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GRASSES MATTER!
RESTORING NATURAL GRASSLANDS AFFECTED BY INVASIVE
WOODY PLANTS AND INCREASING PUBLIC SUPPORT FOR THEIR CONSERVATION

FINAL REPORT

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INTRODUCTION

The activities and results obtained between 2004 and 2005 in the project *Grasses Matter! Restoring Natural Grasslands Affected by Invasive Woody Plants and Increasing Public Support for their Conservation* funded by the Continuation Grant are presented in this report.

During this period the strategy for controlling Aleppo pine (*Pinus halepensis*), the main invasive species in the study area, was optimised. Five homogenous management zones were established in the Ernesto Tornquist Provincial Park (ETPP) and the most appropriate method of control was determined for each one. The resources required for completing the control and recommended frequencies of complementary control actions were estimated. This information was used to adjust the control actions for this species, which allowed work to be carried out in areas of high conservation value in the reserve.

To compliment this data, an evaluation of the importance of feral horse manure as an invasion window for the advance of pines and other invasive plants was carried out.

At the same time, trials of the efficiency of four control methods (cutting, cutting and herbicide treatment of stems, herbicide spray, and fire) for the management of another highly invasive species, Spanish broom (*Spartium junceum*), were undertaken.

Significant progress was made concerning the cultivation requirements of native plants of ornamental interest. In particular alternative techniques for stimulating germination and propagation of cuttings of two species of great ornamental value, *Pavonia cymbalaria* and *Grindelia ventanensis,* were tried out. The latter species is endemic to the study area.

During the study period an intensive educational campaign was carried out to promote the value of natural grassland habitats, in which schools in the region of the reserve were targeted. Students and teachers from the neighbouring area of the ETPP took part in workshops based on a strategy of awareness, supported by games and artistic activities. The botanical garden was opened to the public twice a week as a result of support received from this project.

This report is divided into five sections: Control of Alien Woody Plants; Cultivation Requirements of Native Plants; Education and Public Awareness; and Dissemination of the Project. Papers published during this project are cited throughout the report.

1. CONTROL OF ALIEN WOODY PLANTS

1.1. O*ptimising the strategy for the control of Pinus halepensis*

Data concerning the extension and distribution of the pine invasion in the reserve was updated in order to optimise the strategy for the control of *Pinus halepensis.* Areas of different density were defined by means of an aerial photography survey, and were then verified on the ground. It was found that high density woods (more than 600 pines/ha.) occupy 1% of the reserve, those of medium density (200-600 pines/ha.) represented 2%, low density areas (10-200 pines/ha.) 16% of the total area, and those of very low density (less than 10 pines/ha.) occupied the largest percentage of the area: 73% of the reserve.

Different management alternatives were analysed: biological control, grazing, felling, fire and application of herbicides, and their effectiveness, cost, environmental and social impact were considered, as well as any possible effect on public opinion. Control methods that had seldom been used, or were without confirmed results in the country or similar areas, or which lead to an impact that was not compatible with the objectives of the area, were rejected at this point. Each alternative method for control was evaluated to test its effectiveness in controlling the invasion, considering whether it was necessary to repeat control actions in the same area. The ecological impact of control actions carried out on the whole ecosystem, or more specifically on the problem species, was analysed. Literature reviews and field evaluations were carried out for both aspects. The variable cost and effort of the alternative methods of control were evaluated using field trials or by extrapolating information from previous work on other species. The social impact referred to the effects that the control actions might have on the neighbouring community of the reserve, including effects on public health, economic goods and activities. Public opinion might have opposed the use of some control methods whether or not they caused an impact. Therefore a search was made in the local media for the period 1943-2005 for issues relating to the management of the ETPP in order to analyse these aspects. Representatives of different sectors of the community were also consulted and the visual impact caused by the presence of fallen trees was monitored (1).

The use of biological control was rejected since the method has not often been used and successful results on a large scale are unknown in other regions of the world. Sheep are the main control agents of conifers but grazing pressure only has an affect on young pines of less than two years. This method was not evaluated as an alternative as it would be impossible to eradicate the invasion of pines already established in the Tornquist Park with this method. On the other hand, exotic herbivores actually encourage the establishment of pine seedlings (2), accelerate the establishment of scrub vegetation (3), and favour the propagation of other exotic species (4), according to results obtained from other studies in this project. The other alternatives evaluated for pine control: felling, controlled burning and herbicide application, were found to be the most appropriate methods and the most commonly used on a world scale, so they were selected as the best alternatives for the area.

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[1]CUEVAS, YA, ZALBA SM & RM BOÓ. 2005. Controlling invasive pines in a grassland nature reserve: Proposal of optimization. Annual Meeting of The Ecological Society of America, Mérida, México, 8 al 12/01/2006.

[2]DE VILLALOBOS AE & ZALBA SM. 2003. Efecto del pastoreo sobre el establecimiento de plántulas de *Pinus halepensis*, una especie invasora de pastizales naturales. En Libro de Resúmenes XXIX Jornadas Argentinas de Botánica, San Luis, p. 73.

[3]DE VILLALOBOS AE & ZALBA SM. 2004. Sobrepastoreo y modificación de la vegetación en una reserva de pastizal pampeano. En Libro de Resúmenes II Reunión Binacional de Ecología, Mendoza, p. 254.

[4]LOYDI A & ZALBA SM. 2004. Impacto de los bosteaderos de caballos cimarrones sobre la flora de una reserva de pastizal pampeano. En Libro de Resúmenes II Reunión Binacional de Ecología, Mendoza, p. 207.

Mechanical or manual cutting are the most commonly used methods for controlling invasive plants. In the case of pines no regeneration was observed from underground shoots or stumps, if the trees were cut near to the base, and so this is highly effective when all foliage is eliminated. Mechanical and manual felling proved to be very specific methods that minimized damage to untargeted species. This technique was very effective during this project (5), although the recovery of native vegetation underneath the remains of the felled pines was slow, possibly due to the impact of accumulated pine needles under the felled trees. This effect was at a maximum at the time of felling but decreased over time (6) and the cleared areas showed good recovery with increased vegetation cover and species diversity (7). Moreover, felling is not associated with any impact on the inhabitants of the surrounding area (nil social impact). However when negative public opinion was considered, it was thought that as this alternative would result in notable visual impact it might lead to great opposition. This rejection would be due to elimination of the trees rather than the visual impact of felled trees, but according to our results this impact was overcome in approximately one year (6).

Controlled burning is a method that affects the whole ecosystem, reducing the cover and density of the problem species, which can be applied to standing invasive plants or after cutting or application of herbicides. In the case of pines, in which fire stimulates seed release and creates appropriate conditions for establishment, the use of controlled burning of standing trees (not previously cut) might promote the dispersal of the invasive species (8). However, fire is recommended as a complementary action to mechanical felling: felling the trees and leaving the felled trees on the ground allows seed release and then after one year controlled burning of the cleared area affects the established seedlings.

However, considering the characteristics of the area (strong winds of variable direction) there is a high risk of fire spreading to adjoining properties and therefore controlled burning is considered as an alternative with high potential social impact.

Herbicides have not often been used for controlling pines. The impact on untargeted species and on the environment as a whole (proximity to water sources, depth of the water table, etc.) requires careful consideration, especially when herbicides are used in natural areas. Moreover, its use implies risk of contamination, e.g. by affecting water courses or by accidental spills, with high potential social impact. These disadvantages can be reduced if the appropriate herbicides are selected, as well as the application method, area and timing. For the case in study the eventual use of herbicide is recommended in the form of a foliar application to young plants or the injection of trunks of mature standing pines.

Various aspects of the reproductive biology of *P. halepensis* were studied, including the release of seed from cones of felled trees, variations in the germination percentage of these seeds according to the time of year in which the trees were felled and the survival of seeds in the ground, in order to evaluate the effective frequency of application of different control options, i.e. the time period before which it is necessary to control the species in previously cleared areas.

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[5]ZALBA SM, BARRIONUEVO LB, CUEVAS YA & DE VILLALOBOS AE. 2003. Restauración de ambientes naturales afectados por especies exóticas en el Parque Provincial Ernesto Tornquist. En Anales de las II Jornadas Interdisciplinarias del Sudoeste Bonaerense. Editorial de la Universidad Nacional del Sur. Bahía Blanca.

[6]DISPIGNO L & ZALBA SM. 2003. Cambios en las comunidades vegetales luego del control de ejemplares aislados de *Pinus halepensis*. En Libro de Resúmenes XXIX Jornadas Argentinas de Botánica, San Luis, p. 68.

[7]BARRIONUEVO LB, CUEVAS Y & ZALBA SM. 2001. Control de pinos en una reserva natural de pastizal pampeano. Libro de Resúmenes 1er Encuentro Binacional de Ecología, Bariloche, p. 55

[8]ZUCCHINO EE & ZALBA SM. 2003. Efecto de un incendio sobre el establecimiento y la supervivencia de plántulas de *Pinus halepensis* en el Parque Provincial E. Tornquist. En Libro de Resúmenes XXIX Jornadas Argentinas de Botánica. San Luis, p. 74.

The results showed that there was a massive opening of mature cones from felled trees that remained on the site. The percentage of cones that open was very high, varying between 72 and 90%. Most of the cones from felled pines cut at different times of the year open *en masse* during the summer following felling. Trees felled in November and January immediately released a large amount of seed. Pines felled in March showed two peaks of seed release: one immediately after felling, which ceased during the winter months and another the following summer (nine months after felling). The cones of pines felled in May, July and September opened the following summer, so the cones remained closed for seven, five and three months respectively (Figure 1).

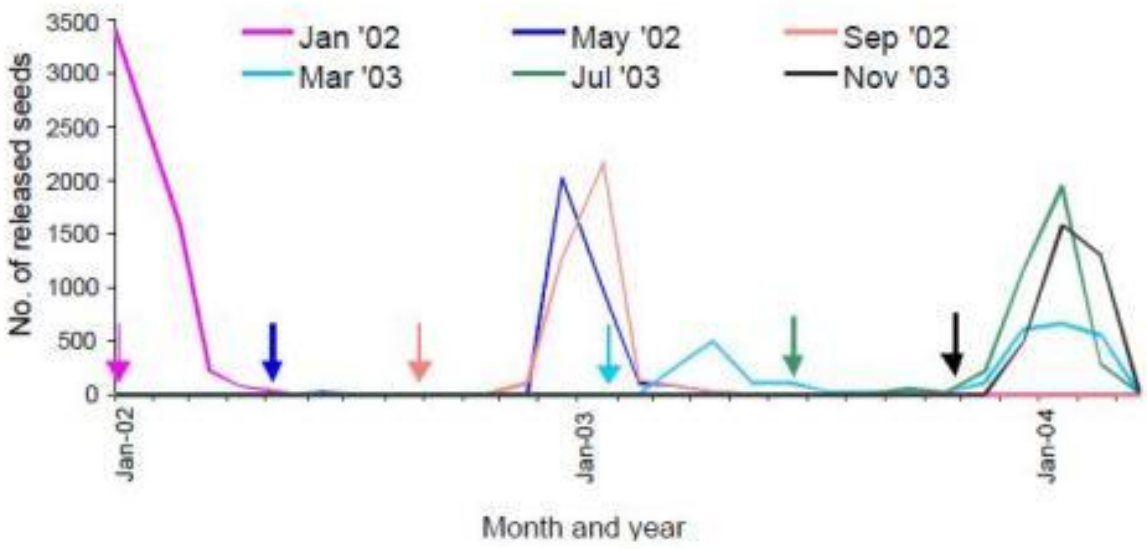

Figure 1. Chronology of seed release from cones of pines felled in different seasons of the year (the arrows show the times of felling, and lines of the same colour represent seed release from cones of pines cut at that time).

The germination tests showed that seed released from pines felled in January, March, September and November (which were retained for a relatively short time in their cones) had significantly higher germination percentages ($F=6,061$; $p<0,001$) than seed that remained in cones for a longer time (pines felled in March that opened their cones after nine months), while seed from pines felled in May and July showed intermediate values (Table 1).

Table 1. Germination percentage of seed released from trees felled during different months of the year. SD standard deviation; *first and **second peak of seed release.

	Pines felled in the month of:						
	Jan	Mar*	Mar**	May	Jul	Sep	Nov
N° seeds released	5288	1017	1960	3256	3705	3796	3403
Opened cones (%)	90	20	52	78	88	75	80
Germination (%)	85 ±	91 ±	64 ±	73 ±	78 ±	86 ±	92 ±
(Average±SD)	7,9	8,21	10,83	8,36	14,4	5,48	6,71

Seeds remained viable in the soil seed bank for at least one year and only one germination peak was observed in the autumn. In an experiment on longevity in the field undertaken with 956 seeds, 202 (21.13%) germinated during March-April and 434 (45.39 %) during May-June. Standard germination tests under ideal conditions of light, temperature and humidity for seed showed 87% percentage germination. However the seeds (320) that remained in the ground for a year without germinating did not germinate in a chamber under optimal conditions (9).

Five homogenous management areas were established as a result of these analyses, taking into account the size and density of the pines and the characteristics of the terrain (accessibility and slope). The most appropriate control method was selected for each area and the respective time and cost evaluated. The frequency of successive controls was determined for the cleared areas. Groups from the local community who were interested in the project's actions, were informed about the procedures of control (10).

The following general recommendations for selecting the control method were established for each of the management areas:

a) Controlled burning should not be used on steep slopes (more than 30º) due to risk of erosion and difficulty of controlling wildfires.
b) Fire should not be used in low density pine areas (up to 200 pines per ha.)
c) Controlled burning should be the priority control method in valleys (slopes less than 30º) with pine regeneration at medium to high densities (more than 200 pines per ha.) and next to roads where there is sufficient access for the Fire Brigade in case of wildfires. The same is recommended for previously felled mature trees.
d) Felling and herbicide application are proposed as alternatives for control in low areas with very low pine density (up to 200 trees per ha.).
e) In the case of mature trees, felling should be selected in preference to herbicide treatment (injections in trunks), since it is more economical, potential problems of contamination are avoided, and there is less risk of seed dispersal over great distances.
f) Mechanical or manual cutting is more highly recommended than application of foliar herbicide for controlling regrowth, as it is more economical and risk of contamination is avoided.
g) It is recommended that the felled pines should be removed to avoid recolonization from seeds that remain in the closed pinecones, where there is easy access to the cleared areas.
h) In all cases priority for clearing should be given to windward areas (predominant winds are from N, NO, and O) to minimize the possibility of recolonization by released seed, and also to high altitude areas to decrease the dispersal distance.

The following guidelines have been established for determining the management frequency for Aleppo pines in the reserve:

a) The frequency of monitoring and thinning the regrowth in cleared areas is not necessary for periods of at least six years, since, in the case of seed arrival or survival of small seedlings which might have gone unnoticed during control actions, this would allow detection and eradication before the trees mature.

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[9]CUEVAS Y, ZALBA SM, DE VILLALOBOS AE & SANHUEZA C. 2003. Claves para el control de una invasión de *Pinus halepensis*: lluvia de semillas y potencial germinativo. En Libro de Resúmenes XXIX Jornadas Argentinas de Botánica, San Luis, p. 51.

[10]CUEVAS, YA. 2005. Plan de Manejo de la Invasión de *Pinus halepensis* en el Parque Provincial Ernesto Tornquist, Buenos Aires. Tesis de Maestría en Manejo de Vida Silvestre, Universidad Nacional de Córdoba.

b) The soil seed bank of *P. halepensis* is short lived. Seeds germinate in the autumn or lose their viability after being in the ground for a year. This implies that the area can be considered free from invasion if the arrival of seed from outside the area is effectively controlled, or if there is no recruitment during the first year after control.
c) It must be emphasized that seed from felled trees that are left on site, release seed *en masse* during the following summer. The percentages of opened cones and seed germination are very high in all cases, but are greatest in pines felled immediately before or during the summer. If pines are to be felled in short periods then it is recommended that this should be carried out between April and July, especially if the trees are not subsequently burnt or removed from the site.
d) The use of fire on the remains of mature felled pines helps to eliminate seedlings as well as seed released after felling, so that no further control is necessary if introduction of seed from external sources is avoided.
e) Application of herbicide to mature pine trunks requires the same frequency as felling.

1.2. Specific control actions for pines

Pine control actions were concentrated on the highest areas of the mountain range during this period, where the potential dispersal is at a maximum. Simultaneously meetings were held with representatives from different sectors of the local community to obtain political support for extending the clearance to new sectors of the reserve.

Felling of *Pinus halepensis* in the Ernesto Tornquist Provincial Park.

1.3. Effect of feral horse manure on the advancement of invasive exotic plants

Favourable conditions in the ETPP have resulted in an increase in the population of feral horses, which has reached a density of approximately 25 horses per km^2. The presence of heaps of manure is a frequent disturbance in grazed ecosystems, and these release nutrients into the soil and leave patches free from competition, modifying the vegetative succession. The objective of this component of the project was to evaluate the effect of the manure on the grassland flora and establish its possible role in the introduction and dispersal of invasive plants in the reserve (11). The area studied covers a sector of mountain grassland with a

[11]LOYDI, A. 2005. Impacto de los cúmulos de estiércol de caballos cimarrones sobre la flora de una reserva de pastizal. Tesina de Licenciatura en Ciencias Biológicas. Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur. 50 pp.

grasses of 50 to 60 cm in height, dominated by *Stipa* and *Piptochaetium* species. Grazing reduces the cover and height of the vegetation. Fifteen 50 metre transects were surveyed to measure the area covered by manure. Fifteen manure patches of more than 1 metre diametre were selected and the heights of the manure heaps were measured as an indicator of the time since they had been left by the horses (age of manure). The cover of plant species on each manure patch was estimated and the species richness and diversity were calculated. Linear regressions were carried out between the calculated parametres and the height of the manure (age). An analysis of principal components (APC) was carried out on the percentage of cover of species in each manure patch and the arrangement of the samples on the principal components were correlated with the height of the manure. The species richness, diversity and Shannon's equivalence were also calculated in 3 or 4 plots, of 0.25 m_2 by 1 m_2 outside the manure patches. The cover of the different plant groups and bare ground was evaluated to analyze the variation over these areas. The frequency of the different groups and species at different distances from the edge of the manure patch were evaluated with the G test of independence. The manure covered 2.5% of the total study area. The richness, diversity and equivalence of plant species on the manure patch increased significantly with age (R_2= 0.461; R_2=0.725; R_2=0.701; respectively) (Figure 2) (12). The first principal component explains 26% of the total variance in the species composition, and the disposition of the manure patches on this component showed a negative correlation with the height of the manure, showing its usefulness as an indicator of the vegetative succession (correlation coefficient = -0.783). When data from the plots outside the manure patches were analysed, it was found that species richness was greater adjacent to the manure patches than at 5 metres distance ($F_{1.14}$= 23.6; $p<0.01$). The percentage of bare soil decreased as the distance from the edge of the manure patch increased. The cover and frequency of exotic species were greater at the edge than at 5 metres, and the abundance of woody species as a group were negatively correlated to the distance from the edge. The area covered by manure in the study area is greater than that reported in similar studies of grazing ecosystems. Moreover, the presence of manure patches appears to favour some exotic species, and so their impact can be considered significant from the point of view of conservation of the native biodiversity (13). The patches of manure might become focal points of propagule dispersal of plants resistant to grazing if the effect of overgrazing in the study area is taken into account.

[12]LOYDI, A y SM ZALBA. 2004. Impacto de los bosteaderos de caballos cimarrones sobre la flora de una reserva de pastizal pampeano. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.

[13]LOYDI, A y SM ZALBA. 2005. Vegetación asociada a cúmulos de estiércol de caballos cimarrones. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.

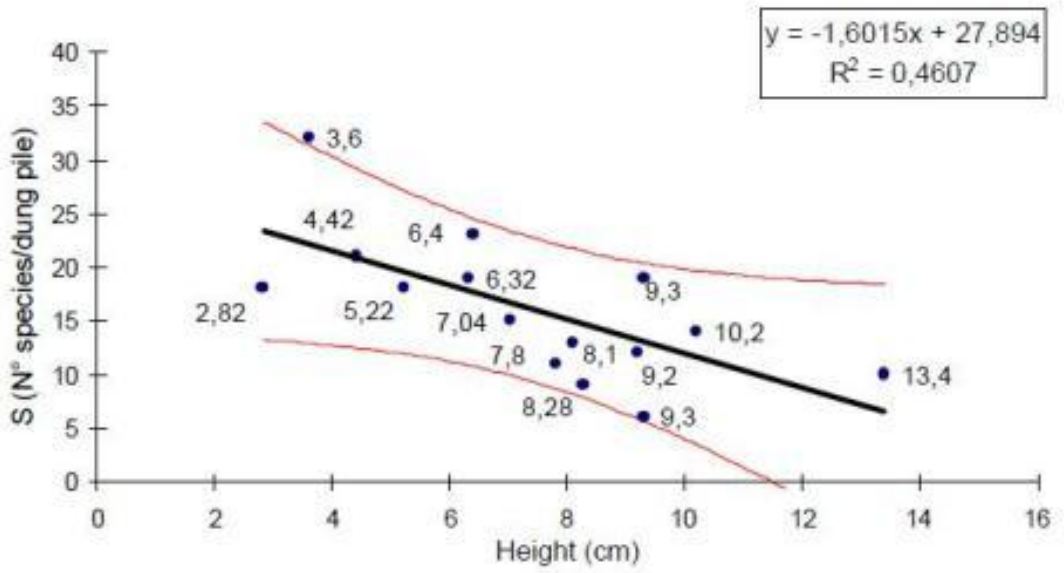

Figure 2. Linear regression between species richness (S) and the height of the manure. The equation of the adjusted regression curve, the coefficient of determination and the height of each manure patch are shown. The red curves show the confidence intervals at 95%.

Feral horses in the Ernest Tornquist Provincial Park and sampling vegetation associated with manure patches.

1.4. Experiments on the control of Spanish and French brooms (*Spartium junceum* and *Genista monspessulana*)

In recent years there has been a notable increase in the distribution and abundance of *Spartium junceum* in the Ernesto Tornquist Provincial Park and it was selected as one of the plants of maximum priority for control. This component of the project was to find out more about the ecology of the species so that there was a better chance of controlling the species successfully. The reserve was surveyed on foot to record the area invaded and describe the type of habitats where this species was found. The area covered by the species is 0.35 km_2 approximately, and 54.5% of the broom bushes were distributed in patches, while 45.5% were growing in isolation. It was also recorded that 25.4% of the bushes were growing along the streams and 23.9% on roadsides or along tracks.

Broom bushes growing along the edges of streams and on a road verge in the Ernesto Tornquist Provincial Park

Germination tests were carried out in a chamber to evaluate the factors that favour germination, analysing the effects of mechanical scarification and imbibition. Mechanical scarification was the most successful method with 100% germination.

Three sections of bush that had been burnt were selected in order to evaluate the effects of fire on the broom populations and the possibility of using it as a control method. The survival (regrowth) of the burnt bushes, the abundance and state of the seeds in the ground, the number of broom seedlings, and the percentage cover of other plant species were measured. A year after the fire 47% of individual bushes had survived, increasing to a density of 3.1 plants/m_2. The average density of seedlings was 85.86 plants/m_2, significantly higher than 0.57 plants/m_2 corresponding to the sector unaffected by fire ($T=2.052$, $p< 0,01$). The mortality of individuals associated with the fire was particularly high for plants with small diameter (between 0-2 cm.). Germination tests carried out with seed collected from ground in the burnt areas gave negative results (no germination) (14).

Experimental control actions for the species were initiated. In the first stage four dense patches approximately 15m. in diameter were selected. Each patch was divided into quarters and three of the patches were given the following treatments: cutting the plants at the base, cutting and herbicide (Togar =picloram + triclopyr, 5% in gasoil), application to the cut stems, spraying with Togar, and the fourth patch was left as a control without cutting or herbicide application. Cutting was done with a chainsaw, herbicide was applied to the stems with a recipient of 750 cm_3 and the spraying with a hand sprayer of 750 cm_3. The herbicide was used under very strict environmental safety regulations since it was a reserve area. The number of emerging seedlings, the number of mature individuals which survived the treatment and the abundance of other species were measured. Ten months later there was 99.3% regrowth in the cutting treatment, 51.9% in the cutting and subsequent herbicide application and 47% in the burnt patch. Whereas the sprayed broom bushes showed initial signs of having been affected by the herbicide (the stems lost their green coloration and had a dry brown appearance and no flowers or leaves were found in the Spring), although after nine months

[14]SANHUEZA, C.C. y S.M. ZALBA. 2005. Estado del banco de semillas de *Spartium junceum* L. (Fabaceae), una especie exótica invasora en un sector del Parque Provincial Ernesto Tornquist (Buenos Aires) afectado por incendios naturales. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.

some regrowth was observed from the base of the plants, which reached a regrowth percentage of 68,2% (15, 16). A second experimental stage was initiated after 12 months. In the same experimental area only the patches of cutting, and cutting with subsequent herbicide treatment were used. Two herbicides were used in each patch (togar 5% in gasoil and 2% glyphosate in water) spraying each individual (n=10) that had had regrowth in the first stage and others maintained as a control. The time taken to spray and the quantity of herbicide used were recorded so that the cost and effort could be calculated. The bushes treated with togar showed no signs of regrowth after 18 months (100% without regrowth) (17).

Patches of cutting, and cutting with subsequently sprayed with herbicide in an area invaded by brooms in the Ernesto Tornquist Provincial Park.

2. CULTIVATION REQUIREMENTS OF NATIVE PLANTS

The requirements for the propagation and cultivation of two native species with potential as ornamentals, *Grindelia ventanensis (Asteraceae) and Pavonia cymbalaria* (Malvaceae), were carefully studied (18 y 19).

The differences were analyzed of the germination percentage of seed under different treatments (cold storage, mechanical scarification, etc.), and variations in the survival of plants that were propagated from cuttings cut in different seasons and then either treated or not with rooting hormone.

In both cases very encouraging results were obtained. The cultivation success was high and the plants from the trials are being grown in the Pillahuincó Botanical Garden.

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[15]SANHUEZA, C.C. y S.M. ZALBA. 2004. Análisis experimental de distintas estrategias para el control de la invasión de retama (*Spartium junceum*) sobre pastizales naturales. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.

[16]SANHUEZA, C. y S.M. ZALBA. 2003. Control experimental de *Spartium junceum* en el Parque Provincial Ernesto Tornquist (Buenos Aires). Página 71, Resúmenes XXIX Jornadas Argentinas de Botánica, XV Reunión Anual de la Sociedad Botánica de Chile. San Luis, 19-23/10/03.

[17]SANHUEZA, C. y S.M. ZALBA. 2005. Effectiveness of different strategies for controlling Spanish Broom (*Spartium junceum*) invading natural grasslands in Argentina. Annual Meeting of The Ecological Society of America, Mérida, México, 8 al 12/01/2006.

[18]NEGRÍN, V. 2005. *Grindelia ventanensis* (Asteraceae), una especie endémica de Sierra de la Ventana. Contribución al conocimiento de su biología y requerimientos de cultivo Tesina de Licenciatura en Ciencias Biológicas. Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur.

[19]TORRES, Y. 2006. Evaluación de las posibilidades de cultivo de *Pavonia cymbalaria* como planta ornamental. Tesina de Licenciatura en Ciencias Biológicas. Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur.

Grindelia ventanensis grows easily from cuttings or seed, if these are collected from wild populations. However, the cypselas lose viability if stored for a long time unless they are kept in cold dry conditions. Their flowering period is seasonal and not very long, however their foliage is attractive and so their ornamental potential is equally high. It is recommended that seed from different populations is used to ensure a wide genetic base when cultivating this species from seed (20).

Grindelia ventanensis growing in a natural habitat in Ernesto Tornquist Provincial Park and cultivated in the Pillahuincó Botanical Garden.

In the case of *Pavonia cymbalaria* propagation by seed requires breaking the hard mericarp which takes a long time and is inefficient if done mechanically. However the seeds can be separated from the remains of the carpels if submerged in 95% suphuric acid for 1 or 2 hours. The liberated seeds are then washed in a sieve held under running water for 5 minutes. The mericarps that have been partially degraded by the sulphuric acid can be gently squeezed against the sides of the sieve to separate all the seeds. It is also recommended that the seeds are treated with a fungicide before sowing to reduce the risk of fungal infections. The percentage of survival of the cuttings was significantly higher for the material collected in the Spring, but no significant differences were found in the survival of the cuttings when they were treated with hormones (21).

[20]NEGRÍN, V.L., M.A. LONG y S.M. ZALBA. 2005. Grindelia ventanensis Bartoli & Tortosa (Asteraceae) ¿una especie apta para el cultivo?. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
[21]TORRES, Y., M.A. LONG y S.M. ZALBA. 2005. Ensayos de reproducción de Pavonia cymbalaria (A. St.-Hil. Et Naudin) (Malvaceae). XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.

Pavonia cymbalaria growing in a natural habitat in the Ernesto Tornquist Provincial Park and cultivated in the Pillahuincó Botanical Garden.

3. EDUCATION AND PUBLIC AWARENESS

The education strategy in the Pillahuincó Botanical Garden is centred on linking the community to the natural habitats in the region, by encouraging an appreciation of nature by direct contact and creating a sense of belonging to the surrounding countryside. The botanical garden acts as a meeting point and centre of activities, which are based on stimulating people's aptitudes for connecting to and interacting with the environment by seeking a change of values that are more emotional than rational. We try to create activities that experiment with all our faculties, by feeling part of nature and making every experience positive, enjoyable and real.

One of our approaches is an artistic approach so that everyone uses their creativity and feels rewarded. One of the topics is Art Education which aims at creating experience of different art forms, and Environmental Education based on Art, which demonstrates that art is a very special way of getting people to understand the environment and become connected to it. Another approach is to use games for amusement and pleasure and in this way instil a greater appreciation of nature so that people become inspired and have rich personal experiences. We also encourage firsthand experience by Teaching Ecology in the School Playground (TESP), and Environmental Interpretation, i.e. learning about the causes, effects and processes from investigations and personal observations, asking questions, analysis and learning from one another.

Activities carried out in this context are aimed at the local community, especially for school ages. During 2005 students of all ages from localities in the neighbourhood (Sierra de la Ventana, Saldungaray, Villa Ventana, Paraje La Gruta, Tornquist and rural schools) visited the Botanical Garden. Workshops are mainly held in the Garden area, which is situated within a Protected Natural Area approximately 10km from the nearest town, and has access from a provincial road. Sometimes we carry out activities, such as cultivating native plants in the gardens of local schools, as many of them find it difficult to get to the Botanical Garden (22). In both cases teachers are encouraged to continue teaching the topics introduced in the workshops.

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[22] LONG, M.A., A.J. NEBBIA y S.M. ZALBA. 2004. Jardín Botánico Pillahuinco: una herramienta para la enseñanza de las ciencias. VI Jornadas Nacionales y 1° Congreso Internacional de Enseñanza de la Biología. Buenos Aires, 7-9/10/04.

As well as activities for schools, we also organize various workshops that are open to the public and which are based on field trips within the reserve, guided by staff from the Botanical Garden. During these field trips for observing the flora and fauna in their natural state, we try to create contact with nature through new perceptions (23).

As a result of the support received, it has been possible to open the Botanical Garden to the public for two days a week so that visitors to the Protected Natural Area can visit our project and understand more about the conservation actions that are implemented in the park. This is also an opportunity to evaluate the visitors' appreciation of the value of species which are found within the reserve in the wild and which are cultivated with dedication and effort in the garden.

Educational activites at the Pillahuincó Botanical Garden.

4. DISSEMINATION OF THE PROJECT

4.1. Training

During this time four members of the team concluded their Master and Bachelor degrees with research thesis developed in subjects covered by the project:

1. **Master in Wildlife Management thesis, Universidad Nacional de Córdoba**. Yannina Cuevas. Advicer: Sergio M. Zalba. Thesis: Plan de manejo de *Pinus halepensis* para el Parque Provincial Ernesto Tornquist (Buenos Aires). Concluded on October 28th 2005.
2. **Bachelor thesis in Biology**, Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur. Alejandro Loydi. Advicer: Sergio M. Zalba. Thesis: Impacto de los cúmulos de estiércol de caballos cimarrones sobre la flora de una reserva de pastizal. Concluded on September 1st 2005.
3. **Tesina de Licenciatura en Ciencias Biológicas**, Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur. Vanesa Negrín. Advicer: Sergio M. Zalba. Thesis: *Grindelia ventanensis* (Asteraceae), una especie endémica de Sierra de la Ventana. Contribución al conocimiento de su biología y requerimientos de cultivo. Concluded on August 17th 2005.

[23]CAIRO, S.L., A.J. NEBBIA, M.A. LONG y S.M. ZALBA. 2005. El sapo y la rana no son novios. VI Congreso Argentino de Herpetología, Paraná, 21 al 23/11/2005.

4. **Tesina de Licenciatura en Ciencias Biológicas**, Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur. Tesinista: Yanina Torres. Advicer: Andrea Long. Thesis: Evaluación de las posibilidades de cultivo de *Pavonia cymbalaria* como planta ornamental. Concluded on March 31st 2006.

4.2. Publications

1. Grosse, A., S.M. Zalba y S.R. Ziller. 2004. Web-accessible Information on Invasive Species in the Americas: A Multinational Invasives Information Network. Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN), Proceedings of a Workshop. 6-8 April, 2004. Baltimore, Maryland, USA. Accessed: [September 27 2004] online at http://www.gisinetwork.org
2. Zalba, S.M. 2005. El manejo científico. Un terreno común para la investigación, la gestión de áreas protegidas y el conocimiento local. Parques Nacionales, 2(2): 41-43.
3. Zalba, S.M. 2005. 2005. Introducción a las Invasiones Biológicas: Conceptos y Definiciones. Páginas 4 y 5 en: Sudamérica Invadida – El Creciente peligro de las Especies Exóticas Invasoras. GISP – Programa Mundial sobre Especies Invasoras. Kirstenbosch, Sudáfrica. Published in English, Spanish and Portuguese.

4.3. Presentations in Scientific Meetings

1. Long, M.A., A.J. Nebbia y S.M. Zalba. 2004. Jardín Botánico Pillahuinco: una herramienta para la enseñanza de las ciencias. VI Jornadas Nacionales y 1° Congreso Internacional de Enseñanza de la Biología. Buenos Aires, 7-9/10/04.
2. Cuevas Y. y S.M. Zalba. 2004. Banco de semillas de *Pinus halepensis*, una especie invasora del pastizal pampeano. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.
3. de Villalobos, A.E. y Zalba, S.M. 2004 Sobrepastoreo y modificación de la vegetación en una reserva de pastizal pampeano. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.
4. Loydi, A. y S.M. Zalba. 2004. Impacto de los bosteaderos de caballos cimarrones sobre la flora de una reserva de pastizal pampeano. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.
5. Sanhueza, C.C. y S.M. Zalba. 2004. Análisis experimental de distintas estrategias para el control de la invasión de retama (*Spartium junceum*) sobre pastizales naturales. 1era Reunión Binacional De Ecología, XXI Reunión Argentina de Ecología, XI Reunión de la Sociedad de Ecología de Chile. Mendoza, 31/10 al 5/5/04.
6. Zalba, S.M. 2005. Adaptive management of biological invasions: a tool for reducing uncertainty and improving diagnosis and effectiveness of control. XIX Meeting of the Society for Conservation Biology. Brasilia, Brasil, 15 al 19/07/05.
7. Zalba, S.M., Y.A. Cuevas, A.E. de Villalobos, C.C. Sanhueza, L. Dispigno, E.E. Zucchino y A. Loidy. 2005. Biological invasions in last relicts of Pampas grasslands (Argentina): impact and management. XIX Meeting of the Society for Conservation Biology. Brasilia, Brasil, 15 al 19/07/05.
8. Rodríguez Rey, D. y S.M. Zalba. 2005. Cambios en la diversidad y abundancia de hormigas (Hymenoptera: Formicidae) asociados a la presencia de árboles y herbívoros exóticos en el Parque Provincial Ernesto Tornquist (Buenos Aires). VI Congreso Argentino de Entomología, San Miguel de Tucumán, 12 al 15/09/2005.

9. Zalba, S.M. 2005. Invasiones biológicas y estabilidad de las unidades fitogeográficas. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
10. Negrín, V.L., M.A. Long y S.M. Zalba. 2005. *Grindelia ventanensis* Bartoli & Tortosa (Asteraceae) ¿una especie apta para el cultivo?. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
11. Sanhueza, C.C. y S.M. Zalba. 2005. Estado del banco de semillas de *Spartium junceum* L. (Fabaceae), una especie exótica invasora en un sector del Parque Provincial Ernesto Tornquist (Buenos Aires) afectado por incendios naturales. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
12. Torres, Y., M.A. Long y S.M. Zalba. 2005. Ensayos de reproducción de *Pavonia cymbalaria* (A. St.-Hil. Et Naudin) (Malvaceae). XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
13. Loydi, A. y S.M. Zalba. 2005. Vegetación asociada a cúmulos de estiércol de caballos cimarrones. XXX Jornadas Argentinas de Botánica. Rosario, 6 al 10/11/2005.
14. Cairo, S.L., A.J. Nebbia, M.A. Long y S.M. Zalba. 2005. El sapo y la rana no son novios. VI Congreso Argentino de Herpetología, Paraná, 21 al 23/11/2005.
15. Zalba, S.M., Y. Cuevas, A. de Villalobos, C. Sanhueza, L. Dispigno y E. Zucchino. 2005. Most successful plant invaders in Argentinean Pampa came from the Mediterranean Basin. Annual Meeting of The Ecological Society of America, Mérida, México, 8 al 12/01/2006.
16. Sanhueza, C. y S.M. Zalba. 2005. Effectiveness of different strategies for controlling Spanish Broom (*Spartium junceum*) invading natural grasslands in Argentina. Annual Meeting of The Ecological Society of America, Mérida, México, 8 al 12/01/2006.
17. Cuevas, Y.A., S.M. Zalba y R.M. Boó. 2005. Controlling invasive pines in a grassland nature reserve: Proposal of optimization. Annual Meeting of The Ecological Society of America, Mérida, México, 8 al 12/01/2006.

4.4. Coordination of Scientific Meetings

XIX Meeting of the Society for Conservation Biology. Sergio Zalba coordinated the symposium “Biological invasions: sharing experiences to develop effective research and management strategies”. Brasilia, Brasil, 19/07/05.

4.5. Training courses

During this period Sergio Zalba gave three training courses about management of exotic species:

1. **Invasoes biologicas: ecologia, impacto e manejo** (Biological Invasions, ecology, impact and management). Universidade Regional do Noroeste do Estado do Rio Grande do Sul, Campus Santa Rosa, Santa Rosa, RS, Brasil, June 2 - 3 2004).
2. **Plantas Invasoras** (Invasive plants). Magister in Conservation Biology, Universidad Internacional de Andalucía, Sede Iberoamericana Santa María de La Rábida, Huelva, España, October 22 - 23 2004.
3. **Manejo de Invasiones Biológicas** (Management of biological invasions). Instituto de investigación de Recursos Biológicos Alexander von Humboldt, Programa Biología de la Conservación, Línea de Especies Focales, Bogotá, Colombia, November 8 - 12 2004.

4.6. Participation in technical meetings

1. Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN) Baltimore (MA), USA, April 5 - 7 2004.
2. IABIN (Interamerican Biodiversity Information Network) General Council Meeting. Panamá, April 6 - 8 2005.
3. CBD - Ad Hoc Technical Expert Group on Gaps and Inconsistencies in the International Regulatory Framework in Relation to Invasive Alien Species. Auckland, New Zealand, May 16-20 2005.
4. I Brazilian Symposium on Alien Invasive Species. Brasilia, October 4 - 7 2005.
5. GISIN Invasive Species Profile Schema Experts Meeting. Agadir, Morocco, February 20-24 2006.