

Fuel characteristics of the invasive shrub *Teline monspessulana* (L.) K. Koch

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Abstract. Some broom species have the ability to modify elements of the fire regime in invaded areas. One such species, *Teline monspessulana* (Syn. *Genista monspessulana*; French Broom), has expanded notoriously in south-central Chile's Mediterranean climate. The biota of this area may be particularly vulnerable to effects of invasive species on the fire regime, as it is less adapted to wildfires. The properties of the fuel accumulated in *T. monspessulana* populations of different ages are characterised in this paper. For this, models were constructed to estimate fuel accumulation in *T. monspessulana* populations, and tests for flammability of foliage were also performed. The results show that the rapid growth of this invasive shrub ensures a significant accumulation of fuel (close to 90 ton ha⁻¹) in periods shorter than a decade, which may influence the severity of wildfires. Further, the fuel has a significant accumulation of fine material and high flammability, both of which may facilitate the ignition of fires. The large volume and high flammability of the fuel accumulated in *T. monspessulana* populations can thus play an important role in changing the fire regime in areas where it has invaded.

Additional keywords: Fire regime, *Genista*, plant invasion, positive feedback.

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Introduction

Invasive plants can alter the fire regime, creating favourable conditions for self-perpetuation (D'Antonio and Vitousek 1992; Mack and D'Antonio 1998; D'Antonio 2000; Brooks *et al.* 2004). Positive feedback between invasive species and wildfires is a major cause of unidirectional changes in invaded ecosystems, especially in ecosystems that have not evolved in conjunction with a fire regime characterised by frequent and intense fires (Brooks *et al.* 2004). This feedback can cause large effects at the community and ecosystems levels, changing the dynamics of the local community, altering biodiversity and generating long-term consequences on biogeochemical cycles (Mack and D'Antonio 1998; Keeley 2002; Grigulis *et al.* 2005).

Invasive plants can increase the fuel load (biomass) or change other fuel properties such as flammability, and both horizontal and vertical continuity (Brooks *et al.* 2004). Moreover, they can be better adapted than their native counterparts to regenerate after a wildfire, allowing rapid recolonisation or invasion of recently burned areas (Radford *et al.* 2001). The effects of fire on local environmental conditions, such as higher levels of solar radiation and wind, greater loss of moisture and

extreme temperature variation may persist for years after the fire (Mandle *et al.* 2011). The ability of native and exotic species to tolerate these new conditions will determine the final composition of the community after a wildfire.

Fire influences and is influenced by the composition and structure of the plant community, resulting in a complex relationship between fire and invasion by exotic plants (Mandle *et al.* 2011). It is therefore essential to analyse the characteristics of the fuel accumulated in exotic plant populations to better understand fire behaviour and the process of invasion. Changes caused by exotic plants in the extrinsic and intrinsic properties of the fuel are reflected in changes in the frequency, timing and severity of wildfires. Some of the attributes of plants associated with an increase in flammability are (a) increased accumulation of biomass, particularly in small-diameter branches, (b) low moisture content in plant tissues and (c) higher flammability and heat released during combustion. (Brooks *et al.* 2004).

Most research on species that modify aspects of the fire regime has focussed on grass species (Brooks *et al.* 2004). However, at least eight woody species have been recognised to increase the frequency or intensity of wildfires (Mandle *et al.* 2011).

Woody species that increase some aspect of the fire regime belong mainly to the Pinaceae and Fabaceae families (Mandle *et al.* 2011). This study is focussed on *Teline monspessulana* (L.) K. Koch (Fabaceae; Syn. *Genista monspessulana*; French Broom). In general, it has been suggested that broom species (a group of shrubs of the Fabaceae family, e.g. *Cytisus* spp.) have the ability to generate a positive feedback with wildfires in various ecosystems worldwide (Alexander and D'Antonio 2003a; Mandle *et al.* 2011). The broom species *T. monspessulana* has the potential to modify the behaviour of fires by promoting crown fire through accumulation of vertical fine fuel (Bossard 2000; Holmes *et al.* 1987; Pauchard *et al.* 2008; Mandle *et al.* 2011). This species could also influence the frequency and severity of wildfires by promoting a significant increase in the load and flammability of fuel, but this has not been quantified previously.

In addition to modifying fire regimes, *T. monspessulana* may also benefit from wildfires (García *et al.* 2010). *T. monspessulana* regenerates abundantly from the seed bank after a wildfire (García *et al.* 2007; Pauchard *et al.* 2008) and shows rapid growth in height during the following months (García *et al.* 2007). The seeds of this species are able to withstand high temperatures in the soil seed bank during fires (Alexander and D'Antonio 2003b; García *et al.* 2010), and seed germination for this species has been shown to increase with increasing temperatures, reaching its maximum when seeds were preheated to between 80 and 120°C (García *et al.* 2010). In systems where wildfires are present, both of these factors give *T. monspessulana* a competitive advantage over native species, which seldom have adaptations to the effects of wildfires (Gómez-González and Cavieres 2009). Thus, *T. monspessulana* could benefit from the action of wildfires through the increase in germination of seeds exposed to high temperatures (García *et al.* 2010). The existence of a positive feedback between wildfires and the invasion of this species necessarily implies that fire and invasion have a real and measurable influence on each other. However, there are still some gaps in the understanding of the real effect of the invasion of *T. monspessulana* on wildfires.

Although natural wildfires are not a common disturbance in the ecosystems of Chile, human-caused fires are currently a major threat to conservation efforts and produce losses to productive sectors (CONAF 2011). Since the 1970s, there has been a steady increase in the number of wildfires related to forest plantations of *Pinus radiata* D. Don in central and southern Chile (Peña and Valenzuela 2008; González *et al.* 2011). In the last decade, the average number of wildfires reached 6005 per season, representing an increase of 5.7% over the former decade (CONAF 2011). Traditionally, the occurrence of wildfires in Chile was concentrated in the Mediterranean climate zone, which extends from 32 to 38°S. However, in recent years a significant increase of wildfires has been observed in the temperate zones, between 38 and 42°S (Peña and Valenzuela 2008).

The main goal of this study was to understand the role of fuel produced by one of the most representative and problematic invasive woody species of central-southern Chile in changing fire regimes in central Chile. Specifically, this study aimed to describe the fuel load, structure and flammability characteristics of communities invaded by *T. monspessulana*. Structural characteristics were determined from different age populations of

T. monspessulana located in the Biobío Region, estimating its biomass and fuel accumulation. Further, we compared the flammability of the tissue of *T. monspessulana* with other species in the region.

Materials and methods

Species and study area

Teline monspessulana (L.) K. Koch is a perennial woody shrub whose stems branch profusely from the base and reach between 1 and 4 m in length. The species is originally from the Mediterranean Basin and the first records of its presence in Chile are from 1847 when it was described as an ornamental species present in different parts of the country (Matthei 1995). It is now possible to find populations of *T. monspessulana* growing in Continental Chile along the Cordillera de la Costa (Coastal Range) from the Valparaiso Region to the Los Rios Region (between 32 and 40°S). It is also present on the islands of Chile in the Juan Fernandez Archipelago (Matthei 1995, Fuentes *et al.* 2013). *T. monspessulana* is common in the understorey of the exotic *P. radiata* and *Eucalyptus* spp. forest plantations and forms extensive thickets in open areas, degraded slopes and forest clearings. It can also be found on roadsides and disturbed sites in remote Andean areas of the central valley (García *et al.* 2010).

Data were collected from different populations of *T. monspessulana* located in the coastal area of the Biobío Region of Central Chile. The populations were distributed from 36°08'S to the north to 37°30'S to the south (Fig. 1). In this area the predominant climate is Mediterranean, characterised by warm temperatures with a short dry season (4 months). The average rainfall reaches 1100 mm per year, 65–70% of which falls between May and August. The annual average temperature is around 12°C and the annual thermal amplitude is 7.5°C. The original dominant vegetation in the area is Mediterranean-temperate deciduous forests of *Nothofagus obliqua* and *Gomortega keule* and deciduous interior Mediterranean forests of *N. obliqua* and *Cryptocarya alba* (Luebert and Plissock 2006). Currently, the main land uses are forest plantations (*P. radiata* and *Eucalyptus* spp.) and agricultural activities, which together cover more than 50% of the landscape (Aguayo *et al.* 2009).

We selected 15 sites dominated by an even-aged population of *T. monspessulana*. The different stages of development of this species were studied using five sites for each stage. All sites were characterised by marked human intervention, reduced presence of native species, and extremely reduced tree cover with isolated individuals of species typical of disturbed areas, such as *Acacia dealbata* Link (invasive) and *Aristotelia chilensis* (Molina) Stuntz (native). In the study area, the return interval of catastrophic wildfires varies between 9 and 17 years (Peña and Valenzuela 2008). Further, most sites showed evidence that wildfires had occurred before the invasion (or recolonisation) of *T. monspessulana*.

Fuel load and size

For the study of fuel, areas were selected according to the dominant vegetation to ensure the presence of populations of *T. monspessulana*. Populations were classified according to the stand developmental stage at each site. The three developmental

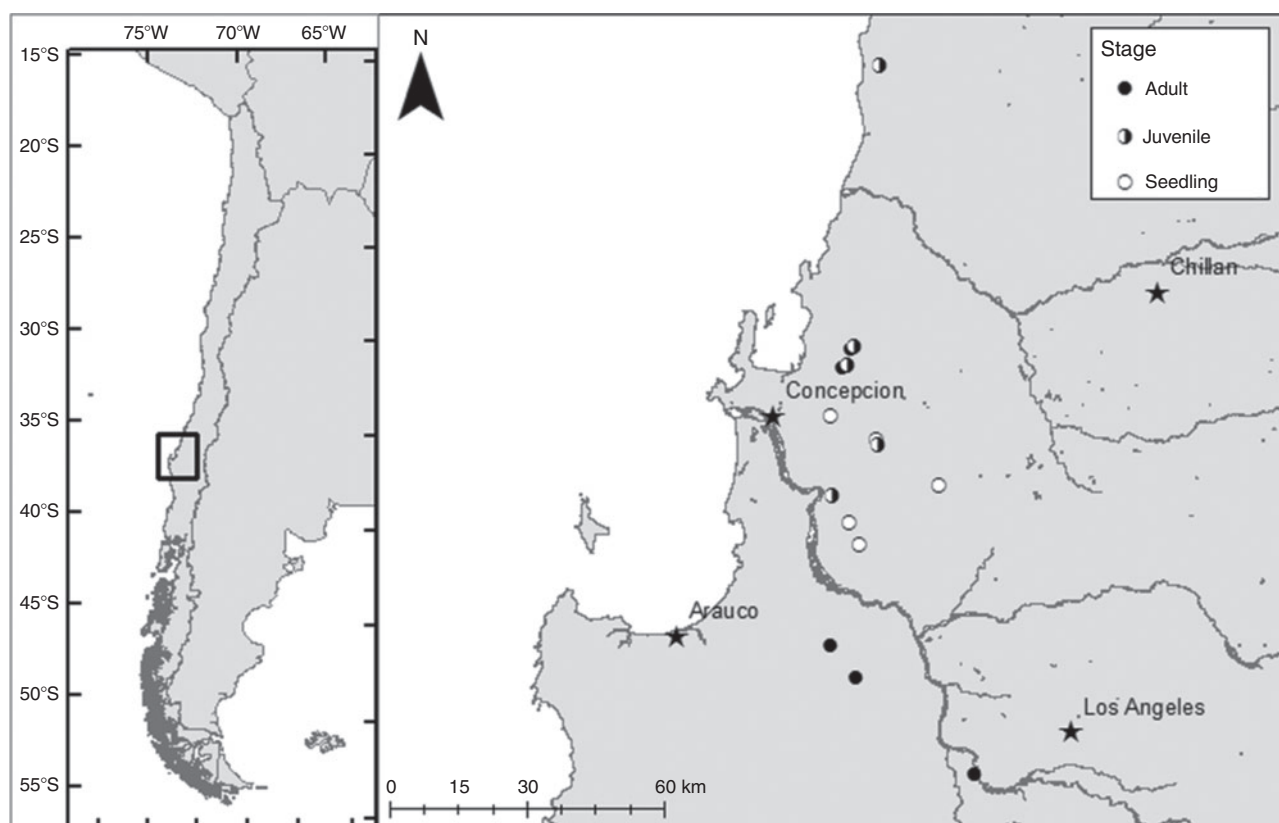


Fig. 1. Study area. Location and developmental stage of each population of *T. monspessulana* selected for this study.

stages were (1) seedlings – dominant plants of less than 1 m; (2) juveniles – dominant plants 1–2 m; and (3) adults – dominant adult plants with height greater than 2 m (Fig. 2).

Four 1-m² plots were randomly established at each site, from which stem height, basal stem diameter (BSD) and the presence of flowers or fruit were measured for all *T. monspessulana* plants. Measurements were made in the summer of 2009 and again in summer of 2010. In addition, the individual with the largest BSD was cut in each plot to estimate plant age based on annual growth rings during the first season. The number of seed pods per plant was recorded from 10 representative plants of each population. The number of seeds per pod was calculated based on 100 pods per population.

To estimate biomass and fuel accumulation, during the summer of 2010 we collected 30 whole plants from each developmental stage. Each plant was cut and classified according to different size fractions of the fuel (Table 1). Each fuel size includes both live and dead material. However, the dead material represents just a reduced proportion of total biomass. After being classified, the samples were dried in a forced air oven at a temperature of 65°C until constant weight was achieved. A dry weight was obtained for each sample, giving a total weight and weight by fuel size for each plant. These data were used to develop allometric equations of biomass for plants of different sizes (Table 2) based on a regression model. Models were fit to estimate the total accumulation of fuel and fuel size per plant for each of the three developmental stages.

Flammability

The flammability of the fuel was evaluated based on thermogravimetric analysis. Foliage samples were collected from adult individuals of *T. monspessulana*, *A. dealbata* Link (invasive) and *A. chilensis* (Molina) Stuntz (native); these last two species are frequent companions of *T. monspessulana*. Three different adult individuals were sampled for each species with 10 leaves collected per individual. Leaves were then dried at ambient temperature for 48 h and milled. Analyses were performed on a Mettler Toledo Thermobalance (TGA/STDA851e/SF1100). This equipment continuously recorded the sample mass during the combustion process under controlled conditions (i.e. temperature and gaseous environment).

Dried leaf samples of 20 mg were heated in ambient air with a flow of 50 mL min⁻¹. The samples were heated from 25 to 900°C over a period of 90 min (10°C increase min⁻¹). Weight loss of the samples and heating rate was continuously recorded along the experiment.

The maximum value of the first derivative of the mass versus time curve was taken as the relative reactivity of combustion of the sample:

$$R = -\frac{1}{m_0} \left(\frac{dm}{dt} \right)$$

where t is time, m_0 is the initial mass and m is the mass-dependent time.

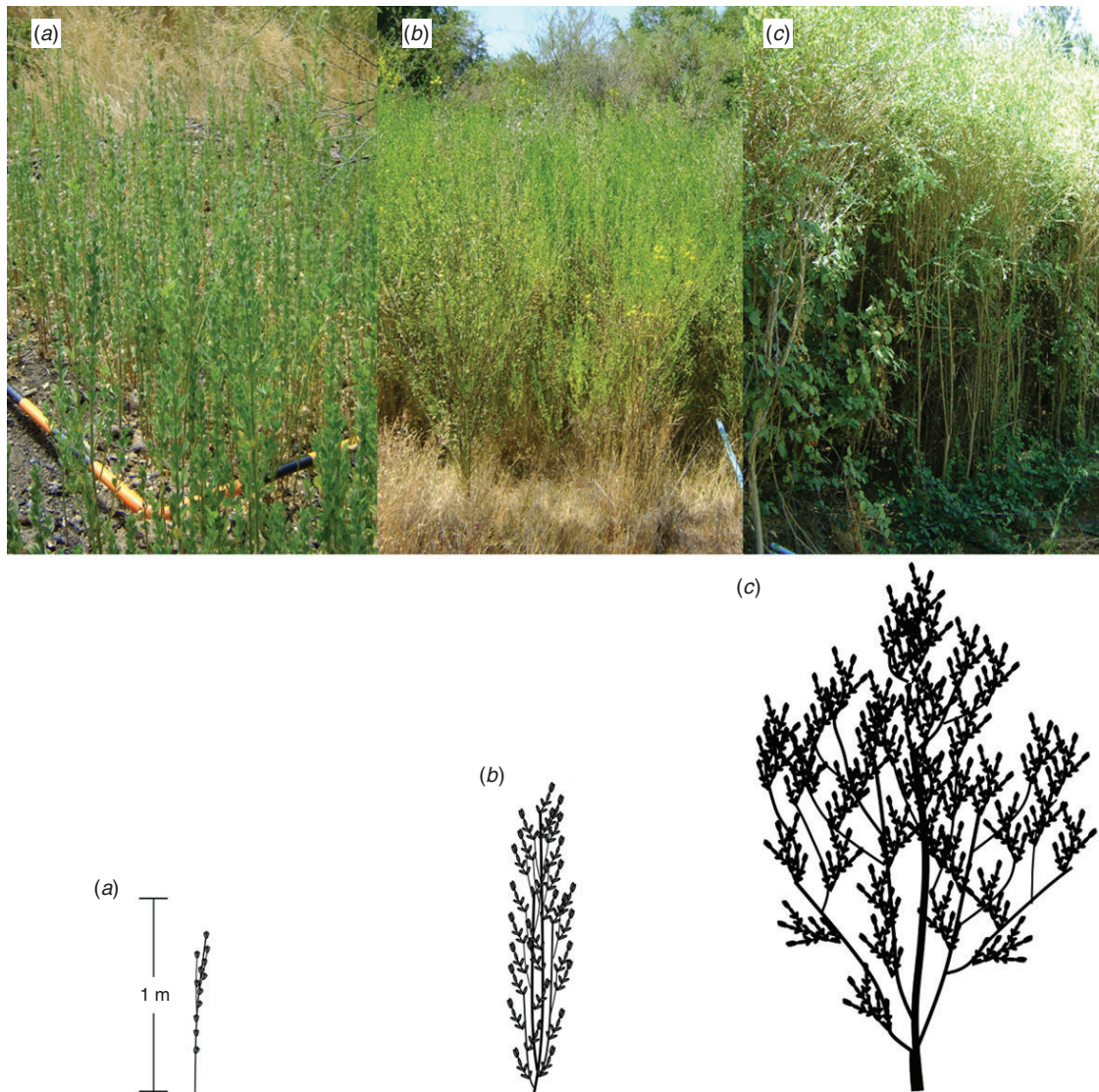


Fig. 2. Structural differences between different developmental stages of *T. monspessulana*: (a) seedling, (b) juvenile and (c) adult. Top: photos of characteristic populations. Bottom: diagram of an average plant in each stage.

Table 1. Classification of different size fractions of the fuel

Fuel size	Characteristics
Very fine fuel	Leaves and branches <5 mm diameter
Fine fuel	Branches and stems 5–25 mm diameter
Medium fuel	Branches and stems 25–75 mm diameter
Coarse fuel	Branches and stems >75 mm diameter

An average reactivity curve for each species was constructed based on the data from the three samples. A greater reactivity value indicates a quicker combustion process in the sample. Each peak of reactivity is linked to a release of compounds during combustion, and the ignition temperature of the sample was considered as the temperature associated with the peak of higher reactivity.

Statistical analysis

An analysis of variance with a Tukey test was performed to compare population density, growth, reproductive attributes and flammability variables. The population variables were compared between the three developmental stages based on data from the first year of measurement. The different sizes of fuel were analysed within each developmental stage in both years. The differences between the two years of measurement for the total fuel load for each stage were analysed with a *t*-test. For 2010 data, two of the adult populations had been cut by landowners. These populations were eliminated from the 2009 data to compare the accumulated fuel in the adult stage between the two years. Prior to analysis we applied a $\log_{10}(x)$ transformation to the plant density and BSD data and a $\log_{10}(x + 1)$ transformation for the data on density of mature plants to meet the assumptions of normality and homogeneity of variance. All analyses were performed with SPSS 15.

Table 2. Functions and parameter estimates for the accumulation of fuel (by fuel size and total fuel) in plants of *T. monspessulana* by height class
 w: dry weight of fuel (g); $x = d^2h$, where d is basal stem diameter (cm) and h is height (m)

Height range (m)	Fuel size	Function	R ²	P
H < 1.3	Very fine	$w = e^{(3.09850+1.03967*\log x)}$	0.853	<0.0001
	Fine		NA ^A	
	Total	$w = e^{(3.33981+1.13831*\log x)}$	0.882	<0.0001
1.3 ≤ H < 2.9	Very fine	$w = e^{(2.89462+0.65375*\log x)}$	0.759	<0.0001
	Fine	$w = e^{(2.18150+1.31992*\log x)}$	0.811	<0.0001
	Total	$w = e^{(3.33603+0.94943*\log x)}$	0.895	<0.0001
2.9 ≤ H ≤ 4.4	Very fine	$w = e^{(1.80591+1.03566*\log x)}$	0.433	<0.0001
	Fine	$w = e^{(3.44871+0.91093*\log x)}$	0.694	<0.0001
	Medium	$w = e^{(-3.98705+2.41980*\log x)}$	0.589	<0.0001
	Total	$w = e^{(3.22485+1.08057*\log x)}$	0.728	0.0008

^Amodel is not significant, plants between 1 and 1.3 m have a fine fuel equivalent to 42% by weight of the very fine fuel. Plants <1 m have only very fine fuel.

Table 3. Average values (±s.e.) of population density, growth and reproductive attributes for *Teline monspessulana* populations in different stages of development

Averages with different letters indicate significant differences between different developmental stages (Tukey test, $P < 0.05$)

Parameter	Seedling	Juvenile	Adult
<i>Population density</i>			
All plants m ⁻²	319.43 ± 67.63 ^c	72.27 ± 12.46 ^b	15.00 ± 3.15 ^a
Adult plants ^A m ⁻²	31.63 ± 11.17 ^b	51.53 ± 10.20 ^{ab}	14.95 ± 3.16 ^a
<i>Growth attributes</i>			
Height of plants (m)	0.67 ± 0.08 ^a	1.41 ± 0.13 ^b	2.74 ± 0.14 ^c
Basal stem diameter (mm)	3.74 ± 0.33 ^a	7.84 ± 0.89 ^b	22.11 ± 2.34 ^c
<i>Reproductive attributes</i>			
Mature plants ^B m ⁻²	7.99 ± 5.91 ^a (4.2)	35.65 ± 6.89 ^b (54.4)	13.08 ± 2.77 ^{ab} (87.3)
Pods per plant	77.28 ± 33.70 ^a	420.18 ± 93.34 ^b	382.74 ± 78.04 ^b
Seeds per pod	4.58 ± 0.13 ^a	4.75 ± 0.20 ^a	4.89 ± 0.04 ^a

^APlants >1 m height.

^BPresence of plants with flowers or fruit (% of total plant).

Results

Structural characterisation of the populations

The three developmental stages showed significant differences in population attributes (Table 3). For the first year of measurement, the mean ages of the developmental stages were (1) seedling, 1.5 ± 0.4 years; (2) juvenile, 2.8 ± 0.2 years; and (3) adult plants, 6.8 ± 0.5 years. The total density of plants differed between the three developmental stages ($F_{2,12} = 48.91$; $P < 0.001$), with marked mortality from the seedling state (319 plants m⁻²) to the adult state (15 plants m⁻²). The large significant difference in BSD ($F_{2,12} = 69.34$; $P < 0.001$) between different developmental stages is indicative of rapid plant growth. The number of sexually mature plants was the lowest in the seedling stage, whereas the juvenile and adult stages did not differ from each other ($F_{2,12} = 7.22$; $P = 0.009$). However the proportion of the population that was reproductive changed among developmental stages, with 4.2% reproductive in the seedling stage, 54.4% in the juvenile and 87% in the adult stage. The number of seed pods per plant was significantly lower in the seedling stage compared with the other two developmental stages ($F_{2,12} = 6.66$; $P = 0.011$). The number of

seeds per pod did not vary among the developmental stages ($F_{2,12} = 1.21$; $P = 0.343$) with average values between 4.6 and 4.9 seeds.

Load and size of fuel

None of the studied populations contained coarse fuel (Table 1). For populations in the seedling stage, the very fine fuel biomass (6.033 ton ha⁻¹) was greater than the biomass of the other fuel sizes (1.816 and 0.000 ton ha⁻¹ fine and medium sizes) in 2009 ($F_{2,12} = 19.76$; $P < 0.001$). In 2010, the largest biomass accumulation was concentrated in very fine (16.545 ton ha⁻¹) and fine fuel (10.778 ton ha⁻¹) sizes ($F_{2,12} = 7.32$; $P = 0.008$) (Fig. 3). For juvenile populations, the fuel biomass was concentrated in very fine (11.204 ton ha⁻¹) and fine (11.689 ton ha⁻¹) sizes in 2009 ($F_{2,12} = 5.97$; $P = 0.016$) and 2010 ($F_{2,12} = 21.54$; $P < 0.001$) (13.218 and 15.968 ton ha⁻¹ very fine and fine sizes) (Fig. 3). The fine fuel size (46.551 ton ha⁻¹) had the greatest biomass in adult populations in 2009 ($F_{2,12} = 39.69$; $P < 0.001$). In 2010, the greatest fuel loads were concentrated in very fine (20.430 ton ha⁻¹) and fine (65.624 ton ha⁻¹) sizes ($F_{2,6} = 5.94$; $P = 0.038$) (Fig. 3).

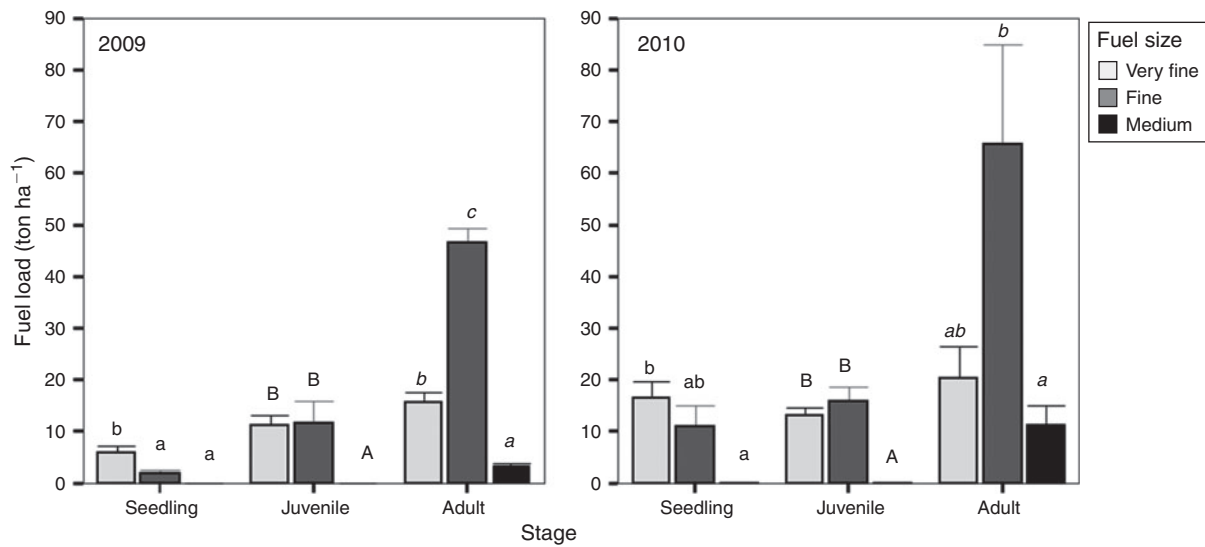


Fig. 3. Average biomass (\pm s.e.) by fuel size in each developmental stage and years. Means with different letters indicate significant differences between different sizes of fuel (Tukey test, $P < 0.05$). Different letter styles indicate independent analysis for each developmental stage.

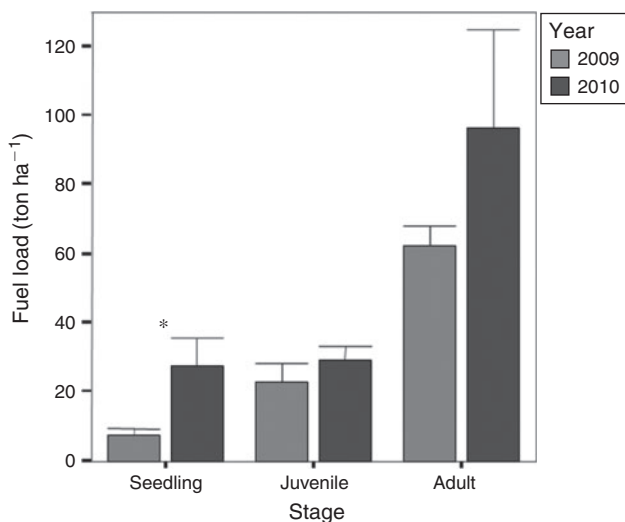


Fig. 4. Total fuel load (\pm s.e.) accumulated in populations of *T. monspessulana* in three developmental stages in the different years of measurement. *statistically significant difference ($P < 0.05$).

There was a significant increase in the total accumulation of fuel between 2009 and 2010 (Fig. 4) for the seedling stage populations ($t = -2449$, $P = 0.040$), rising from 7.55 to 27.43 t ha^{-1} . In juvenile populations, the increase from 22.75 to 29.01 ton ha^{-1} was not significant ($t = -0.0900$, $P = 0.394$) (Fig. 4). The increase in fuel load in the adult stage, from 64.82 t ha^{-1} and 2010 of 96.33 t ha^{-1} , was not significant ($t = -1089$, $P = 0.337$) (Fig. 4).

Foliage flammability

The three analysed species, *T. monspessulana*, *A. dealbata* and *A. chilensis*, have two transitions centred at temperatures close to 85 and 300°C (Fig. 5). The first event is indicative of the loss

of moisture from the sample and the second to the ignition of the material. The mean reactivity of the foliage of *T. monspessulana* reached 0.045 ± 0.002 min^{-1} , which was significantly higher ($F_{2,6} = 6.415$; $P = 0.032$) than the reactivity achieved by the other species (0.035 ± 0.001 min^{-1} and 0.036 ± 0.003 min^{-1} for *A. chilensis* and *A. dealbata*). *Teline monspessulana* showed the lowest average temperature of ignition ($285.8 \pm 0.14^\circ\text{C}$) followed by *A. dealbata* ($304.9 \pm 9.04^\circ\text{C}$) and *A. chilensis* ($309.5 \pm 3.14^\circ\text{C}$); nevertheless, this difference was marginally significant ($F_{2,6} = 5.180$; $P = 0.049$).

Discussion

The rapid growth of *T. monspessulana* ensures a significant accumulation of fuel in less than a decade. In addition, the fuel has a high portion of fine material and high flammability, both of which may facilitate fuel ignition and subsequent spread of fires. Thus, the high load and flammability of the fuel accumulated in populations of *T. monspessulana* could potentially play an important role in changing fire regimes in the invaded areas. However, the ignition of a wildfire will still depend on external factors, especially human action. Hence, while the invasion of *T. monspessulana* would not necessarily lead to an increase in ignition of wildfires, it will certainly accentuate the negative effects of fire on the ecosystem once a fire is started.

The regeneration dynamics of this species are strongly linked to human perturbations, especially wildfires (Alexander and D'Antonio 2003a; Pauchard *et al.* 2008). These perturbations cause the replacement of older plants with new plants from the soil seed bank (García *et al.* 2010), generating an even-age structure within populations. The rapid growth of the species produces plants close to 1 m in height only a few months after germination (García *et al.* 2007), which then reach an average height of 2.7 m by the adult stage (~ 6 years). This rapid growth leads to extensive intraspecific competition that is reflected in marked mortality in populations, with densities decreasing from 300 to 15 plants m^{-2} in less than a decade. Adult populations in

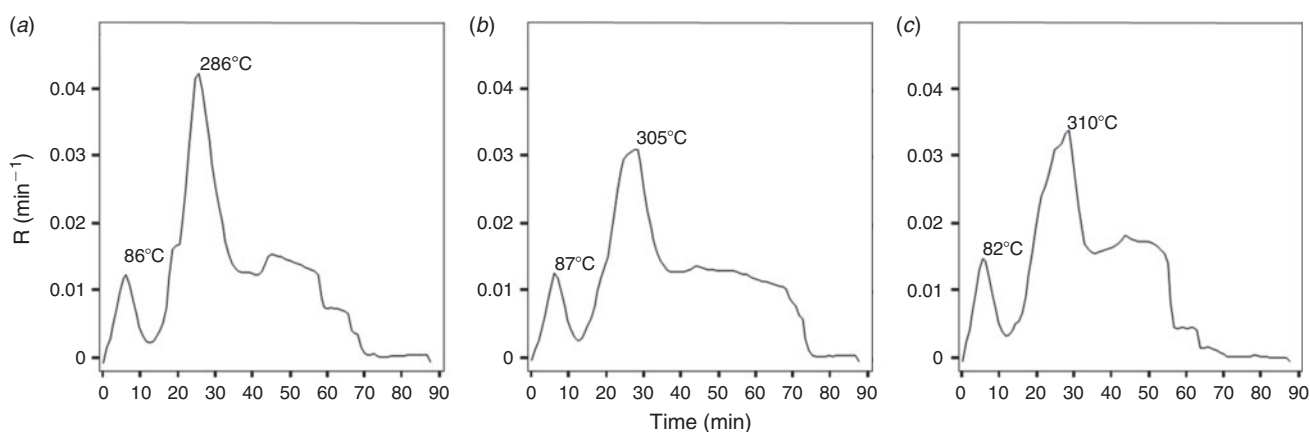


Fig. 5. Average reactivity curves for leaf samples from *T. monspessulana* (a), *A. dealbata* (b), and *A. chilensis* (c). The temperatures indicated correspond to the average value reached at the peak of reactivity.

central-southern Chile are similar to *T. monspessulana* populations measured by Herrera *et al.* (2011) in California, in that both areas have invasive populations which are more dense, with taller and larger diameter plants than are present in the native range of this species in Europe.

The rapid recolonisation of the sites invaded by *T. monspessulana* after disturbance produces an accumulation of over 20 t ha⁻¹ of fuel in less than 3 years. This ensures a constant replenishment of the fuel load, enabling the development of high-severity wildfires. Once populations of this shrub reach the adult stage, they accumulate fuel loads close to 100 t ha⁻¹, of which over 85% are fine fuel with diameters less than 25 mm. These large fuel loads with a high proportion of fine material are characteristic of the broom species group. In shrublands of eastern Spain, *Ulex parviflorus* Pourr accumulates from 19.8 to 36.7 t ha⁻¹, where fine fuel with a diameter less than 25 mm represents ~75% (De Luis *et al.* 2004). Meanwhile *Ulex europaeus* L achieves a fuel load between 46 and 52 t ha⁻¹ in Spain (Vega *et al.* 2005) and between 26 and 74 t ha⁻¹ in New Zealand (Fogarty and Pearce unpubl. data in Anderson and Anderson 2010). About 50% of the fuel in *Genista scorpius* (L) DC plants in France corresponds to fine fuel less than 5 mm in diameter, and, depending on plant development, the fuel load can vary between 27 and 115 t ha⁻¹ (Papió and Trabaud 1991). Due to the fuel characteristics of this group of species, several invasive broom species have been listed as fire cycle modifiers, mainly in Mediterranean climates (Mandle *et al.* 2011).

In addition to the fuel load and size, the height reached by the adult *T. monspessulana* plants accelerates the spread of fire. Taller fuels are more flammable and act as 'ladder fuel', allowing the fire to spread more easily than shorter fuels such as surface litter because they are more exposed, more aerated and faster drying (Anderson and Anderson 2010). Additionally, *T. monspessulana* has a lower ignition temperature than the native species. Hence, there is greater probability of fuel ignition and combustion of material occurs at a higher speed. In addition, it is common to find populations of *T. monspessulana* along or within forest plantations of exotic species, increasing the vertical continuity (Pauchard *et al.* 2008) of fuel in these plantations.

This vertical continuity of fuel, along with the fact that this species produces thin branches a few inches away from the soil, may increase the likelihood of crown fires of high severity in south-central Chile.

Even though the fuel accumulated in populations of *T. monspessulana* has characteristics that make it highly flammable and likely to increase (1) the likelihood of ignition, (2) rate of spread and (3) intensity and severity of wildfires, it is difficult to prove that invasions of this species result in new fire regimes (e.g. Brooks *et al.* 2004). However, it is highly likely that the presence of fine fuel together with the rising temperatures due to global warming will result in a larger surface area being affected by wildfires, as has been reported in other regions (Piñol *et al.* 1998; Westerling *et al.* 2006). Since 99% of wildfires in Chile are of anthropogenic origin (intentional or accidental), the maintenance of this new fire regime is more closely linked to human activity than to the presence of *T. monspessulana* in the landscape. Thus, this new fire regime could return to more natural levels with cultural changes related to the use of fire in rural communities and in the urban-rural interface, even if distribution of this invasive species is not changed. However, in order to decrease the severity of wildfires once they are ignited, this species should be managed in such a way that fuel accumulation is reduced and ladder fuels are removed.

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