾害，其中地中海盆地及其他地中海型气候带地区尤甚。这些地区夏季干燥、炎热，植被具有易燃、火灾适存的特点，且存在大量可燃物质。为应对这类挑战，人们开始探索更有效、更综合、兼具多重效益的管理技术。

尽管已经尝试了多种管理方式来降低野火风险，但当前人们对于这些方式的应用潜力和局限性的认识仍然有限。放牧管理系统是其中一项策略性综合管理途径：通过啃食、踩踏，驯养的牛、羊、马等牧群在植被间（水平及垂直方向）创造出空隙，以此控制可燃物量，增强场地的野火适应性。本文探讨了两项放牧管理技术：1）“密林放牧”（Fire Flocking），一项在过度繁茂的森林中区划轮牧的技术，在减少可燃物的同时建立生态产业链；2）“基建之下”（Infrastructure Shadowing），一种在高压线下方实行计划性放牧的技术，有助于降低场地自燃风险，也从属于一项更大尺度的多功能综合景观管理规划项目。本研究以两个分别应用上述技术的项目为例，基于文献研究、利益相关者访谈和空间分析，从项目场地背景、应用技术、技术实施过程，以及发展趋势四个方面，阐述了这两个项目各自在开发及建成后评估过程中所取得的成果和所面临的挑战。

研究结果表明，策略性放牧管理途径经济有效，能够削减场地可燃物量，从而降低并减缓火势蔓延速度；其通过将场地划分为若干景观斑块，能够创造符合生态需求的栖息地；还能通过将项目带入人们的视野、引入公众参与环节或宣传推广，提高公众对于野火的认识。本研究展示了多功能综合景观管理系统通过可再生、演变式的方式应对野火的潜力。后续研究或可进一步探讨放牧降低野火风险的具体机制，建立行之有效的、全面的绩效评估体系，并探索如何将策略性放牧管理途径与多功能景观设计相整合。

关键词

野火；气候变化；野火管理；土地管理；景观适应；放牧管理措施

编辑 周佳怡，田乐