 doi:10.20944/preprints201906.0305.v1

The invasive niche, a multidisciplinary concept illustrated by gorse (*Ulex europaeus*)

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Abstract

This study analyzes the natural and social factors influencing the emergence and publicization of the invasive status of gorse (*Ulex europaeus*) by comparison between countries on a global scale. We used documents collected on the web in a standardized way. The results show that in all the countries studied, there are several public statuses attributed to gorse. The invasive status is the one that is most shared. The other most frequently encountered status are those of noxious weed, and of economically useful. Invasive plant status is publicized in nearly all countries, including those where gorse is almost absent. We quantified the publicization of the invasive gorse status of gorse by an indicator with 5 levels, and then performed a multivariate analysis that combines natural and social explanatory variables. The results lead us to propose the concept of invasive niche: the set of natural and social parameters that allow a species to be considered invasive in a given socio-ecosystem.

Keywords: biological invasions; invasive species, status, ecological niche, invasive niche, *Ulex europaeus*

 doi:10.20944/preprints201906.0305.v1

1. Introduction

Biological invasions, which are considered part of global change and a major threat to biodiversity, are matters of nature and societies (Barbault and Atramentowicz, 2010, Kueffer 2013). A matter of nature, because they concern species introduced into a new territory, within a new ecosystem, that adapt, evolve biologically and genetically, and interact with other species, including humans. A matter of society, because human activities are at the origin of their introduction, voluntary or not, and because they often promoted their dispersion in the new environment. In addition, their categorization as invasive depends, for most authors, on their impacts on biodiversity - assessed by a variety of criteria, mainly scientific, but also aesthetic and moral, and on their impact on society, economy, human health and well-being (IUCN, 2017). The status of invasive species is granted according to criteria that seem objectified, but that depend on the actors and situations. In most administrative documents and regulations, they are called Alien Invasive Species, and the overall concept is shared: they are species introduced into a new environment, naturalized, able to form autonomous populations, and... invasive. However, the terms of the definition do not make consensus. To be qualified as exotic, a species must have been introduced recently, but for how long and from how far? It depends on the authors, even among scientists (Young and Larson 2011, Humair et al, 2014). Is it necessary for the introduction to be of human origin? Is it necessary that the introduction has a human origin? It depends on the texts. For some ecologists, it is enough for one exotic species to be naturalized to be considered as invasive. For others, there must be a proven geographical expansion, for most managers of natural areas and legislators, there must be a negative impact on ecosystems, economy or human health. On the other hand, economic considerations may prevent the classification as invasive, when the legislation prohibits the commercial exploitation of invasive species. Some cultural elements may also be involved to refuse to categorize a species as invasive, especially when it is considered indigenous by the local population, who claims it as part of its culture (this may be the case for example for Guava in Reunion or Hydrangeas in the Canaria). In general, categorization as invasive, even when shared by institutional actors, finds little resonance among local populations. Indeed the endemic / exotic dichotomy, so important for ecologists, is not shared by the populations, who categorize the species rather as domestic or wild, useful or harmful (Larrère and Larrère, 2009).

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Studies aimed at predicting the risk of biological invasions are numerous, since the fight against invasive species is difficult, expensive, and not always successful, so that early management actions are considered to be a determining factor in their effectiveness (IUCN). , 2019). All of this studies focus on biological and ecological aspects, either to try to predict whether or not a species will become invasive, or, when a species is listed as such, to estimate its potential geographical range, the places where it has the biological and ecological possibility of establishing itself and forming autonomous populations. In the latter case, ecologists refer to the concept of niche. The ecological niche of a species can be considered as the set of environmental conditions necessary for its establishment (Odum, 1959). Its main dimensions are the bioclimatic dimension, the edaphic dimension, and the ecosystem dimension (e.g. competitors, pollinators…). At large geographical scales, it is the bioclimatic dimension that is limiting, and climate is considered to act as the main initial filter of invasive species distribution (Vicente et al. 2010; Cabra-Rivas et al. 2016). Species Distribution Models (SDM) focus on the climatic dimension. They use bioclimatic variables, extracted from raw climatic variables such as rainfall or temperature, but either combined, or considered over significant time periods, such as maximal temperature of warmest month, or average rainfall of the warmest quarter. These models make it possible to determine the potential niche of a species, that is to say the regions of a territory where it can settle if it is introduced. However, the settlement of an exotic species is not sufficient the society that inhabits and uses or manages the territory to consider the species as invasive. The species that become invasive in their new environment are rarely considered problematic in their area of origin, and therefore have a particular propensity to change their status depending on the situation. The status of invasive species, among ecologists but even more so among managers or public institutions, varies according to geographical areas, periods, and socio-economic context (Larson 2007; Kull et al., 2018; Udo et al., 2018). Understanding the risk for a species to become invasive therefore implies taking into account not only natural factors (biological properties of the species and biophysical properties of the territory), but also social factors. It is this hypothesis that we want to test at a global scale through the case of the gorse *Ulex europaeus*.

Ulex europaeus is a very common thorny bush on the Atlantic coast of Europe, in Spain, Portugal, France, UK, and Ireland. It has long been used in agriculture, as fodder, for hedges, litter etc., which, combined with the aesthetic aspect of its flowering it produces flower, has made it the

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emblematic species of several regions, such as Brittany (West of France) and Galicia (Northwest of Spain) (Atlan et al., 2015). It flowers 8 months a year, and produces fragrant, bright yellow flowers. The species was introduced into many European colonies during the 19th century on a voluntary basis as hedges or fodder, but quickly spread out of control in agricultural and natural areas, and is now considered a major invasive species by IUCN (Lewe et al., 2010). Its rapid growth, its abundant fructification and its strong capacity to resprout makes it very difficult to eradicate once established (Hill et al., 20118). Many countries have implemented control programs, the oldest of which date back to the 1930s in New Zealand, others were gradually implemented in Australia, Tasmania, Hawaii, Chile, and Reunion Island (Hill et al., 2008; Hornoy et al., 2013, Udo et al., 2018). It has been a highly studied species since the 1970s; moreover, it is easily identifiable from afar, which means that a great deal of data is available in the scientific literature and on the web on its presence, ecology and evolution. Its worldwide distribution, compiled from various sources, is available in Open Access on the GeoNetwork website (Atlan and Limbada, 2019).

The analysis of the bioclimatic niche of gorse has been carried out by several authors at the regional level (e.g. Hernández-Lambraño et al., 2016) and has shown that gorse is far from having filled its potential niche, confirming that its geographical expansion capacity is still important (Hill et al., 2008). We have extended this analysis of the bio-climatic niche to the global level, which allows us to estimate the level of adequacy of the local climate of all regions of the world with the ecological needs of gorse (Christina et al., 2019).

An analysis of the natural and human factors leading gorse to be considered invasive in the public sphere was carried out on a particular territory, Reunion Island (Udo et al., 2016. 2018). This territory has the advantage of being small, well circumscribed, and documented by abundant archives. The study was based on field survey, literature review and semi-structured interviews with stakeholders concerned or impacted by the expansion of gorse. We use the term "status", initially proposed for humans by Linton (1945), to describe the place attributed to a species in a given social system at a given moment. A status can reflect personal skills, abilities, and efforts of a person, and is thus linked to the attributes of an individual. Applied to plants and animals, this concept makes it possible to link the biophysical characteristics of a species to its place in the social system (Udo et al., 2018). We called “public status” the status carried by public groups, such as state institutions, recognized authorities or organized groups, and proposed the word “publicization” to designate the processes and media by which an issue is integrated and gains

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visibility in the public sphere (Carrel, 2015). Five types of status were identified for common gorse in Reunion (useful, nationalistic, indigenized, agricultural pest, and invasive), each peaking at a certain time, and then reverting to a low-key presence (Udo et al., 2018). These statuses partly overlap with those identified by historical surveys in New Zealand: useful plant, noxious weed, invasive plant (Isern, 2007; Bagge, 2014).

In the present study, we made a macroscopic analysis of the natural and social factors influencing the emergence and publicization of the different status of gorse, and in particular its invasive status, at a global scale, by a comparative analysis between countries. Data were collected on the web in a standardized way. We selected a first set of a small number of countries to identify the main status assigned to gorse, before making a specific request for invasive status to a larger number of countries. Our objective was not to allow a detailed analysis of all the factors involved in the invasiveness of gorse, but to identify some of the macroscopic factors involved in the emergence and spread of the invasive status of gorse in the public sphere.

2. Methods

The study was based on data collected on the web. It took place in two stages. First, we identified all the representations and status of gorse on a subset of countries. These countries were chosen either because our team had studied the sociological and ecological aspects of gorse in the MARIS[1] research program (2014-2018), or because of their advantage to perform a comparative analysis. The three countries studied in the MARIS program are Reunion Island (France Overseas, Indian Ocean), Tenerife Island (Spain, Atlantic Ocean) and New Zealand (Pacific Ocean). We have added all the countries of South America with gorse to this list. Indeed, on this continent, gorse is present in 11 countries, with a great diversity of situations. In all these countries, we carried out a complete analysis of the gorse's status and constructed an indicator of the publicization of the invasive status. This indicator has been studied for 7 complementary countries; to include almost all the countries where gorse is present.

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2.1. Identification of the status of the gorse

Data were collected between August and October 2016. We used three sets of keywords on three search engines (Table 1). We have made requests with the name of gorse in the local languages, in English, and with its official Latin name. When there were several common names for the same country we started with a google image search to see which one brings out the most photographs or illustrations of gorse, and retained that one for the analysis. This made a total of 7 combinations, and for each combination, we consulted the first 20 results. For English-speaking countries where the name in the country's language and the name in English are identical, we consulted the first 40 results when two combinations were identical.

Table 1: Details of the research carried out to identify the status of gorse in the countries studied.

request	**Google**	**Google scholar**	**Google news**
gorse local name country name in local langage	sites housed in the country	/	national and local press of the country
gorse latin name country name in local langage	sites housed in the country	language of the country	international press
gorse latin name country name in English	all sites	all languages	/

For each country studied, we counted the total number of documents corresponding to each of the identified statuses. Seven main types of documents were identified: scientific articles, scientific reports, websites linked to public institutions, national or local press articles, regulatory texts, private non-commercial websites (e.g. blogs), private commercial websites. We also noted in which types of spaces gorse is present (land use, land status, type of natural habitat...), which types of actors or social groups use these spaces, which stakeholders are mobilized on gorse, with whom they are in network, which are the most often cited types of impacts of gorse, what are the techniques of control used, what are the most cited usages.

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Beyond this systematized research, we looked for factors related to the country's mobilization on the more general themes of environment and biodiversity. For the theme of invasive species, we looked for the existence of an official list by the government and for the existence of research institutions that devote part of their work to that topic. For nature protection, we looked for the existence of national parks, nature reserves, research institutions on ecology, the proportion of the country classified as protected areas, the presence of natural or mixed UNESCO sites, the involvement of IUCN. For land use, we looked for the country's proportion of agricultural land and permanent grassland.

2.2. Construction of an invasive status indicator

We have created a five-level indicator of the publicization of the invasive status of gorse:
Level 0: no publicization of the invasive status.
Level 1: only publications in specialized literature by scientists and environmental managers.
Level 2: Level 1 + mention of gorse on the official national list of invasive species and/or on sites of public institutions.
Level 3: Level 2 + implementation of gorse management action.
Level 4: Level 3+ mention by amateurs (often naturalists) and by the general public (through blogs, private sites, local press).

The assignment of a level of this indicator for each of the countries studied was first based on the set of data collected on google, google scholar and google news. Then, in order to ensure that we did not underestimate the level of publicization in each country, we supplemented this with targeted research on regulations, the management strategies and on the expression of invasive status by amateurs and the general public. This second data collection was done both for the initial subset of countries, and for some additional countries, chosen to include all types of situations. These countries are South Africa, Australia, Canada, USA West Coast, USA Hawaii, Madagascar, and Sri Lanka.

To analyze the factors that may explain the value of this indicator, we identified and estimated a set of explanatory variables. The choice of the explanatory variables tested was based on our previous work on gorse, in biology (Hornoy et al., 2011, Christina et al., 2019), history

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(Atlan et al., 2015, Udo et al., 2016) and sociology (Udo et al., 2018). These variables had to be both relevant to this work and available in a standardized way for all the countries studied.

- Bioclimatic factors. At large geographical scales, climate is considered to act as the main filter of invasive species distribution (Vicente et al. 2010; Cabra-Rivas et al. 2016). We used the results of the global SDM model performed to establish the bioclimatic niche of gorse (Christina et al., 2019). We retained the presence probability threshold, calculated using the sensitivity-specificity maximization method (Liu et al., 2005), and calculated the proportion of the country whose climate is above that threshold. This corresponds to the proportion of the country where the climate fulfills the requirements of gorse.

- The effective presence of gorse. We have retained three variables: the presence of gorse in protected natural areas and the presence of gorse in agricultural areas (mainly permanent grasslands), and added the proportion of the country in permanent grasslands (Source: https://www.cia.gov/library/publications/the-world-factbook). It would have been interesting to include the total area occupied by gorse, but this data was not available. The date of introduction: were not included: they are almost all during the19th century (Atlan et al., 2015),), so that their differences, often below the estimation error, has no relevant significance.

- A geographical variable, the latitude. We have retained this variable because in high latitudes (equatorial and tropical zones), gorse is present in mountains, while in temperate zones it is present at sea level (Hornoy et al., 2011, Christina et al., 2019). Mountainous areas are often the least anthropized, the richest in biodiversity and/or protected areas. Lowland areas generally host more agricultural or silvicultural areas and less protected areas (excluding wetlands in which gorse cannot settle). As countries can extend over a wide range of latitude, we have chosen to group them into three main classes (tropical, temperate equatorial) rather than averaging or choosing centroids.

- Sociological variables. To estimate the sensitivity to the protection of biodiversity we have the proportion of the country classified as protected areas (Source: https://www.protectedplanet.net/), and the Social Progress Index, a multidimensional index that includes environmental quality (Source : www.socialprogressimperative.org/global-index/). This index considers information on waste treatment, biodiversity and habitats, greenhouse gas emissions, and mortality attributed to outdoor air pollution.

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We conducted a multivariate statistical Hill and Smith analysis (performed with R software), which allows the combination of quantitative and qualitative variables.

The explanatory variables were coded as follows:

CLI = Proportion of the country above the bioclimatic threshold of gorse presence

LAT = Latitude 1: [0-15], 2= [16-30], 3= [50-60].

PRO = Proportion of the country classified in protected natural area.

GNA = Presence of gorse in protected natural areas: 0=none, 1= one area, 2= several areas.

PER = Proportion of the country in permanent grassland.

GPX = Presence of gorse in permanent grasslands or other agricultural areas:

GPY=Yes, confirmed presence

GPN=No, absence or no information detected with our requests.

SPI = Social Progress Index

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3. Results

3.1. Identification of the public status of gorse in a subset of countries

In all the countries studied, we observed several public statuses attributed to gorse (table 2). The invasive status is the most shared, it is present everywhere except in Peru and Madagascar, and it is often dominant or co-dominant in the public sphere. The second most frequently encountered status is that of economically useful plant but this status is never dominant. The agronomic pest/weed status is present in only 5 of the 11 Latin American countries and in all the MARIS countries. When it is present, it is generally dominant or co-dominant. We have divided the status of useful plants into three sub-categories: economically useful (agricultural uses as hedges or fertilizers, economic valuation of flowers or cutting wastes), ecologically useful (mention of positive biotic interactions with native animal or plant species, ability to retain soil), and biomedically useful (Bach flowers, infusions).

Table 2: The public statutes of gorse identified in the specialized literature (report, academic article) and in the sites of public institutions. D: dominant status. C: co-dominant status.

	Country	Invasive	Agronmic pest	Landscaping	Useful		
					economy	ecology	medical
South America	Argentina (AR)	C	C	x	x		x
	Bolivia (BO)	C			C		
	Brazil (BR)	D	x		x		
	Chile (CL)	x	D		x		
	Colombia (CO)	D			x		x
	Costa Rica (CR)	D		x	x		x
	Ecuador (EC)	x		x			x
	Falkland (FK)	D	x	x	x	x	
	Mexico (MX)	x		x	x		x
	Peru (PE)			x			x
	Uruguay (UY)	C	C	x	x		x
MARIS	Tenerife (TE)	D	x				
	New Zealand (NZ)	x	D	x	x	x	x
	Reunion (RU)	D	x	x	x	x	x

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3.2. Analysis of the factor determining the publicization of the invasive status

For each country studied, we collected all the documents expressing the invasive status of gorse and calculated the invasive status indicator (Table 3)

Table 3: Type of documents where the invasive status of gorse is publicized, and corresponding level of the indicator of the invasive status.

	Type of documents	Scientific publications manager's reports	Regulations government website	Gorse management	Popularization books, amateur websites	Private websites blogs, local newspapers	Invasive status indicator
	autors/public	Scientists and managers	Politics, jurists	Managing organisations	Amateur naturalists	General Public	
South America	Argentina (AR)	X	X				2
	Bolivia (BO)	X					1
	Brazil (BR)	X	X	X	X	X	4
	Chile (CL)	X	X	X	X	X	4
	Colombia (CO)	X	X	X	X	X	4
	Costa Rica (CR)	X	X				2
	Ecuador (EC)	X					1
	Falkland (FK)	X	X				2
	Mexico (MX)	X					1
	Peru (PE)						0
	Uruguay (UY)	X	X	X			3
MARIS	Tenerife (TE)	X	X	X	X	X	4
	New Zealand (NZ)	X	X	X	X	X	4
	Reunion (RU)	X	X	X	X	X	4
Other countries	South Africa (SA)	X					1
	Australia (AU)	X	X	X	X	X	4
	Canada (CA)	X	X	X			3
	Hawai (HI)	X	X	X	X	X	4
	Madagascar (MG)						0
	Sri Lanka (SK)	X	X	X			3
	West Coast USA (US)	X	X	X	X	X	4

The multivariate statistical analysis of Hill and Smith (performed with R software) explains 85% of the variance of the indicator. The first three axes of the analysis explain 43.2, 27.9% and 12.6% respectively The spatial structuration of the indicator between the first two axes is clear (Figure 2). The variables contributing to each axes are presented in Table 4. The first axis mainly includes socio-ecological variables (presence of gorse in protected areas, absence in agricultural areas, Social Progres Index) and latitude. The second axis corresponds to land use variables, the proportion of the country in permanent grasslands and the country's proportion of protected natural areas. The third axis corresponds to the variables related to the ecology of gorse: the proportion of

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the country climatically favourable to gorse, but also the proportion of protected areas and the presence of gorse in protected areas.

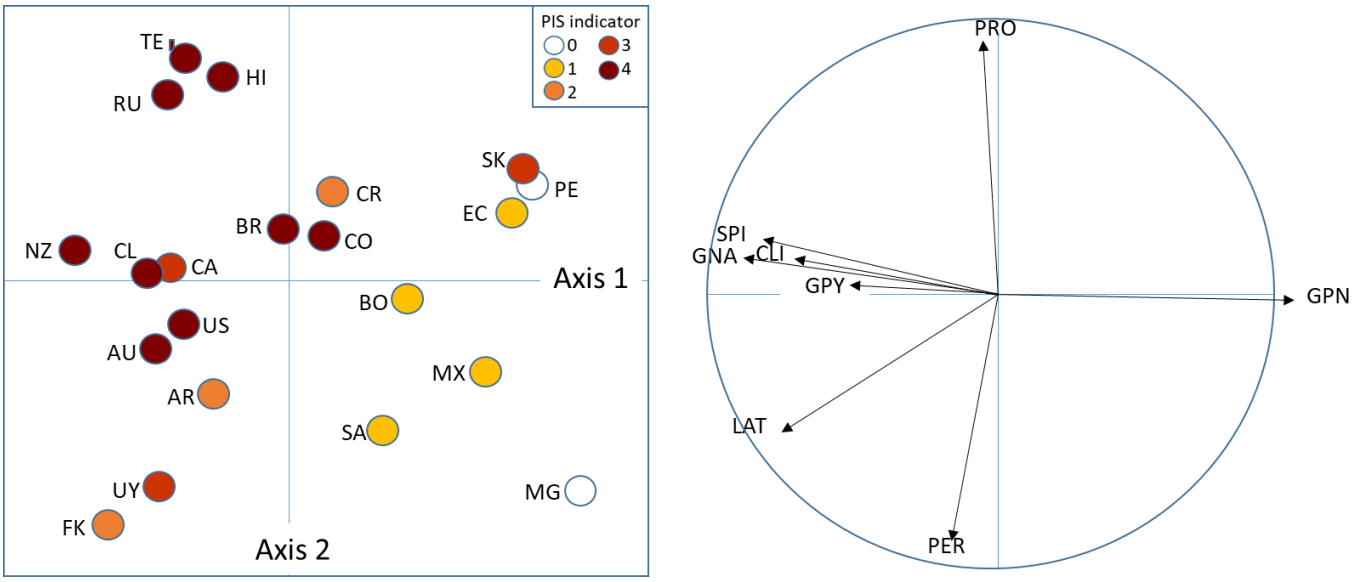

Figure 1: Results of Hill and Smith Analysis on the Publication of Invasive Status (PIS) indicator.
Left: distributions of the countries studied on the first two axes. Right: projection of the explanatory variables on the first two axes. Country abbreviations are given in Table 3, variables abbreviations are given in Methods, paragraph 2.2.

Table 4: Absolute contribution of the first 3 axes and relative contribution (%) of each variable to first 3 axes. In bold, contributions >15%.

	Axe 1 (43.2%)	Axe 2 (27.9%)	Axe 3 (12.6%)
CLI	**10.27**	4.11	**61.41**
LAT	**22.32**	5.61	3.28
GNA	**20.06**	7.06	10,00
GPN	**16.90**	1.49	2.26
GPY	5.28	0.46	0.71
PRO	0.67	**35.90**	**18.34**
SPI	**23.05**	5.90	2.68
PER	1.44	**39.47**	1.32

 doi:10.20944/preprints201906.0305.v1

4. Discussion

4.1. The diversity of the status of gorse in the public sphere

In all the countries studied, we identified several statuses of gorse. The invasive status is the most expressed, and when present, it is generally dominant or co-dominant in the public sphere. The other two statuses that can have significant public expression are the status of agricultural pest/weed and the status of useful plant. The status of agricultural pest is directly related to its presence in agricultural areas (mainly permanent grasslands) or its ability to spread fires. The usefulness of gorse is expressed in a differentiated way according to the countries. The economic utility (agricultural for hedges of fertilizer, or related to the valorization of flowers or cutting waste) is the majority. It is partly related to the initial causes of the voluntary introduction of gorse (Atlan et al., 2015), but other uses, such as dyeing, are independent of the causes of the first introductions. Ecological utility (positive effect as a shelter for animals, nursery effect for plants, ability to retain soil) is the least frequently mentioned, and mainly in recent documents, probably reflecting the emergence of the concept of "novel-ecosystem" (Hobbs et al., 2009, Backstrom et al., 2018). Biomedical utility is often mentioned, but applied on a small or even individual scale and the therapeutic indication is not mentioned (except for Bach flowers, where gorse is used to "fight deep despair"). The "landscaping" status, linked to its abundant flowering and photogenic aspect, is rarely expressed in texts, but is characterized by the abundance of gorse photos, in private sites or in tourist sites and travel guides and documents. These statuses have already been identified in New Zealand (Isern, 2007; Bagge, 2014), and in Reunion Island (Udo et al, 2018). On the contrary, one of the statuses identified in Reunion Island (that of a patriotic plant) has not been found in any other country. This status, expressed during the Second World War, is the result of the Reunion particular isolation during the war. For the other countries, we did not take into account temporality in identifying the status. The time of the analysis mainly covers the period from 1980 to 2016, which corresponds to the digital age and the diffusion of specialized literature on the web. The dominant statuses in the public space may have been different before 1980. This is obviously the case for the invasive status, since the concept began to be widespread only after 1980 (Richardson and Pyšek, 2006). In addition, the same status in different regions of the world may have a different history or components. Only a thorough analysis of each territory would make it possible to trace the history of each status.

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4.2. The relationship between agricultural pest and invasive status

These two statuses correspond to the presence of gorse in two different spaces, agricultural and natural areas, but also to two different socio-ecological models. In some countries, the noxious status of gorse is very present in specialized literature such as reports, institutional texts, private sites and press articles (Chile, Uruguay, USA, Australia, New Zealand). The negative impacts described are related to agricultural areas, loss of lands and productivity, and the type of argument is agro-economic. The majority of the scientific documents mentioning these justifications were published around 1980-2000, but some are more recent. From the 2000s onwards, articles on the expansion of gorse in these countries combine agro-economic arguments with ecological arguments, linked to the loss of biodiversity, habitats and the increasing scarcity of indigenous species. The status of agronomical weed has been a springboard for publicizing the invasive plant status. On the websites of public institutions, amateurs and blogs of the general public, the economic and ecological impacts are also linked. The countries concerned by this process are rather the countries of temperate regions, where gorse populations, like most agricultural areas, are located at sea level. It is within this group of countries (namely New-Zealand) that the pioneering teams on gorse control techniques, whether mechanical, chemical, or biological are found. It is also in these countries that there is the greatest diversity of projects for the economic development of gorse. This can be explained on the one hand because gorse is easier to manage and collect mechanically in agricultural areas than in natural areas. It is thus more likely to be used in a traditional or industrial way. On the other hand, these countries express less conceptual incompatibility between economic development and control than those where gorse is mainly present in (protected) natural areas.

At another extremity, the agricultural weed status is absent or dissociated from the invasive status in the public sphere. In this case, the current dominant status is that of invasive (Colombia, Brazil, Sri Lanka, Hawaii, Reunion Island). The negative impacts described are related to natural areas, the type of argumentation is scientific, based on the need to protect biodiversity, ecosystems, indigenous and endemic species. This kind of advertising began in the early 2000s. Research teams working on gorse are often linked to institutes of ecology, environmental management and nature protection associations. The countries concerned by this advertising process are rather the countries of tropical latitudes, where gorse and natural areas are both located at high altitudes. All

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mountainous tropical islands fall into this category, as they combine the above-mentioned characteristics and are also recognized as particularly rich in endemic species. In these countries, we have identified projects for the economic development of flowers or gorse cutting waste, but not projects for the development of the whole plant as in Chile or New Zealand. This can be explained by the difficulty of mechanizing collection in natural areas, where the topology is steep, and gorse often mixed with native and endemic vegetation that must be preserved. It can also be explained by a conceptual rather than technical blockage, on the risk of economically valuing a species that managers want to eradicate.

4.3. Factors explaining the publicization of the invasive status of gorse

We have constructed an indicator based on the presence of the invasive status of gorse in the public sphere, and analyzed its variation with a multivariate analysis. This analysis explains 85% of the variance, which shows that the variables used have a very important explanatory power. Axis 1 alone structures 43.2% of the variance, it includes in particular the presence of gorse in protected areas, and its absence in agricultural areas, the first factor being characteristic of situations where gorse has invasive status, and the second characteristic of situations where gorse has an agronomic pest status. The invasive status may become more easily the dominant one in the public space when the agronomic pest status is absent. Latitude also contributes to that axe, which comes partly from the socio-ecology of gorse (the species grow in increasingly higher and less humanized areas as the latitude decreases). The Social Progress Index contributes largely to this axis, which can reflect both the greatest ecological concern of countries with high IPS and the greatest Internet access of their inhabitants. The second axis is composed of land use variables, the proportion of the country in permanent grasslands and the proportion of the country in protected natural areas, which are negatively correlated. The first is linked to the publication of the invasive status, and the second is linked to the publicizatoin of the agronomic pest status. The main variable contributing to axis 3 is the fit with the bioclimatic niche of gorse, i.e. the ability of gorse to grow in large areas of the country. The presence of gorse in natural protected natural areas also contributes to structuring this axis.

This analysis shows that the publicization of the invasive status of gorse combines ecological, socio-economic and geographical factors. Estimating and predicting the invasive risk

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associated with this species cannot therefore be the result of ecological studies alone. The relatively weak explanatory power of the bioclimatic niche in our model must however be tempered by the fact that we have only included countries where gorse is present, i.e. where at least part of the territory is bioclimatically favourable to the establishment of the species. It is obvious that bioclimatic compatibility is a limiting variable in the estimation of invasion risk. But once the country has a climate compatible with gorse, then it is rather the variables of land use and social progress that play a decisive role. In countries where gorse can settle, a high level of publicization of the invasive species status implies a relatively high Social Progress Index (above 70, the international average being 65.82), a high proportion of protected areas (> 20%) and the presence of gorse in at least one protected area. On a finer scale, a multidisciplinary study of each territory, that includes a higher number of social variables, would be necessary to refine the relative contribution of each factor and the accuracy of their predictive value.

4.4. Conclusion

The study has several limitations. The indicator used was estimated with data collected on the Internet via Google's search engines; it reflects the publicization of the invasive status on a particular media. Although that media compiles a lot of different sources, the indicator is not constructed to reflect the experience of the population or environmental professionals (scientists, experts, politicians) who may have a dissonant discourse in relation to official publications. Furthermore, the achievement of advertising level 3 (effective management of gorse) and then 4 (recovery of invasive status by amateurs and the general public on private sites) depends on the material, logistical, management and private capacity to publish and disseminate on the Internet their works or their personal thoughts. Finally, to carry out a quantitative study at a global scale, we had to select only variables that could be obtained in a standardized way for all the countries studied, while additional social and ecological variables may also have been relevant.

Despite these limitations, the model that combines the selected natural and social variables explains 85% of the variance of the invasive status of gorse in the public sphere. This shows that at this large scale, the variables we used to predict the publicization of the invasive status of gorse are relevant and provide a fairly good prediction. It confirms the importance of taking into account both social and ecological variables in biological invasions, and leads us to propose the concept of invasive niche. As the concept of ecological niche, it is composed of several dimensions and can be applied at different scales, and can be relevant even when only a subset of these dimensions are studied. We thus propose the following definition: The invasive niche of a species is the set of natural and social parameters that allow a species to be considered as invasive in a given socio-ecosystem.

Acknowledgements

The author thank Maya Gonzales, Véronique van Tilbeurgh, Catherine Darrot and Philippe Boudes for constructive discussions on the concept of invasive niche. They also thank Fawziah Limbada and Mathias Chistina, for their help in the statistical analysis. The study was financially supported by the MARIS ANR project (Agence Nationale de la Recherche, grant ANR-14-CE03-0007-01).

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