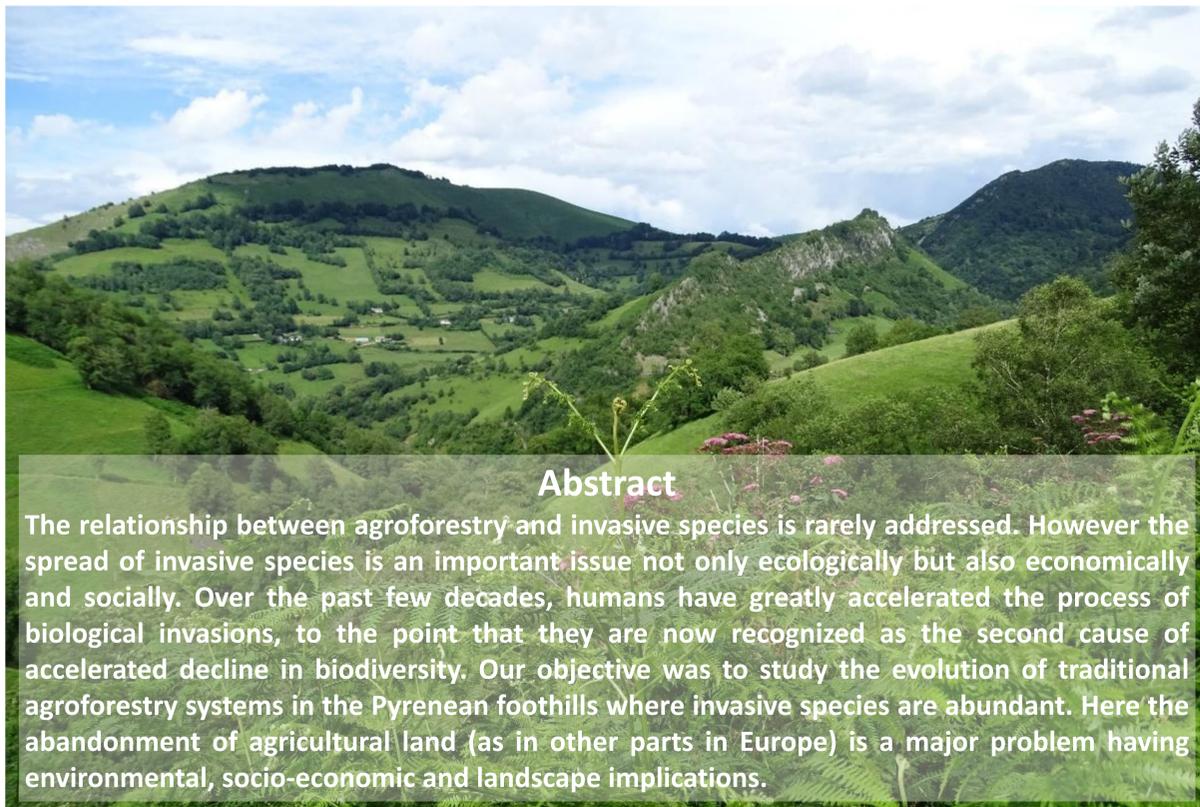


Evolution of traditional agroforestry landscapes and development of invasive species

Lessons from the Pyrenees (France)



Fig.7. Some of the invasive species of the area



Abstract

The relationship between agroforestry and invasive species is rarely addressed. However the spread of invasive species is an important issue not only ecologically but also economically and socially. Over the past few decades, humans have greatly accelerated the process of biological invasions, to the point that they are now recognized as the second cause of accelerated decline in biodiversity. Our objective was to study the evolution of traditional agroforestry systems in the Pyrenean foothills where invasive species are abundant. Here the abandonment of agricultural land (as in other parts in Europe) is a major problem having environmental, socio-economic and landscape implications.

Fig.1. The landscape of the Oussouet valley : an age-old form of agroforestry combining trees, crops and livestock, in the foothills of the Pyrenees mountains



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Methods

The area we surveyed is located in the Oussouet valley, representative of traditional agroforestry landscapes based on the combination of crops, trees and livestock, located in the Pyrenees mountains - south of France (Fig.1, 2). The dynamics of this agroforestry landscapes were assessed through the use of archival documents, diachronic mapping and testimony of local stakeholders. Their perceptions and practices about agroforestry evolution and invasive species were also studied through in-depth interviews. A botanical survey was also conducted. Finally the mapping of the invasive species (total surface and frontiers progress outside tree-covered areas) was characterised by using very high-resolution spatial drone-based technologies (UAV's - Unmanned Aerial Vehicle) and satellite images (Fig.3).



Fig.2. Oussouet valley : study area

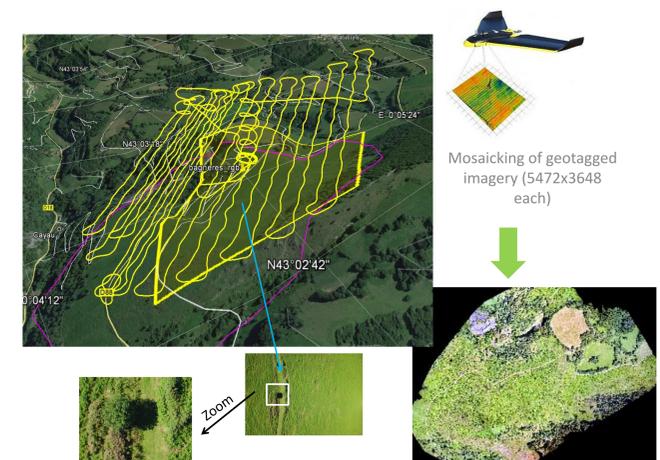


Fig.3. Drone Image Treatments [45563 x 30678 pixels / July 2017 (Labassère – 65) ; 85% of the targeted invasive plants could be detected by remote sensing]



Fig.4. Evolution of the traditional agroforestry landscapes of the Oussouet valley (Trébons village, 1954-2016). The landscapes' enclosure process is the result of the abandonment of agricultural and pastoral activities that maintained the landscapes ; this process also favoured the overgrowth by different invasive species (Aerial images, IGN)

Results (1) A decline of the agroforestry complex which favoured invasiveness

The past agroforestry landscape of this valley and the dynamics of the territory have been highlighted by a diachronic mapping, archival work and social survey (Fig.4). In this area the age-old agroforestry that shaped those landscapes was also linked to the economic activity of slate quarries. International competition has put an end to this activity and undermined agriculture. Many villagers left to settle in cities, gradually leaving the valley abandoned. Some farmers remained, but are unable to maintain the agroforestry structure. Woods, brambles, ferns and invasive species have gradually spread, closing the landscapes (Fig.5, 6, 8).



Fig.5. The hedgerow structure has disappeared due to the gradual abandonment of hedge maintenance. The closing landscapes favours the development of various invasive species in the undergrowth.

Results (2) A contrasting perception of invasive species

These landscape dynamics are regretted by farmers essentially. Our botanical surveys show the significant presence of species listed as invasive by the European Commission (Fig.7). For scientists, these species affect local biodiversity, and their eradication represents an important technical and economic challenge for local authorities. But for the farmers interviewed, the only species they qualify as invasive are essentially brambles and ferns, native species they experienced as problematic. On the contrary, this varied vegetation represents an attractive feature for neo-rural people who choose to settle in the valley.



Fig.6. In the lower valley the meadows are invaded by *Impatiens glandulifera*

Results (3) The difficulty of mapping invasiveness

Mapping invasive plant pattern requires metric or submetric spatial resolution due to the punctual nature of the invasion process in order to understand its dynamics. Until now, the few invasive plant maps exist in the form of spot surveys (SI FLORE database) or also carried out by botanical inventory directly in the field but with very limited geographical extents (at best several hundred linear metres) because of the scope of the work. We used airborne technology with a drone (UAV) equipped with a multispectral sensor to produce a submetric land use map by remote sensing and particularly to extract targeted invasive plants (Fig.3).



Fig.8. The presence of livestock is no longer sufficient to maintain the traditional agroforestry landscapes. Woods, brambles, ferns and *Spiraea japonica* have replaced the meadows and groves on the upper slopes.

Conclusions : Temporal, spatial and human issues of invasive species for agroforestry

- The decline of agroforestry favored the spread of invasive species, the landscapes not being maintained anymore.
- New management will be difficult to undertake due to contrasting perception by the different stakeholders about what is considered as invasive and what has to be protected or eradicated.
- Mapping the spatial spread of particular species is highly strategic for such a management but also a technical challenge in agroforestry conditions because the presence of trees complicates the use of drones for surveys.