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**Papadimitriou M., Tsougrakis Y., Papanastasis V.P.**

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# Vegetative and reproductive plant height of species populations in relation to land use changes in Mediterranean rangeland ecosystems

M. Papadimitriou\*, Y. Tsougrakis and V. P. Papanastasis

Aristotle University of Thessaloniki, School of Forestry and Natural Environment, Laboratory of Rangeland Ecology, P.O. Box 286, GR - 54124, Thessaloniki, Greece

\*email: mpapadim@for.auth.gr

**Abstract.** Plant height is a functional trait that is directly related with plant competitive ability and its capacity to tolerate or avoid disturbance and environmental stress. The aim of this paper was to study the vegetative and reproductive plant height of plant populations of the same species in relation to land use changes in Mediterranean rangelands. At the area of Lofiskos, Lagadas County, Thessaloniki, N. Greece, four land use types were selected: a) abandoned arable field, b) grassland, c) open shrubland and d) dense shrubland with four replicates each, representing four stages of secondary succession after land use extensification and/or abandonment. Vegetative and reproductive plant height of the populations of plant species that were abundant in at least two of the land use types was measured. Vegetative plant height was significantly different between the populations of the same species for the 71% of the species under study, while reproductive plant height was significantly different for the 64% of the species studied. In both cases, the majority of the species appeared significantly higher height in their populations in the advanced stages of succession. Vegetative and reproductive plant height of species population's responds to land use changes caused by extensification and/or abandonment in Mediterranean rangelands.

**Keywords.** Plant Functional Traits - Secondary succession – Extensification - Abandoned field – Grassland - Shrubland

***Hauteur végétative et reproductive des populations de plantes en relation avec les changements d'utilisation des terres dans les parcours méditerranéens***

**Résumé.** La hauteur de la plante est un trait fonctionnel qui est directement lié à sa capacité compétitive et à son aptitude à tolérer ou à éviter les perturbations et le stress environnemental. L'objectif de cet article était d'étudier la hauteur végétative et reproductive des populations végétales d'une même espèce en relation avec les changements d'utilisation des terres dans les parcours méditerranéens. Dans la région de Lofiskos, comté de Lagadas, Thessalonique, Grèce du Nord, quatre types d'utilisation des terres ont été sélectionnés : a) champs arables abandonnés, b) prairies, c) zones arbustives ouvertes et d) arbustiaies denses avec quatre répétitions chacune, représentant quatre étapes de succession secondaire après l'extensification et/ ou l'abandon de l'utilisation des terres. La hauteur végétative et reproductive des populations d'espèces végétales abondantes dans au moins deux des types d'utilisation des terres a été mesurée. La hauteur végétative des plantes était significativement différente entre les populations d'une même espèce pour les 71% des espèces étudiées, tandis que leur hauteur reproductive était significativement différente pour les 64% des espèces étudiées. Dans les deux cas, la majorité des espèces semblaient avoir une hauteur significativement plus élevée dans leurs populations aux stades avancés de la succession. La hauteur végétative et reproductive des populations de plantes répond aux changements d'utilisation des terres causés par l'extensification et/ou l'abandon dans les parcours méditerranéens.

**Mots-clés.** Traits fonctionnels de la plante - Succession secondaire - Extensification - Champ abandonné - Prairie - Arbuste

## I - Introduction

Plant height is a functional trait that is directly related with plant competitive ability and its capacity to tolerate or avoid disturbance and environmental stress (Weiher *et al.*, 1999; Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007; Pérez-Harguindeguy *et al.*, 2013). The ecological importance of this trait has been globally recognised and it has been largely used in a number

of plant ecological strategy schemes (Westoby *et al.*, 2002). According to Grime (2001), plant height can determine the survival and the relative abundance of a species during its competition for light.

Land use changes are the main factor that affects terrestrial ecosystems more than any other factor of environmental change (Vitousek *et al.*, 1997; Sala *et al.*, 2000; Chapin III *et al.*, 2002). They usually consist of two opposite directions, intensification on the one hand and extensification and abandonment on the other (Chapin III *et al.*, 2002; Poschlod *et al.*, 2005). In the rural areas of the Mediterranean ecosystems, abandonment and/ or extensification of traditional land uses usually occur (Caraveli, 2000; Mulligan *et al.*, 2004; Papanastasis and Chouvardas, 2005). The above changes have led to woody species encroachment on open areas and sequentially to vegetation secondary succession to shrublands and woodlands (Tatoni *et al.*, 2004; Chouvardas and Vrahnakis, 2009).

Plant height is a trait that is expected to respond to disturbance (Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007). Short plants have been found to be favoured by grazing over tall ones by many researchers such as Pakeman (2004), de Bello *et al.* (2005) and Diaz *et al.* (2007). On the other hand, it has been found that tall plants increase as vegetation succession proceeds (Prach *et al.*, 1997; Kahmen and Poschlod, 2004; Castro *et al.*, 2010). The plant height of the populations of a species during an environmental gradient or change is expected to vary (Garnier *et al.*, 2007; Pérez-Harguindeguy *et al.*, 2013) but no many studies have focussed on investigating this. The aim of this paper was to study the vegetative and reproductive plant height of the same species populations in relation to land use changes in Mediterranean rangelands.

## II - Materials and methods

The research took place at the area of Lofiskos, Lagadas County that is located near the city of Thessaloniki in North Greece. The altitude of the area is approximately 500m a.s.l., with a mean annual air temperature of 12.1°C and a mean annual rainfall of 586mm. Four land use types with four replicates each were selected: a) abandoned arable field, b) grassland, c) open shrubland and d) dense shrubland. These four land use types represent four stages of secondary succession after land use extensification and/ or abandonment.

For fourteen plant species (Table 1 and 2) that were abundant in at least two of the above-indicated land use types, as it was found by Zarovali *et al.* (2007), vegetative and reproductive plant height of their populations was measured for each type separately. The measurements followed the protocols of Cornelissen *et al.* (2003) and Pérez-Harguindeguy *et al.* (2013) and were taken on healthy and vigorous plants that were in open or in the least shadowed places. Vegetative plant height was measured as the vertical distance of the highest main photosynthetic tissues of a plant (leaves) and the soil surface, excluding any exceptional branches. In accordance, reproductive plant height was measured as the vertical distance of the upper limit of the reproductive organs of a plant (inflorescence) and the soil surface. Both traits were measured on twenty individuals of each species and each land use type that it was abundant. In some cases, vegetative and reproductive plant height was identical.

Differences of the mean vegetative and reproductive height of the populations of a species between the land use types were investigated using the t – test and one way Anova when a species was abundant in two or more land use types respectively (Fowler *et al.*, 1998). In the last case, when significantly differences were found, Duncan multiple range test was used for further investigation at the 0.05 probability level. The software package PASW Statistics 18.0 (SPSSInc., 2009) was used for all the analyses.

### III - Results and discussion

Vegetative plant height was significantly different between the populations of the same species for the 71% of the species studied (Table1). On the contrary, the rest 29% of the species, including the grasses *Chrysopogon gryllus* (L.) Trin. and *Taeniatherum caput-medusae* (L.) Nevski and the woody species *Pyrus amygdaliformis* Vill. and *Quercus coccifera* L., did not appear significant differences among their populations for this trait.

**Table 1.** Vegetative plant height (cm) of each species population for the different land use types.

Species	Abandoned field	Grassland	Open shrubland	Dense shrubland
<i>Chrysopogon gryllus</i> (L.) Trin.	26.25a <sup>1</sup>	27.25a	25.10a	28.95a
<i>Dactylis glomerata</i> L.	10.45c	20.45b	16.80βc	37.00a
<i>Dianthus pinifolius</i> Sm.	-	7.85b	-	10.95a
<i>Dichanthium ischaemum</i> (L.) Roberty	-	21.45b	26.25a	-
<i>Genista carinalis</i> Griseb.	-	9.45c	13.50b	18.90a
<i>Plantago lanceolata</i> L.	9.7b	14.10a	-	-
<i>Pyrus amygdaliformis</i> Vill.	-	263.00a	234.00a	-
<i>Quercus coccifera</i> L.	-	-	263.50a	248.75a
<i>Taeniatherum caput-medusae</i> (L.) Nevski	5.68a	6.78a	-	-
<i>Thymus sibthorpii</i> Benth.	-	10.15b	9.90b	13.25a
<i>Trifolium angustifolium</i> L.	22.40a	-	-	17.10b
<i>Trifolium hirtum</i> All.	10.90b	6.60c	12.70b	20.30a
<i>Trifolium ochroleucon</i> Huds.	6.70c	-	9.25b	12.95a
<i>Vicia cracca</i> L.	40.50a	28.60b	26.80b	-

<sup>1</sup>Different letters in the same line indicate significant differences ( $p \leq 0.05$ ) according to the t – test and the Duncan test when a species was abundant in two or more land use types respectively.

As table 1 showed, the majority of the species had significantly higher vegetative height in their populations in the advanced stages of vegetation succession, compared with the ones in the early stages. This was the case for the 57% of the species studied. Even though, the populations of these species were not all measured in the same land use types, they followed the same trend.

On the other hand, the legumes *Trifolium angustifolium* L. and *Vicia cracca* L. appeared with different trends. They both had significantly higher vegetative height in their population in the abandoned field (an early stage of vegetation succession) and lower in their population(s) on the other land use types.

As far as the reproductive plant height was concerned, it was found to be significantly different among the various land use types for the populations of the 64% of the species studied (Table 2). The rest 36% of the species, more than in the case of the vegetative plant height, did not show significantly differences between their populations for this trait. This was the case for the species *Dichanthium ischaemum* (L.) Roberty, *Plantago lanceolata* L., *Pyrus amygdaliformis* Vill., *Quercus coccifera* L. and *Trifolium angustifolium* L..

The reproductive plant height of the species populations followed the same trend with vegetative plant height. In this case, the 50% of the species had significantly larger reproductive height in their populations on the advanced stages of vegetation succession compared with the ones on the early stages.

**Table 2.** Reproductive plant height (cm) of each species population for the different land use types.

Species	Abandoned field	Grassland	Open shrubland	Dense shrubland
<i>Chrysopogon gryllus</i> (L.) Trin.	158.25a <sup>1</sup>	139.15b	128.80b	136.80b
<i>Dactylis glomerata</i> L.	54.35c	77.60b	76.00b	93.25a
<i>Dianthus pinifolius</i> Sm.	-	39.55b	-	46.00a
<i>Dichanthium ischaemum</i> (L.) Roberty	-	80.50a	71.10a	-
<i>Genista carinalis</i> Griseb.	-	17.10c	20.10b	28.35a
<i>Plantago lanceolata</i> L.	41.65a	44.40a	-	-
<i>Pyrus amygdaliformis</i> Vill.	-	263.00a	234.00a	-
<i>Quercus coccifera</i> L.	-	-	263.50a	248.75a
<i>Taeniatherum caput-medusae</i> (L.) Nevski	27.35b	32.90a	-	-
<i>Thymus sibthorpii</i> Benth.	-	15.70b	14.65b	18.80a
<i>Trifolium angustifolium</i> L.	28.15a	-	-	24.65a
<i>Trifolium hirtum</i> All.	16.15b	10.60c	18.10b	27.10a
<i>Trifolium ochroleucon</i> Huds.	11.35c	-	14.70b	18.80a
<i>Vicia cracca</i> L.	41.00a	35.90ab	33.60b	-

<sup>1</sup>Different letters in the same line indicate significant differences ( $p \leq 0.05$ ) according to the t – test and the Duncan test when a species was abundant in two or more land use types respectively.

Nevertheless, the populations of two species appeared the opposite trend. Those species were *Vicia cracca* L., as in the case of vegetative height, and *Chrysopogon gryllus* (L.) Trin. In both cases, the population of the abandoned field (early stage of vegetation succession) had significantly greater reproductive height than the other populations of the species.

In both cases, vegetative and reproductive plant height, the majority of the species appeared significantly higher height in their populations in the advanced stages of succession and lower in the early stages. This finding comes in agreement with a number of researches, which concluded that plant height increased as vegetation succession proceeded (Prach *et al.*, 1997; Prach and Pysek, 1999; Kahmen and Poschlod, 2004; Castro *et al.*, 2010), as well as, with the reduction of grazing intensity (Westoby, 1999; de Bello *et al.*, 2005; Louault *et al.*, 2005; Peco *et al.*, 2005; Pakeman and Marriott, 2010). Plant competitive ability is closely related with its height, so this trait has a high response to disturbance (Weiher *et al.*, 1999; Diaz *et al.*, 2001; Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007).

It must be noted that the populations of some species did not follow the above general trend of the majority of the species. This was probably because they found more favorable conditions in other stages of vegetation succession and also due to the more intensive competition for light in the later stages (Grime, 2001). Finally, the populations of a small number of species did not appear any significant difference in their vegetative and/ or reproductive height. The woody species *Pyrus amygdaliformis* and *Quercus coccifera* were two of them that did not show any difference among their populations for both traits. As woody species, they were taller from all

the other, so competition for light was less for them and this was probably the reason why their height remained the same.

## IV - Conclusions

Both vegetative and reproductive plant height of species populations respond to land use changes caused by extensification and/ or abandonment in Mediterranean rangeland ecosystems. The majority of the species appear with higher vegetative and reproductive height in their populations in the advanced stages of succession. Nevertheless, some species populations do not follow the general rule, depending on their competitive ability and their niche differentiation.

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