



## *Ulex europaeus*: Update on the presence and control in the eastern region of Uruguay

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### Abstract

*Ulex europaeus* is an invasive exotic species that is reported in Uruguay associated with forest crops and grasslands in the eastern region of the country. With the objective of updating the records of its presence, and characterizing the environmental conditions where it is reported and the control measures applied, in 2019, livestock and forestry producers from the Eastern region were surveyed. In parallel, a survey was carried out with the "snowball" method to collect more sites with the presence of gorse. New reports account for 38 sites in the region. The invader was reported mainly in rocky lands, high areas and on wire fences. The controls most used by the producers were chemical control and grazing, while they considered the mechanical and chemical combination as the most effective. The greatest difficulty they pose to carrying out controls is the economic cost. Likewise, the lack of coordination between neighbors is a limitation to achieve results in the controls carried out. Most of the respondents do not perform preventive controls. The respondents indicate that reductions in sheep stock have been one of the causes for the presence of gorse in the region. The problem caused by *Ulex europaeus* must be addressed through the application of an integrated weed control in a coordinated and continuous manner by the different members of the society involved, and also communicate the results to sensitize the community.

**Keywords:** gorse control, forestry, grasslands, invasive species

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## *Ulex europaeus*: Actualización de la presencia y las medidas de control en la región este de Uruguay

### Resumen

*Ulex europaeus* es una especie exótica invasora que se reporta en Uruguay asociada a cultivos forestales y pastizales en el este del país. Con el objetivo de actualizar los registros de su presencia, caracterizar las condiciones ambientales donde se reporta y las medidas aplicadas para su control, en 2019 se encuestaron productores ganaderos y forestales de la región este. En paralelo, se realizó una encuesta con el método "bola de nieve" para recolectar más sitios con presencia de tojo. Se registraron nuevos reportes de la presencia de la especie, totalizando 38 sitios en la región. La invasora fue reportada principalmente en zonas pedregosas, altas y sobre alambrados. Los controles más utilizados por los productores fueron control químico y pastoreo, mientras que consideraron como el más efectivo la combinación mecánico-químico. La mayor dificultad que plantean para realizar los controles es el costo económico. Asimismo, la falta de coordinación entre vecinos resulta una limitante para alcanzar resultados en los controles realizados. La mayoría de los encuestados no realiza controles preventivos. Los encuestados indican que la reducción en el stock ovino ha sido una de





las causas de la presencia de tojo en la región. La problemática causada por *Ulex europaeus* debe ser abordada mediante la aplicación de un control integrado de forma coordinada y constante por parte de los diferentes integrantes de la sociedad involucrados y comunicar los resultados para sensibilizar a la comunidad.

**Palabras clave:** control de tojo, forestación, especie invasora, pastizales

## ***Ulex europaeus*: atualização sobre o presença e medidas na região leste do Uruguay**

### **Resumo**

*Ulex europaeus* é uma espécie exótica invasora que é relatada no país associada a culturas florestais e pastagens na região leste do país. Com o objetivo de atualizar os registros de sua presença, caracterizar as condições ambientais onde é relatado e as medidas aplicadas para seu controle, em 2019 foram pesquisados produtores pecuários e florestais da região leste do Uruguai. Paralelamente, foi realizado um levantamento com o método "bola de neve", para coletar mais locais com a presença de tojo. Novos relatos da presença da espécie foram registrados, totalizando 38 sítios na região. O invasor foi relatado principalmente em áreas pedregosas, altas e cercas de arame. Os controles mais utilizados pelos produtores foram o controle químico e o pastejo, em quanto eles consideraram o mais eficaz a combinação mecânica e química. A maior dificuldade que representam para a realização dos controles é o custo econômico. Da mesma forma, a falta de coordenação entre vizinhos é uma limitação para alcançar resultados nos controles realizados. A maioria dos entrevistados não realiza controles preventivos. Os entrevistados indicam que a redução no rebanho ovino tem sido uma das causas da presença do tojo na região. O problema causado pelo *Ulex europaeus* deve ser resolvido através da aplicação de um controle integrado de forma coordenada e constante pelos diferentes membros da sociedade envolvidos e comunicar os resultados para sensibilizar a comunidade.

**Palavras-chave:** controle de tojo, silvicultura, espécies invasoras, pastagens

## **1. Introduction**

The problem of Invasive Alien Species (IAS) is considered as the second cause of loss of biological diversity in the world. According to the International Union for Conservation of Nature (IUCN), *Ulex europaeus* L. (gorse) is among the 100 most harmful invasive alien species worldwide<sup>(1)</sup>. It can affect native species by competence or even displacing them, which affects the composition, structure and processes of ecosystems and causes significant economic losses and environmental degradation, as well as damage to human and animal health<sup>(2)(3)(4)</sup>.

*Ulex europaeus* is a legume native to central-western Europe and North Africa<sup>(5)</sup>. It is shrubby, woody, thorny, and perennial. Its morphological and physiological characteristics make it a very competitive species, with a great capacity to advance and colonize free spaces. It can grow in various types of soil, in disturbed areas and in soils poor in nutrients, since it is capable of fixing up to 200 kg/h/year of nitrogen, and, due to this, it does not present great soil requirements<sup>(6)(7)</sup>. It is quite clear, therefore, that landscape characteristics play an important role on the establishment and spread of gorse, but few studies have examined how transportation structures affect these processes<sup>(8)</sup>.

The adult plant blooms after 18 months; it can have flowers all year round, with peaks in spring and autumn, although in some places it blooms once a year only in spring. Its main form of natural dispersion is by seed, it occurs in times of warm temperatures, when the pods open and expel them<sup>(9)</sup>. It produces large seed banks in the soil, reaching about 20,000 seeds/m<sup>2</sup>/year, and they can remain viable in the soil for up to 30 years<sup>(10)</sup>. It



presents a rapid vegetative regeneration after disturbances by cutting or fire. In addition, its cover is dense, which limits the availability of light to understory species<sup>(6)(11)(12)</sup>.

The climates suitable for its presence are those with relatively low seasonal fluctuations in temperature, corresponding to temperate oceanic climates<sup>(13)</sup>; it can survive periods of low rainfall, although its climatic niche excludes areas with annual rainfall of less than 300 mm per year<sup>(6)(7)(8)(9)(10)(11)(12)(13)</sup>. It is widely distributed around the world and has been introduced intentionally as hedgerows to contain grazing animals, as fodder, and accidentally with imported animals and hay. In South America it has been reported as invasive in Argentina, Chile, Brazil, Colombia, Bolivia and Ecuador<sup>(14)(14)</sup>.

In Uruguay it was introduced for ornamental use and to form living fences, and there are records of its presence in the country since 1890<sup>(15)</sup>; however, evidence of its invasion has been reported more recently in the south-east<sup>(16)(17)(18)(19)</sup>. The Uruguayan territory has been the one with the highest rates worldwide in recent years<sup>(20)</sup>. Between 1990 and 2011 there was a change in land use, associated with productive sectors, agriculture, livestock and the forestry sector. In the case of the livestock sector, the main responsible for the change was the shepherd, who decreased his stock by 65%<sup>(21)</sup>, a factor that could have favored the advance of gorse expansion<sup>(22)</sup>. For the forestry sector, the period presented an accumulated increase of 2.4 million hectares<sup>(21)</sup>. The invasion constitutes a problem in the forestry sector, it makes forest management and harvesting operations difficult<sup>(23)</sup>. In the livestock sector, it affects natural grasslands, seriously reducing their surface, acting as a barrier to the transit of cattle and reducing the productivity of the natural field, among other effects<sup>(16)(21)</sup>. Contarín and others<sup>(16)</sup> and Arocena and De León<sup>(17)</sup> reported the presence of the invader in 22 and 38 sites in the eastern part of the country, respectively. The species is part of the list of priority invasive alien species for control in the country defined by the Committee on Invasive Alien Species<sup>(19)</sup>.

The objectives of the case of study are i) to contribute to updating the record of the presence of *Ulex europaeus* in the eastern region of Uruguay, with emphasis on beef cattle farms; ii) to collect information on the environmental conditions where it invades, and the control measures for *Ulex europaeus* applied by livestock and forestry producers in the eastern region.

## 2. Materials and methods

To identify the sites with the presence of gorse and the environmental characteristics, surveys were conducted with 31 producers in the eastern part of the country. The choice of producers was made through consultation with local and institutional referents. The survey consisted of closed questions that included the following aspects: data and characterization of the respondent, gorse presence on the property, and environmental characteristics associated with it, such as landscape, soil characteristics, proximity to watercourses, predominant vegetation, location in the landscape, and control measures applied. Between May and August 2020, surveys were carried out on livestock and forestry producers by phone calls, WhatsApp messages and emails. Subsequently, an interview with open-ended questions was conducted with nine producers, selected based on whether they carried out active control on the farm. Likewise, a survey was applied using the "snowball" technique<sup>(24)(25)</sup> aimed at producers and advisors to complete the registry of invaded sites in other regions of the country. This methodology consists of sending the survey to known contacts and then them forwarding it to their contacts, in order to spread the survey. The questionnaire was carried out using a Google form and reached 35 agronomist and forest farmers. The responses were processed as frequencies with descriptive statistics.

A gorse presence map was generated using Google Earth, from the sites provided by the respondents. The new records were added to those reported by Contarín and others<sup>(16)</sup> and Arocena and De León<sup>(17)</sup>. To avoid duplicates, the criterion applied was to consider that those records that were less than 3 km apart correspond to the same site.

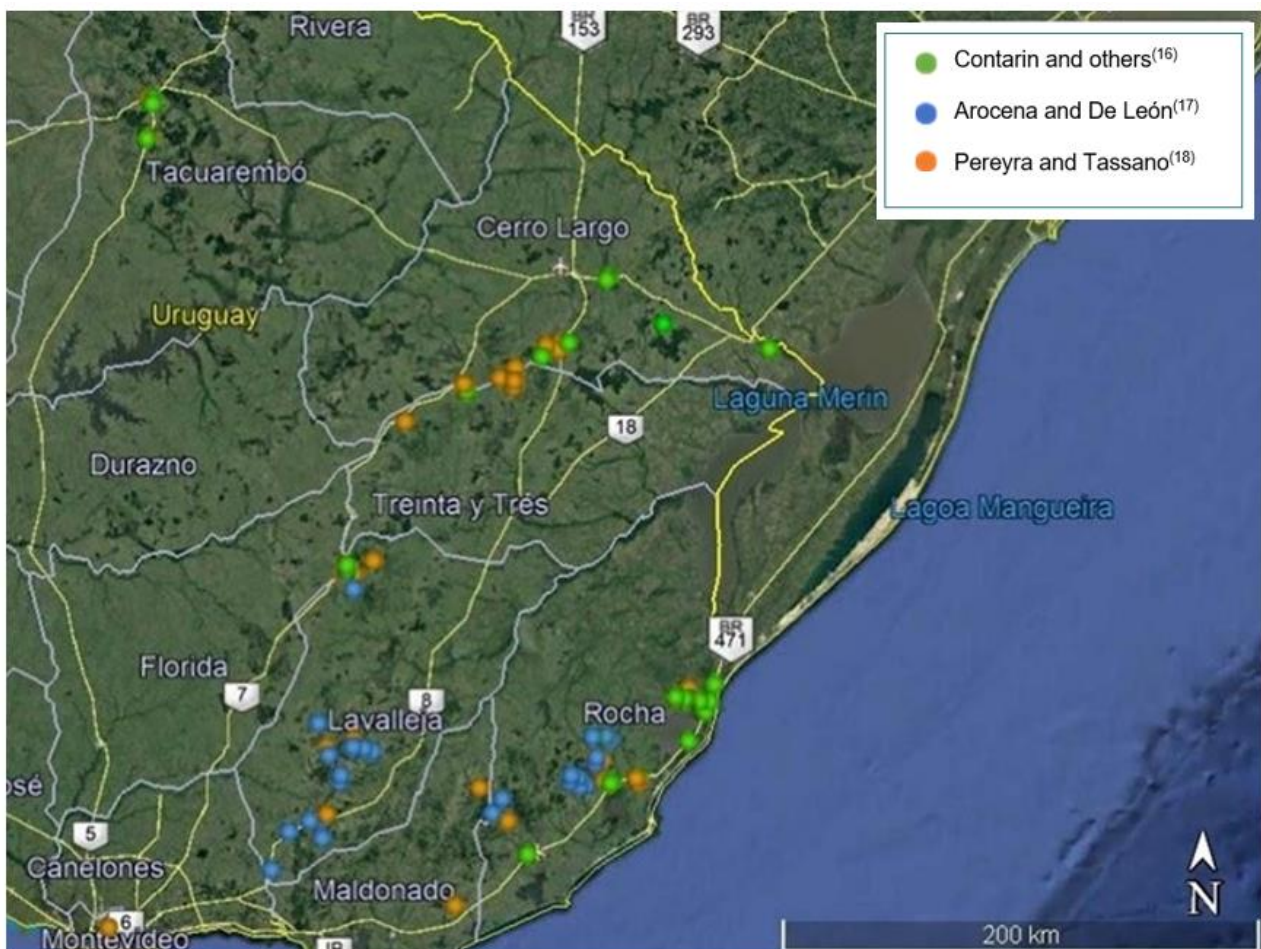
### 3. Results

#### 3.1 Characterization of the participants

Of the 38 respondents, 68% were linked to livestock production, 13% to forestry production, and 19% to mixed production. In relation to the extension of the properties surveyed, 52% have an extension of less than 500 ha, 26% between 501 and 1,250 ha, and 22% more than 1,250 ha. The presence of gorse was reported in all the properties.

#### 3.2 Update of gorse records

Based on surveys of farmers and agronomists in the eastern region of the country, and on the snowball survey, 43 sites with gorse presence were reported, five of these sites coincide with the thesis by Arocena and De León<sup>(17)</sup> (three in Rocha and two in Lavalleja), so 38 new sites are reported, in addition to previous surveys by Contarín and others<sup>(16)</sup>, and Arocena and De León<sup>(17)</sup> (Figure 1).



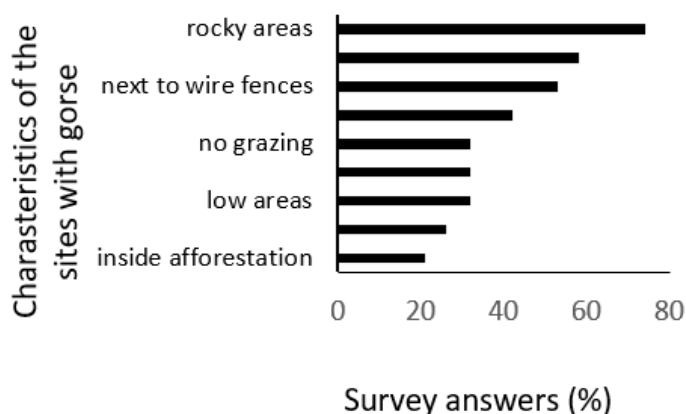
**Figure 1.** Total points surveyed in the northeast and east regions of Uruguay by 2020. Green circles represent the records of Contarín and others<sup>(16)</sup>, blue circles, the records of Arocena and De León<sup>(17)</sup>, and orange circles, records of Pereyra and Tassano<sup>(18)</sup>



### 3.2 Characteristics of the sites with presence of gorse

The characteristic landscape of the area with presence of gorse was mainly hills, with medium-depth soils that are moderately shallow and rocky on the surface, with grasslands and riparian vegetation.

In relation to the identified sites' characteristics that present gorse invasion, in the surveys half of the producers identify: rocky areas, high areas, accompanied by wire fences and the sides of roads. Some respondents commented that water springs and small creeks play an important role in the transport of seeds, since there is gorse near them (Figure 2).

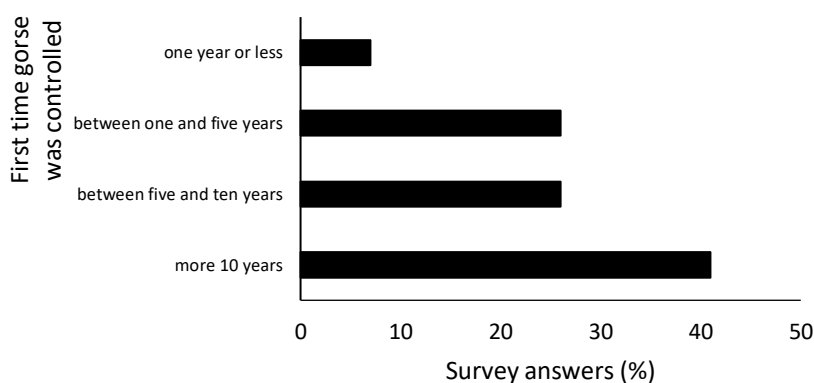


**Figure 2.** Percentage of respondents on the environmental characteristics of the sites where presence of gorse had been recorded (n = 31)

### 3.3 Gorse control methods

With the exception of one case, respondents are aware of some method to control invasive species. One hundred percent of respondents have access to machinery and some equipment to control gorse, and 90% of those surveyed carry out controls' measurements. The 10% that do not do it is because they consider it expensive, and/or because they have had unsuccessful results.

Of those who applied gorse control measures, 41% indicated that they have carried them out periodically for more than 10 years (Figure 3). Regarding the efficacy of the control, 97% indicated that they detected the presence of gorse 30 days after the measures of control were applied.



**Figure 3.** Percentage of respondents on the first time they applied measures of gorse control (n = 31)



The percentage of respondents regarding the application time of mechanical and chemical controls was 60 and 64% in spring, and 44 and 43% in autumn, respectively. From the surveys it appears that the methods reported as most effective are those that combine control techniques, such as mechanical and chemical methods (Figure 4).

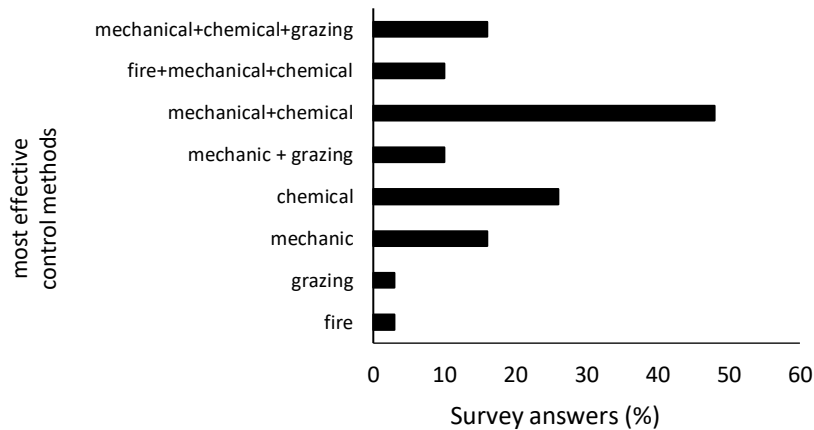


Figure 4. Percentage of respondents on most effective gorse control methods (n = 31)

The analysis of the interviews showed that in relation to (local) social organization, the interviewees consider the joint work of neighbors in the area to be very important, but it is not practiced. The reasons they pointed out are the difficulty in coordination since each case presents different realities and resources. In relation to this, they mentioned: the time available, the degree of invasion, and the knowledge they have in order to carry out the control, the costs, the workforce, and the farm machinery available. Likewise, an additional difficulty for the joint coordination of control measures is that there are beef cattle farmers who do not identify the presence of gorse as a problem.

## 4. Discussion

In this study, it was possible to incorporate new records of the presence of gorse in beef cattle farms in the departments of Cerro Largo, Tacuarembó, Treinta y Tres and Florida, as well as in Maldonado and Montevideo. This shows that the distribution of gorse would not be exclusively associated with the eastern region of the country.

The respondents associate the presence of gorse with characteristics of a wide range of physiographic conditions of sites, such as superficial and deep soils, which shows great phenotypic plasticity.

In relation to the control method chosen by producers and technicians, it is associated with the resources available. Most of them carried out a post-control follow-up, and detected the presence of gorse in the controlled area, which would indicate difficulties in reducing abundance or preventing its expansion with a single control intervention. According to the experiences collected and the background<sup>(4)(26)(27)</sup>, the combinations of several methods generate greater control efficacy.

### 4.1 Update of gorse records

From the surveys carried out, particularly in the eastern part of the country, the departments where an increase in sites with gorse infestation was identified were Rocha and Lavalleja. This confirms the importance of the



presence of the species in these departments, and the challenge of analyzing and understanding what would be the causes that promoted its successful dispersion is posed.

According to **Figure 1**, in relation to the location of sites with gorse, it can be inferred that the closeness to communication roads would favor dispersion, as reported. In this sense, according to León Cordero and others<sup>(8)</sup>, the structure of the road networks can facilitate the spread of gorse to the different departments, probably associated with the traffic of heavy vehicles that transport wood logs, cattle, among other loads, coming from infested regions. At the same time, other means of dispersion must also be taken into account, such as the handling of tools, agricultural machinery, vehicles and operators, as well as the movements of animals in the properties.

#### 4.2 Characteristics of the sites with the presence of gorse

The respondents associate the presence of gorse with characteristics of the site such as superficial soils, rocky and stony areas, high areas, what agrees with Hoshovsky<sup>(10)</sup>, who pointed out that gorse can develop on various types of soil, but it is generally associated with sandy or rocky soils. In addition, these types of soil have low water retention, and, according to studies carried out by Guido and others<sup>(26)</sup>, the water deficit would increase the incidence of the species. Likewise, some respondents also reported its presence in deeper soils, for example. This would show its tolerance to a wide range of soil humidity conditions, which demonstrates its great phenotypic plasticity<sup>(6)(27)</sup>.

The results obtained from the interviews agree with those of the survey, indicating that high and rocky areas, soils without vegetation cover, as well as soil removal favor the emergence and establishment of plants from the soil seed bank. In particular, in forest farms, after harvest the soil is exposed to greater availability of light, and this may be one of the moments with the greatest risk of invasion of the system due to promotion of germination and emergence from the seed bank. Another characteristic mentioned associated with the invasion of the species is the absence of sheep. Forest producers mention that, in their history of agricultural use, the sites were beef cattle ranches, mostly with the presence of sheep, and had no changes in land use. Interviewees suggest that when grazing is done with a low stocking rate, it would not be enough to control invasive species. Likewise, intensive grazing would not be recommended either, due to the reduction in the cover and height of the natural mat, which would generate less competition with gorse, favoring its growth and development, as proposed by Rees and Hill<sup>(28)</sup> and Clements and others<sup>(6)</sup>. The producers also indicated that sheep grazing would be more effective to control the invader than cattle grazing, so the absence of the former could be a factor that favors the invader's success. As previously stated, the reduction in stock by 65% between 1990 and 2011<sup>(21)</sup> could be a determining factor in the colonizing and expansive success of the invader in the region. León Cordero and others<sup>(8)</sup> observed that in the grasslands of Rio Grande do Sul the livestock selectively feed on various life stages of gorse: cows can only feed on gorse seedlings, while sheep and horses prefer adult gorse. The change in land use, evidenced mainly by forestry activity, could have promoted the invasion of gorse, in agreement with what was previously commented on the change in land use that occurred in Uruguay from 1990 according to the MGAP-DIEA<sup>(21)</sup>. The generation of bare soils, as well as disturbed soils, as in forest management, favors the development of gorse due to the absence of competition with other plants. What was reported in the responses obtained coincides with Broadfield and McHenry<sup>(29)</sup>, who propose the degradation and loss of stability of the soil as a facilitator of invasion.

In relation to the aspect of invasion and the proximity to the watercourse, it is considered by producers as a seed transport factor, as reported by Clements and others<sup>(6)</sup>. To understand the mechanisms that operate in the dispersal process of the species in this region, it is necessary studies that look into the detection of the environmental factors that promote it.



### 4.3 Gorse control methods

The responses indicate the use of various methods, alone or in combination, as well as their frequency of application. According to Castro<sup>(30)</sup>, this diversity of methods applied would confirm, on the one hand, that there are no single effective control measures to adequate to all situations. The choice of control methods depends on factors such as the size of the plant, the density of the invasion, the type of production concerned, the availability of time, and the costs of control.

The combination of chemical and mechanical controls was identified as the most effective, as reported by Balero and Gándara<sup>(31)</sup>, Davies and others<sup>(32)</sup>, and Roberts and Florentine<sup>(4)</sup>. However, when defining the use strategy when applying them, the majority opted for the individual application of chemical control or grazing management. This is explained because the costs turn out to be a limiting factor, as mentioned by some producers. On the other hand, this economic cost also affects the frequency of application necessary to achieve greater control success. Likewise, most of the producers carried out post-control monitoring, and detected the presence of gorse in the controlled area, which would indicate the difficulties to reduce abundance or prevent its expansion if it were done with a single intervention.

In summary, this study intended to contribute to the local perspective of producers and technicians on the invasion of *Ulex europaeus* (gorse) in the eastern region of the country, as well as to aspects related to the invasiveness of the environment and the control measures commonly used to avoid or minimize the invasion. We understand that the gorse invasion problem is complex and requires prevention strategies and permanent monitoring, combined and periodic early control. The approach to solutions implies a level of individual and collective commitment, which is essential to achieve long-term changes.

## 5. Conclusions

We found that there has been an update in the report of the presence of *Ulex europaeus* in places and departments where previously there were no records of it. The update of the records of the invasive species in the country provides a total of 38 sites distributed in eight departments (Cerro Largo, Florida, Lavalleja, Maldonado, Montevideo, Rocha, Tacuarembó, and Treinta y Tres).

Beyond the intrinsic capacity of colonization, establishment and dispersion that *Ulex europaeus* presents as an invader, human intervention would have favored its development, beginning with the change in land use since the 1990s, favoring its increase in areas already invaded and the colonization of new areas. The presence of the invader was reported in disturbed and degraded environments, in superficial soils, high parts of land, and in the vicinity of watercourses.

Although there is a positive assessment of the results in the use of combined controls, as the most effective, the most applied management and control methods were grazing, chemical, and secondly the mechanical.

## 6. Considerations

Given the demand of the productive sector, some topics and lines of research are proposed to be developed in order to understand the conditions of the invasion process in the region:

- To advance in the study of the main routes and dispersal vectors that are causing the spread of gorse in the Uruguayan territory.





- To build future scenarios incorporating information on changes in land use, management characteristics of production systems, and changes in climatic variables, which allow anticipating the process of invasion of the territory, as well as the impacts generated, in order to carry out action plans.
- And finally, the need to strengthen the articulation and cooperation between the productive sector, public institutions and academia is evident to generate prevention, control and monitoring actions sustained over time and with ecological, economic and social sustainability.

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## Transparency of data

Available data: The entire data set that supports the results of this study was published in the article itself.

## Author contribution statement

CT: Conceptualization; Methodology; Investigation; Writing –original draft

MP: Conceptualization; Methodology; Investigation, Writing – original draft

CM: Conceptualization; Supervision; Writing –review & editing

DB: Conceptualization; supervision; Writing –review & editing

## References

- (1) Lowe S, Browne M, Boudjelas S, De Poorter M. 100 de las Especies Exóticas Invasoras más dañinas del mundo: una selección del Global Invasive Species Database. Auckland: ISSG; 2004 [cited 2023 May 17]. 12p. Available from: <http://www.issg.org/bookletS.pdf>
- (2) Brugnoli E, Masciadri S, Muniz P. Base de datos de especies exóticas e invasoras en Uruguay: un instrumento para la gestión ambiental y costera. Montevideo: EcoPlata; 2009. 23p.
- (3) Olivera JM, Riaño ME, Etchebarne V, García de Souza ML, Justo C. Monitoreo de especies exóticas invasoras del bosque nativo de Uruguay mediante sensoramiento remoto. Montevideo: MGAP; 2020. 56p.
- (4) Roberts J, Florentine S. Biology, distribution and control of the invasive species *Ulex europaeus* (Gorse): a global synthesis of current and future management challenges and research gaps. *Weed Res.* 2021;61:272-81. Doi: 10.1111/wre.12491.



- (5) Hill RL, Ireson J, Sheppard AW, Gourlay AH, Norambuena H, Markin GP, Kwong R, Coombs EM. A global view of the future for biological control of gorse, *Ulex europaeus* L. In: Julien MH, Sforza R, Bon MC, Evans HC, Hatcher PE, Hinz HL, Rector BG, editors. Proceedings of the XII International Symposium on Biological Control of Weeds. Wallingford: Cabi; 2008. p. 680-86. Doi: 10.1079/9781845935061.0680.
- (6) Clements D, Peterson D, Prasad R. The biology of Canadian weeds: 112. *Ulex europaeus* L. Can J Plant Sci. 2001;81(2):325-37.
- (7) Magesan G, Wang H, Clinton P. Nitrogen cycling in gorse-dominated ecosystems in New Zealand. N Z J Ecol. 2012;36(1):21-8.
- (8) León Cordero R, Torchelsen FP, Overbeck GE, Anand M. Analyzing the landscape characteristics promoting the establishment and spread of gorse (*Ulex europaeus*) along roadsides. Ecosphere. 2016;7(3):e01201. Doi: 10.1002/ecs2.1201.
- (9) Gouldthorpe J, Austen L, Moore J, Poulish G, Sandiford L, Ireson J, Laird A, Hurley H, Williams S, Vincent D. Gorse: National Best Practice Manual: Managing Gorse (*Ulex europaeus* L.) in Australia. 2nd ed. [place unknown]: Australian Government; 2009. 101p.
- (10) Hoshovsky M. Element stewardship abstract for *Ulex europaeus* Gorse. Arlington: The Nature Conservancy; 1989. 22p.
- (11) Duhart K. Estudio de la composición de alcaloides de *Ulex europaeus* L. (fabaceae) en Chile y su actividad biológica [master's thesis]. Concepción (CL): Universidad de Concepción, Facultad de Ciencias Naturales y Oceanográficas; 2012. 72 p.
- (12) Solorza J. Evaluación de la regeneración de *Acacia decurrens*, *Acacia melanoxylon* y *Ulex europaeus* en áreas en proceso de restauración ecológica. Luna Azul [Internet]. 2012 [cited 2023 Dec 29];(34):66-80. Available from: <https://revistasoj.s.ucaldas.edu.co/index.php/lunazul/article/view/1135>
- (13) Christina M, Limbada F, Atlan A. Climatic niche shift of an invasive shrub (*Ulex europaeus*): a global scale comparison in native and introduced regions. J Plant Ecol. 2020;13(1):42-50. Doi: 10.1093/jpe/rtz041.
- (14) Herrera I, Goncalves E, Pauchard A, Bustamante R. Manual de plantas invasoras de Sudamérica. Santiago de Chile: Instituto de Ecología y Biodiversidad; 2016. 116p.
- (15) Porcile J. El tojo (*Ulex europaeus* L): maleza introducida que no debe ser subestimada. Uruguay Forestal. 2001;10(26):17-9.
- (16) Contarín S, Corti JL, Faguaga P, Fernández S, Figarola G, Ihlenfeld J, Techeira W. Relevamiento tojo 2017: situación actual. Montevideo: MGAP; 2017. 6p.
- (17) Arocena I, De León A. Sistematización de experiencias de control de *Ulex europaeus* (tojo) en la región este del país [grade's thesis]. Montevideo (UY): Universidad de la República, Facultad de Agronomía; 2018. 82p.
- (18) Pereyra M, Tassano C. *Ulex europaeus* (tojo) en la región este del país: relevamientos de experiencias de prevención y control [grade's thesis]. Montevideo (UY): Universidad de la República, Facultad de Agronomía; 2020. 87p.
- (19) Aber A, Ferrari G, Porcile JF, Rodríguez E, Zerbino S. Identificación de prioridades para la gestión nacional de las especies exóticas invasoras. Montevideo: UNESCO; 2012. 99p.
- (20) Rama G, Lezama F, Baeza S. Cambios recientes del uso del suelo en la cuesta basáltica del Uruguay. Oecologia Aust. 2018;22:210-23. Doi: 10.4257/oeco.2018.2203.01.
- (21) Ministerio de Ganadería, Agricultura y Pesca, DIEA (UY). Regiones agropecuarias del Uruguay. Montevideo: MGAP; 2015. 38p.
- (22) Radcliffe JE. Gorse control with sheep and goats. New Zealand J Agric Res. 1985;13(2):181-90.
- (23) García A, Lezama F, Quiñones A, Ayala W, Bermúdez R. Tojo: características de la especie y resultados experimentales nacionales para su manejo. In: Taller Interinstitucional de Manejo de Malezas en Campo Natural; Tacuarembó. Montevideo: INIA; 2015. p. 1-37.



- (24) Alloatti M. Una discusión sobre la técnica de bola de nieve a partir de la experiencia de investigación en migraciones internacionales. In: IV Encuentro Latinoamericano de Metodología de las Ciencias Sociales [Internet]. La Plata: Universidad Nacional de La Plata; 2014 [cited 2023 Dec 29]. 19p. Available from: [https://www.memoria.fahce.unlp.edu.ar/trab\\_eventos/ev.8286/ev.8286.pdf](https://www.memoria.fahce.unlp.edu.ar/trab_eventos/ev.8286/ev.8286.pdf)
- (25) Alperin M, Skorupka C. Métodos de muestreo: Muestreo: técnica de selección de una muestra a partir de una población [Internet]. La Plata: Universidad Nacional de La Plata; 2014 [cited 2023 Dec 29]. 18p. Available from: <https://www.fcnym.unlp.edu.ar/catedras/estadistica/Procedimientos%20de%20muestreo%20A.pdf>
- (26) Guido A, Velez-Martin E, Overbeck G, Pillar V. Landscape structure and climate affect plant invasion in subtropical grasslands. *Appl Veg Sci*. 2016;19(4):600-10. Doi: 10.1111/avsc.12263.
- (27) Muñoz E. El espinillo (*Ulex europaeus* L. 1753) un invasor biológico en el sur de Chile: estado de su conocimiento y alternativas de control. *Gestión Ambiental*. 2009;17:23-44.
- (28) Rees M, Hill RL. Large-scale disturbance, biological control and the dynamics of gorse populations. *J Appl Ecol*. 2001;38:364-77. Doi: 10.1046/j.1365-2664.2001.00598.x.
- (29) Broadfield N, McHenry MT. A World of Gorse: Persistence of *Ulex europaeus* in Managed Landscapes. *Plants (Basel)*. 2019;8(11):523. Doi: 10.3390/plants8110523.
- (30) Castro F. Estrategia de control de Tojo-*Ulex eurpaeus* en campos forestales y ganadaeros. In: Dia de campo forestal en zona sureste. Montevideo: INIA; 2011. p. 13-9.
- (31) Balero R, Gándara J. Respuesta de *Ulex europaeus* L. a la quema controlada [grade's thesis]. Montevideo (UY): Universidad de la República, Facultad de Agronomía; 2003. 75p.
- (32) Davies JT, Iresona JE, Allen GR. The impact of gorse thrips, ryegrass competition, and simulated grazing on gorse seedling performance in a controlled environment. *Biol Control*. 2005;32:280-6. Doi: 10.1016/j.biocontrol.2004.10.007.