LIFE10 NAT/GR/000638

Safeguarding the Lesser White-fronted Goose Fennoscandian population in key wintering and staging sites within the European flyway

Action C3: Suitable habitat management at key feeding and roosting sites in Evros delta

FINAL REPORT

Hellenic Agricultural Organisation "DEMETER" / Forest Research Institute

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The present report includes the research results regarding the habitat management in Dimitriadis grassland at Evros Delta National Park, Greece. The research was implemented in the framework of Action C3: "Suitable habitat management at key feeding and roosting sites in Evros delta", during the LIFE project «Safeguarding the Lesser White-fronted Goose Fennoscandian population in key wintering and staging sites within the European flyway» (LIFE10 NAT/GR/000638). The project was funded by the European Commission and the Norwegian Directorate for Nature Management.

The action was implemented by the Hellenic Agricultural Organization "DEMETER"/ Forest Research Institute.

Cover photo: Geese foraging around and inside the fenced and seeded plot in Dimitriadis grassland, Evros Delta, Greece (photo: S. Kazantzidis).

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Summary

Coastal grazing lands of the Evros Delta serve primarily as feeding and resting areas for several avian and mammalian herbivores like the Lesser White-fonted Goose (hereafter LWfG) and livestock, mainly cattle. Dimitriadis grassland (33.25 ha) constitutes the main feeding area for livestock, wild geese and other herbivores in the Evros Delta. The action C3 of the LIFE project «Safeguarding the Lesser White-fronted Goose Fennoscandian population in key wintering and staging sites within the European flyway» aimed to provide optimal feeding and roosting conditions of the remnant European LWfG population at the Evros Delta during the wintering period. For this purpose, grassland restoration focused both on the increase of the area covered by grass-legume-forb patches which are heavily used by all herbivores and on the decrease of the high halophytic dominance by using mechanical methods (light ploughing with a tiller and a tractor) in three halophytic dominant sites which subsequently were seeded with grasses and legumes. The whole area is dominated mainly by two vegetation communities, halophytic and grass-forb communities, forming a temporal dynamic mosaic due to many involved factors such as the presence and the quality of the water, salinity of the soil, etc.

In the Dimitriadis and the Paloukia grasslands, six halophytic dominant sites (50 X 40m each) were lightly ploughed with a tiller and a tractor and subsequently were seeded with a mix of *Lolium perenne*, *Dactylis glomerata* and *Trifolium repens*, at a seeding rate of 6kg/site, on the middle of November 2013. The half (50x20m) of the five seeded sites, three in Dimitriadis and two in Paloukia, was fenced to protect the vegetation from cattle grazing (regulation of grazing pressure). At the end of the three next wintering periods (2014-2015, 2015-2016 and 2016-2017), we evaluated the dynamics of the cover and the availability of the most important forage categories, i.e. graminoids, halophytes, legumes, other forbs and of the bare soil in Dimitriadis grassland (the fences in Paloukia grassland were damaged). Geese droppings were also counted in all treatments and natural habitats during the same wintering periods. In spring 2015, a quarter of the total area of each one of the protected from cattle grazing sites was unfenced and in spring 2016 all fences were removed and cattle grazed freely in the treated sites. In addition, a 30 ha halophytic dominant area was also seeded by hand with *Bromus inermis*, at the seeding rate of 30kg/ha, without any preparation of the soil both before and after the seeding process.

Light ploughing and subsequently seeding a mix of two grass species and one legume can be considered a successful management practice, as the graminoids' coverage was about 6-

fold higher in the seeded and protected from cattle grazing sites than that in the natural halophytes patches (control group). However, natural graminoids contributed the majority of this increment three years after seeding. These results indicate that light ploughing without seeding also seems to benefit grasses and contributes to the substantial reduction of the halophytic dominance. Future research should investigate the potential positive effects on the vegetation composition and structure, the responses of tame and wild herbivores and the ways that light ploughing could be applied in the study area in favour of geese and the other herbivores.

No protection at all from cattle grazing had temporarily poor benefits and resulted to a great increase of the cover proportions of bare soil during the first year after the implementation of light ploughing and seeding. However, during the next two years this negative effect was diminished. Obviously, cattle activities (grazing, trampling, etc.) had a negative effect on the vegetation re-establishment in treated sites only for one year. On the contrary, protection from cattle grazing right after the appliance of the ploughing and the seeding process increased the relative cover and the availability of the preferred forage for geese and reduced the respective percentages of the halophytic species even from the first year. Additionally, seeding and protection from cattle grazing increased the use of these sites by the geese as feeding places. Protection from cattle grazing seems essential in order to improve this grazing land during the first year after light ploughing and seeding, but had no significant benefits concerning the coverage of the available food categories for herbivores when this regime is maintained for another one year. Under this aspect, protection from cattle grazing should be hold during the first grazing period after the appliance of the seeding process (i.e. from March – April to late November – early December) and after that time cattle grazing should be allowed.

Seeding *Bromus inermis* by hand without any preparation of the soil before and right after the appliance of the seeding process was failed. Only a few small patches of individuals of this species were found in the seeded area one year after seeding. The lack of light ploughing, the non-covering of seeds with soil after seeding and perhaps the relatively high numbers of seed-eaters passerine species are considered the major factors contributed to the failure of establishment of *Bromus inermis*.

In Dimitriadis area, there are several slightly elevated zones (no more than 25-30 cm elevated difference) dominated by grasses, legumes and forbs while the low elevated zones are usually dominated by halophytes. In coastal wetlands, this is usually the outcome of differences in soil salinity between high- and low-elevated zones. The creation of several technical slightly elevated zones dispersed throughout the study area may contribute to the local reduction of the soil salinity and halophytic coverage in favour of grasses, legumes and forbs. Controlled freshwater inundation of parts of this area may help in a complementary way to the deterioration of current halophytic expansion. Future research should verify the above assumptions in order to manipulate the vegetation characteristics (cover, composition, availability, structure, etc.) in a desirable way.

In November 2013, an extensive grass cut was implemented on two small islets at Drana lagoon. The aim of the action was to reduce the height of the halophytic vegetation in order to provide alternative safe roosting site for geese near their feeding grounds. A halophytic dominant area in each of the islets was cut with brush cutters. However, due to the relatively low number of geese in the wider area during the period of project, the Dranas islets were not used by geese as resting or roosting sites at all. Halophytes may constitute a low importance feeding resource for geese and the other herbivores, but they may be of prime importance for their survival ability and the protection against predators. For vulnerable herbivores, such as the LWfG, both available cover and food must be considered in conservational plans. Furthermore, the importance of halophytic vegetation as resting or nesting habitats for other bird or mammal species (e.g. skylarks – *Alauda arvensis* and European hares – *Lepus europaeus*) present in the study area may be crucial too for their survival ability and reproduction success. The investigation of the role of the halophytic community in wildlife ecology and how this community can be manipulated through cattle grazing will also contribute to the sustainable multiple use of coastal grazing lands of the Evros Delta.

Cattle activities seem to respond to temporal changes in quality and availability of forage by changing their activities throughout the year. High frequency of grazing was observed in May and especially in December is probably an effect of both the higher availability and quality of forage in May. The higher availability of halophytes and graminoids in relation to that of legumes and other forbs throughout the year is also reflected to the higher frequency of cattle grazing upon halophytes and graminoids. Frequency of cattle grazing upon graminoids was high during the periods of high availability and quality (March, May and July) and low in October and December when both availability and quality of graminoids was reduced. On the contrary, the availability of halophytes was high in October and December and low during the other periods and this was also reflected to cattle activities. The high availability and quality of forage in spring (March and May) reflected to reduced frequency of walking and ruminating by cattle in relation to the other periods (i.e. July, October, December).

When forage availability is limited, as probably happens in years with high numbers of wild herbivores, cattle stocking rates should be kept at a relatively low level and livestock raisers should provide increased quantities of supplementary food dispersed throughout the study area or in neighbouring available areas. In addition, the main and highly selected food for geese in the study area is C3 grasses (*Poa* spp., *Bromus* spp., *Hordeum* spp., etc.) which usually sprout in November. Because of the relatively limited availability of these species, cattle activities (grazing and trampling) should be stopped at least by the end of November in order to protect the preferred food resource for geese during the rest of the wintering period. Placement of supplement by the farmers in halophytic dominant patches throughout the study area is expected to attract cattle and to improve their distribution and the grazing pressure in a more evenly way. In addition, target livestock grazing on halophytic patches may further contribute to the reduction of halophytic dominance and height in favour of geese and other wild herbivores. More research is needed on the effects of cattle grazing and especially target livestock grazing on vegetation composition and structure and if these effects indirectly influence the behaviour of geese. Cattle grazing seem to be vital for geese and the other herbivores in Evros Delta by deteriorating density and height of vegetation as it has been well documented in northwestern European coastal lands. However, because feeding and movement behaviour of herbivores are influenced by multifactor systems, future research should also focus on the effects of the other human disturbances in the Evros Delta, except livestock grazing, mainly the touristic activities including the effects of the road network and the traffic volume.

Introduction

The Evros Delta in Greece is a wetland with high biodiversity, since more than 300 bird species, including many protected and globally threatened species use this area, either for specific periods or all year round (Goutner 1997). Coastal grazing lands of the Evros Delta serve primarily as feeding and resting areas for several avian and mammalian herbivores like the LWfG and livestock, mainly cattle. It is well known that livestock grazing can influence the abundance and spacing of animal populations, as well as their feeding strategies (van der Graaf et al. 2002). Survival and reproduction capability of many geese species are greatly influenced by habitat characteristics and vegetation structure; therefore, grazing may influence the population dynamics of geese, as well (Bos et al. 2005).

Several studies have shown that livestock grazing benefits species of *Anseriformes,* by retarding vegetation succession and maintaining a low vegetation height. We also know from previous research that geese and other waterfowl have also been recorded to use the grass–legume–forb patches with a low vegetation height more than the halophytic ones with much taller vegetation in the Evros Delta (Karmiris et al. 2008). Grasses, legumes and other forbs also constitute the main dietary items of cattle, geese and other herbivores in this area (Karmiris et al. 2011, Karmiris et al. 2014). Livestock grazing can aid in keeping the vegetation height in relatively low levels in favour of geese. Under this perspective, livestock grazing can even be used as a 'tool' to manipulate the habitat in order to favour the avian herbivores in this area. That's why it was an urgent need to design and implement a rational management plan focusing on the conservation of this grazing land which will regulate the livestock grazing and will improve the availability of the preferred forages for the herbivores. This need was met in part by the special study of the wet meadows of the Evros Delta (Platis et al. 2013) which thoroughly describes and defines the grazing capacity, the grazing pressure, the herbage and halophytic production and other relative parameters in the study area.

The action C3 aimed to provide optimal feeding and roosting conditions of the remnant European LWfG population in the Evros Delta during the wintering period. For this purpose, we tried to increase the quantity of the heavily used grass-legume-forb patches and to decrease the high halophytic dominance by using mechanical methods (light ploughing with a tiller and a tractor) in three halophytic dominant sites which subsequently were seeded with grasses and legumes. Systematic monitoring of the effects of ploughing and seeding along with the herbivores' responses was undertaking during the last two years in order to evaluate the success of the management practice (ploughin and seeding) and to propose appropriate management actions incorporating the needs of both cattle and geese.

Study area

Dimitriadis grassland (33.25 ha) constitutes the main feeding area for livestock, wild geese and other herbivores in the Evros Delta (Appendices D and E). The whole area is dominated mainly by two vegetation communities, halophytic and grass-forb communities, forming a temporal dynamic mosaic due to many involved factors such as the presence and the quality of the water, salinity of the soil, etc. Halophytes are the dominant species in this landscape and the most common ones are *Halimione portulacoides*, *Salicornia europaea* and *Limonium bellidifolium*. Grasses are the most valuable plants in the Evros Delta, since from precious research we know that the major herbivore assemblages in this area, i.e. cattle, feral horses, European hare and white-fronted goose, use more intensively the grass communities and their main dietary items are the grasses (Karmiris et al. 2008, 2011). Other vegetation categories, which may encounter in these sites are legumes (mainly medics and trefoils), forbs (with a great diversity of plant species, but they constitute only a minor portion of vegetation composition) and woody species which grow either solitary or in small groups.

Three Range Units (Appendix E) were recognized in this area for management purposes (Platis et al. 2013). Cattle graze freely in this area (about 130 individuals during the previous years but only 70 in 2015-2016) usually for 9 months yearly. The estimated grazing capacity in all Range Units was calculated as 950 AUM (Platis et al. 2013). However, grazing pressure is not uniform in the whole area – there are heavily grazed sites and others which are lightly grazed. The balance of stocking rates and grazing capacity could be achieved with a better regulation of livestock distribution. More information on the study area can be found in the spatial study of the wet meadows in Evros Delta by Platis et al. (2013).

Similar vegetation characteristics were more or less recorded at Paloukia grassland, an adjacent grazing land available to studied herbivores (Appendix D). The islets at Drana lagoon, which also serve as resting and feeding areas for geese, are dominated by halophytic vegetation (mostly *Salicornia europaea*).

Methods

In the Dimitriadis grassland, restoration was carried out on 3 halophytic dominant sites (50 X 40m each) that were lightly ploughed with a tiller and a tractor and subsequently were seeded with a mix of *Lolium perenne*, *Dactylis glomerata* and *Trifolium repens*, at a seeding rate of 6kg/site, on the middle of November 2013. The seeded species were selected according to the results of studies regarding the vegetation and the diet of the geese wintering at Evros Delta (Platis et al. 2013, Karmiris et al. 2014). Half of each site (50x20m) was fenced to protect the vegetation from cattle grazing during the next spring, summer and autumn (regulation of grazing pressure). Another three plots of the same size and vegetation characteristics were established at Paloukia grassland and two of them were fenced in the same way as in Dimitriadis grassland. Concerning the natural vegetation, another two major feeding habitats were distinguished in a patchily mosaic form, i.e. halophytic and grass-legume-forb patches, based on the dominant plant species in the study area (Karmiris et al. 2008). A full timetable of all management implications and data collection at Evros Delta grasslands within the framework of C3 action is presented in Appendix A.

At the end of the wintering period 2014-2015, we evaluated the dynamics of the cover and the availability of the most important forage categories, i.e. graminoids, halophytes, legumes, other forbs and of the bare soil. Vegetation cover was assessed in 25 squared plots (0.25 m^2), randomly dispersed in the treated and natural habitats (Cook & Stubbendieck 1986). We collected data from plots which were more than three meters from the boundaries of the artificial and the natural feeding habitats to avoid edge effects. The availability of the major forage categories for all herbivores was based on the relative cover of vegetation in the study area. Data were collected at the end of the two next wintering periods (2014-2015 and 2015-2016), i.e. when the Lesser White-fronted Goose (LWfG – *Anser erythropus*), the Greater White-fronted Goose (GWfG – *Anser albifrons*) and, rarely the Greylag Goose (*Anser anser*) use the Dimitriadis grassland as a wintering feeding place. Cattle were not grazing at that time in the area for more than two months (by the end of November 2014). They are traditionally removed from the study area during November until March, i.e. almost the whole wintering period. At the end of 2015 the herd was infected by the lumpy skin disease virus and was removed from the study area. Half of the herd was replaced by healthy animals about one month later which grazed in this area during the remaining of the wintering period. The availability of each major forage category was estimated by excluding litter, bare soil and water proportions. Woody vegetation was also excluded, since this forage category was a negligible component in both the plant community and the herbivores' diet (Markkola et al. 2003).

Along with vegetation data, in the same plots, geese droppings were also counted in all treatments and natural habitats during the wintering periods 2014-2015, 2015-2016 and 2016-2017. During the two latter wintering periods, only a small portion of the total LWfG population (less 30 individuals) wintered at Evros Delta for a few days (www.piskulka.net). However, evaluating habitat use with the dropping-counting method assumes at least 7-10 days acclimation period for the birds after arrival to their new habitat and another 2-3 weeks after that period for the accumulation of a sufficient number of droppings on the soil surface. Subsequently, the geese droppings counted during the wintering period 2015-2016 do not belong to the LWfG but to other goose species, mainly the GWfG. In order to infer conclusions and to propose management guidelines concerning the LWfG, as well as because of the limited number of droppings which were founded at the end of the wintering periods 2015-2016 and 2016-2017, the relative data were excluded from further analysis even though they followed the same trend with the 2014-2015 wintering period.

In spring 2015, a quarter of the total area of each one of the protected from cattle grazing sites at Dimitriadis grassland plots was unfenced, thus, at the end of November 2015, there were three levels of the factor protection from cattle grazing (i.e. two years protection, one year protection, no protection at all). At the end of November 2015, i.e. at the end of the cattle grazing season, we also evaluated the effects of the late spring, summer and autumn grazing by cattle on the coverage and subsequently the availability proportions of each forage category in artificial and natural feeding habitats using the same methodology as described previously. Data from Paloukia grassland were not collected because fencing has been intentionally damaged and cattle were freely grazed in the treated plots. In addition, all fences were removed in April 2016 and cattle grazing was allowed in the treated sites. During the next wintering period (2016-2017), the effects of cattle grazing on vegetation of the treated sites were evaluated too under the same protocol as described before.

Cattle activities were evaluated using the direct observation method from 2014 through 2016. Observation periods include March, May, July, October and December. Within each of the five periods, five cattle were observed for three consecutive days. Observations began at first light and ended when it was too dark to see cattle clearly, from approximately 30 min before sunrise to 30 min after sunset. Activity of each cattle was recorded at 5-second intervals for 1 minute and then the observer recorded the activities of another animal. Activities were categorized as grazing in halophytes, grasses, legumes and other forbs, lying, ruminating, walking, and other (including defecaeting, urinating, scratching etc.). Ruminating activity included ruminating while lying and standing. Cattle behavior was influenced by the human presence, therefore observations were made with binoculars from distances of 50 to 100 m.

A 30 ha halophytic dominant area at Dimitriadis grassland was also seeded by hand with *Bromus inermis* at the seeding rate of 30kg/ha, without any preparation of the soil both before and after the seeding process. This management practice is undoubtedly more cost effective and will produce less disturbance on natural plant communities than the methods which involve preparation of the soil before and after the appliance of the seeding process.

The halophytic vegetation (mostly *Salicornia europaea*) of two small islets in Drana lagoon was cut using brush cutters in order to create roosting or resting area for geese near their feeding grounds. The natural vegetation height was about 30-40 cm which was reduced after cutting at the level of -15-20 cm. A similar action on one of the islets was implemented just the previous year by the management authority of Evros Delta National Park in order to create attractive vegetation structure for birds to nest.

From October of 2015 to May of 2015 as well as from April 2016 to March 2017, we also collected and analyzed representative samples of the most common halophytic species (*Halimione portulacoides*, *Salicornia fruticosa* and *Limonium* spp.) as well as of the herbage (a mix of grasses, legumes and other forbs). These samples were collected separately for each plant species and forage category in three representative sites in the Dimitriadis area, oven-dried (55 ^{o}C for 48 hrs), grounded in a Wiley meal (1-mm screen) and used for the determination of nitrogen (AOAC 1990; crude protein (CP) was determined by N x 6.25), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) (Goering and van Soest 1970, van Soest et al. 1991).

A non-parametric analysis of variance (Kruskal–Wallis test using rank data), was applied to the coverage proportions of each forage category as well as to bare soil in order to detect significant differences among the four feeding habitats available to herbivores, i.e. the treatments (3 years protection of cattle grazing, less than 2 years protection from cattle grazing) and the natural halophytic and grass-forb patches (Siegel and Castellan 1988). In the cases where significant effects were found, Mann–Whitney *U*-tests, corrected for multiple testing with the sequential Bonferroni test, were applied to examine further differences between pairs of treatments. A one-way analysis of variance was used to evaluate the differences between the mean numbers of geese droppings deposited in the four available feeding habitats (Petrie & Watson 1999). Habitat types were treated as fixed factors. In order to check the homogeneity of variances Levene's test was performed prior to the analysis. Mean differences were evaluated with Tukey's HSD. In all tests, a significant statistical difference was assumed when $P < 0.05$.

Results

Vegetation characteristics

Significant differences (Kruskal-Wallis 1-way ANOVA) were found in the total cover of the graminoids (χ^2 = 229.375, p < 0.001), halophytes (χ^2 = 199.769, p < 0.001), legumes (χ^2 = 39.628, p < 0.001), other forbs (χ^2 = 25.717, p < 0.001) and the bare soil (χ^2 = 55.252, p < 0.001) among the natural (halophytic and grass-legume-forb communities) and the seeded habitats (protected or not). Further significant differences were found under pairwise comparisons (Mann–Whitney *U*-test). More particularly (Figure 1), graminoids' cover was significantly higher in the seeded and 3-years protected from grazing sites in relation to the natural halophytic sites (the control group) (U = 472.5, p < 0.001). This effect was obvious even from the first year after seeding. However, the graminoids' cover was significantly less in the seeded and 3-years protected from grazing sites than in the natural grassland sites (U = 17.5, p < 0.001). Seeded grasses (i.e. *Dactylis glomerata* and *Lollium perenne*) constituted about a quarter of the total graminoids' cover one year after seeding but this percentage fell to 10% during the second year, and less than 5% during the third year after the appliance of the light ploughing and the seeding processes.

Halophytic coverage was significantly less in the seeded and 3-years protected from grazing sites (U = 472.5, p < 0.001), as well as in the seeded but no protected at all or protected for less than 2 years sites (U = 333.5, p < 0.001) than in natural halophytic sites which constituted the control group.

Legumes' coverage was significantly higher in the seeded and 3-years protected sites (U = 1792, p < 0.001) and the freely grazed seeded sites or the sites protected less than two years (U = 2068.0, p < 0.001) than in natural halophytic patches.

The same trend with legumes' coverage was also observed in other forbs' coverage. More specifically, significantly higher coverage by other forbs were found in the seeded and 3-years protected sites than in the natural halophytic sites (U = 1962, p < 0.001).

No significant differences were found in the mean cover of any forage category were found between the seeded and 3-years protected sites and the freely grazed seeded sites or the sites protected less than two years (p > 0.05 in all cases).

Finally, no significant differences of the cover percentages of bare soil were found between all treatments and the natural grass-forb patches three years after the appliance of the light ploughing and the seeding processes (p > 0.05 in all cases), despite the fact that a significant increase of the bare soil percentages were detected during the first two years. However, coverage of bare soil in natural halophytic patches was still significantly higher than in treatment sites and the natural grass-forb patches ($p > 0.05$ in all cases).

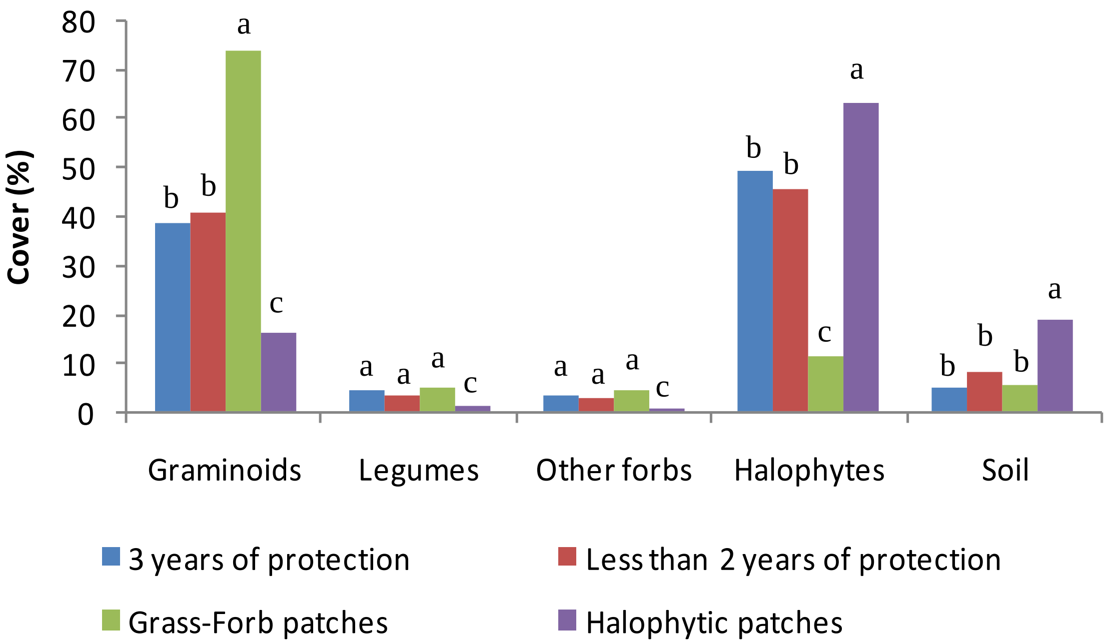

Figure 1. Mean cover (%) of forage categories and bare soil in the treated sites (3 years of protection from cattle grazing, less than 2 years protection from cattle grazing) and the 2 natural habitats (grass-forb and halophytic patchess) in the Dimitriadis grassland. Different letters indicate significant differences ($p < 0.05$) in the mean cover of each one of the 4 forage categories and the bare soil among the 4 habitats.

Habitat improvement in favour of all herbivores assemblages using the Dimitriadis grasslands was obvious only one year after the appliance of the light ploughing and the seeding processes. Specifically, availability of graminoids and halophytes was greatest in the natural grassland and the natural halophytic sites respectively (Figure 2). However, the availability of graminoids was clearly higher in the protected from grazing sites than that both of the natural halophytic sites (control group) and the seeded but no protected at all from grazing by cattle during the next wintering period after ploughing and seeding. The availability of the other two important forage categories (legumes and other forbs) in the seeded sites (either protected or not) were more than double fold and more or less equal in relation to the natural halophytic sites and the natural grassland sites respectively.

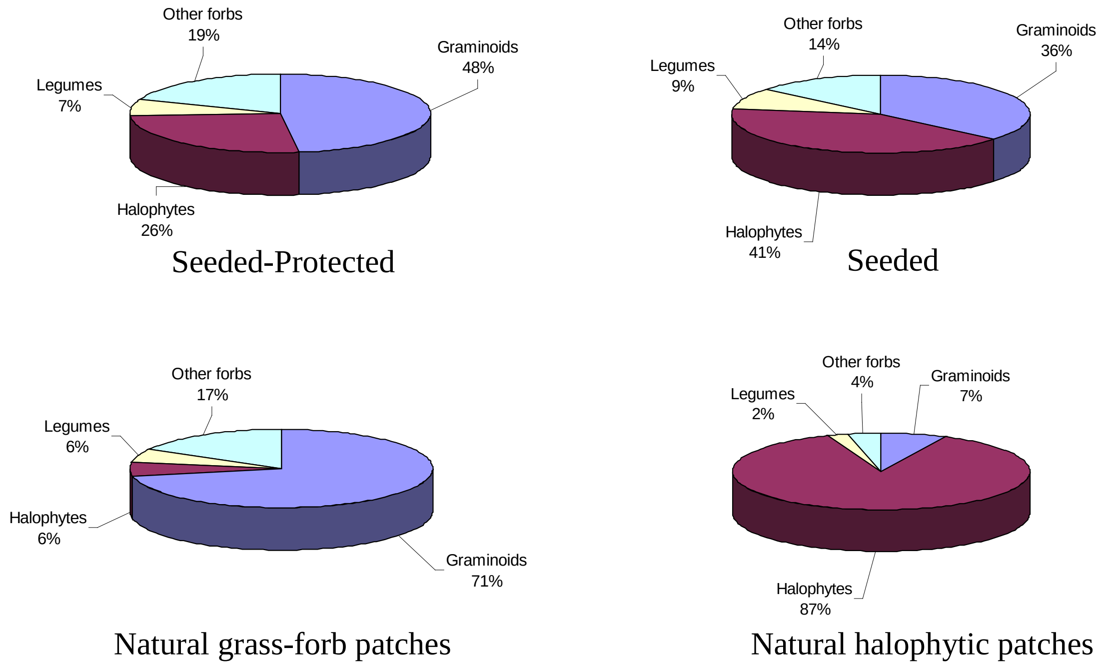

Figure 2. Availability (%) of the 4 major forage categories in the 2 artificial (seeded and protected from cattle grazing and seeded but not protected from cattle grazing sites) and the 2 natural feeding habitats (grass-forb and halophytic patches) one year after habitat improvement.

Herbivores' responses

Habitat use by geese

Geese used the natural grassland sites more intensively (F = 50.313, d.f. = 3, p < 0.001) than any other type of habitat (Figure 3). Post hoc comparisons (Tukey’s test) revealed a significantly higher mean number of geese droppings in the natural grassland sites than in any other type of habitat (p < 0.001 in all cases). Significantly higher mean number of geese droppings was also found in the seeded and protected from cattle grazing sites than in both the seeded but no protected and the natural halophytic sites (p < 0.001). Finally, no significant differences were found in the use of geese between the freely grazed seeded sites and the natural halophytic sites (p = 0.141).

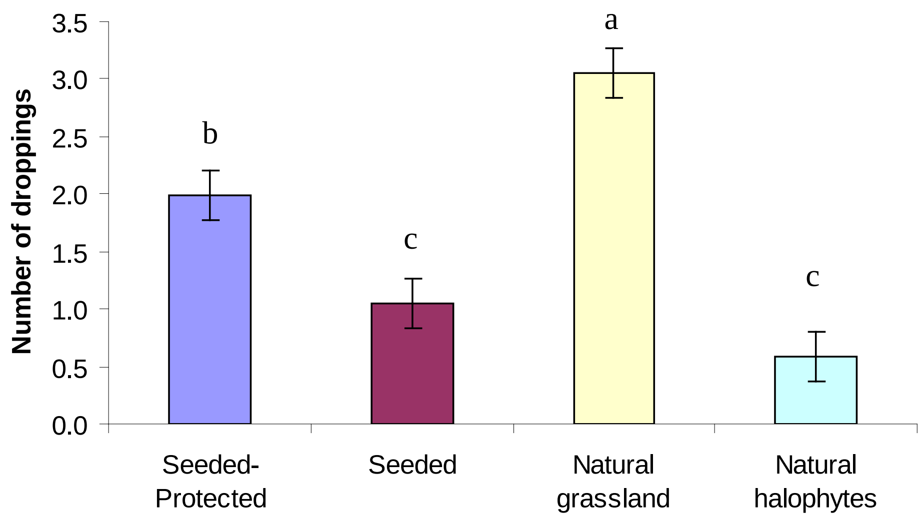

Figure 3. Mean number of geese droppings (± SE) in the seeded and protected from cattle grazing sites, the seeded but not protected and the 2 natural available habitats in the Dimitriadis grassland. Different letters indicate significant differences ($p < 0.05$) in the mean number of droppings among the 4 habitats.

Cattle activities

Direct grazing (without chewing) upon all forage categories (i.e. halophytes, grasses, legumes and other forbs) constituted about 1/3 of the total activities of cattle during daytime in all periods (Figures 4-8). Frequency of grazing was less in December (25.5%) and higher in May (36.0%). Within this type of activity, grazing upon halophytes and graminoids were predominant while grazing upon legumes and other forbs were at a relatively low level throughout the year. However, grazing upon graminoids was higher in March (15.1%), May (18.7%) and July (17.6%) and lower in October and December (less than 10% in both periods). On the contrary, grazing upon halophytes was higher in October (14.9%), March (16.8%) and especially in December (17.8%) and lower during the remainder periods. Frequency of walking was higher in July (27.4%), October (27.6%) and December (28.4%) and lower in March (18.1%) and May (22.6%). Ruminating frequency was higher in October and December (20.1% and 21.1% respectively) and lower in March, May and July (14.5%, 11.7% and 14.6% respectively). Concerning the frequency of other categories of cattle activities, these were fluctuating more or less in low percentages in all periods (less than 10% in all cases).

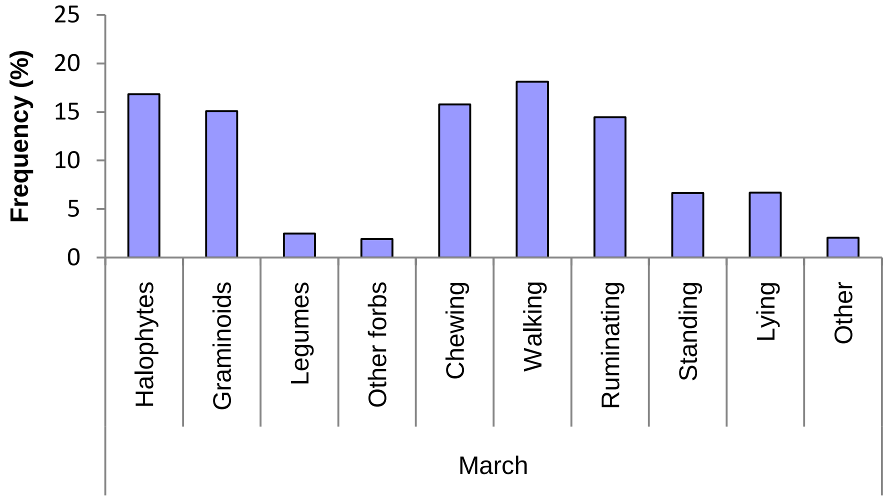

Figure 4. Frequency (%) of cattle activities during daytime in March.

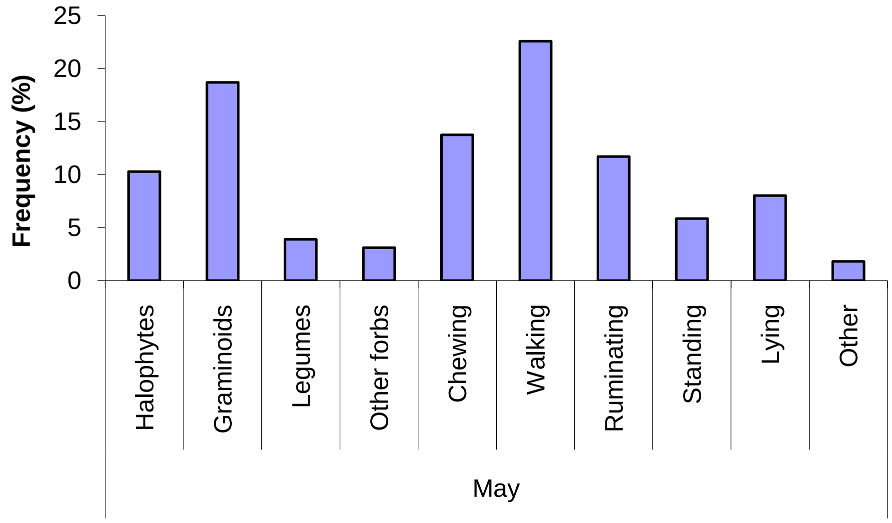

Figure 5. Frequency (%) of cattle activities during daytime in May.

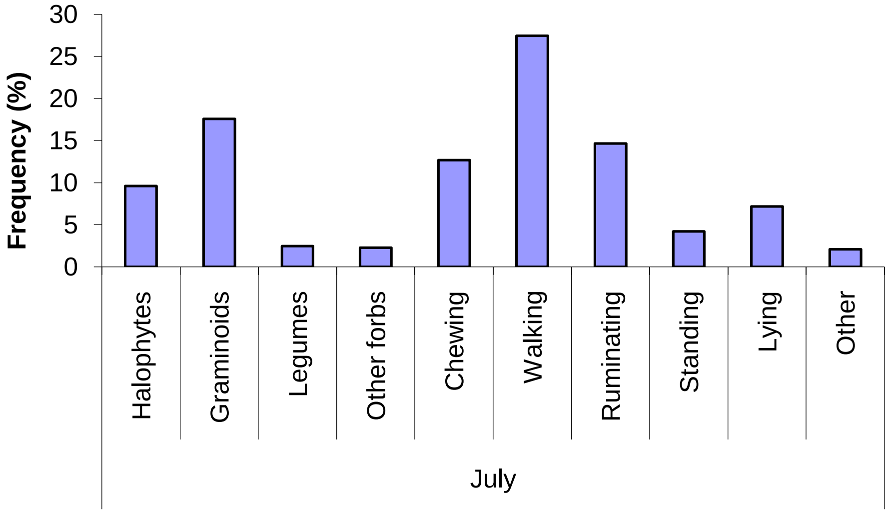

Figure 6. Frequency (%) of cattle activities during daytime in July.

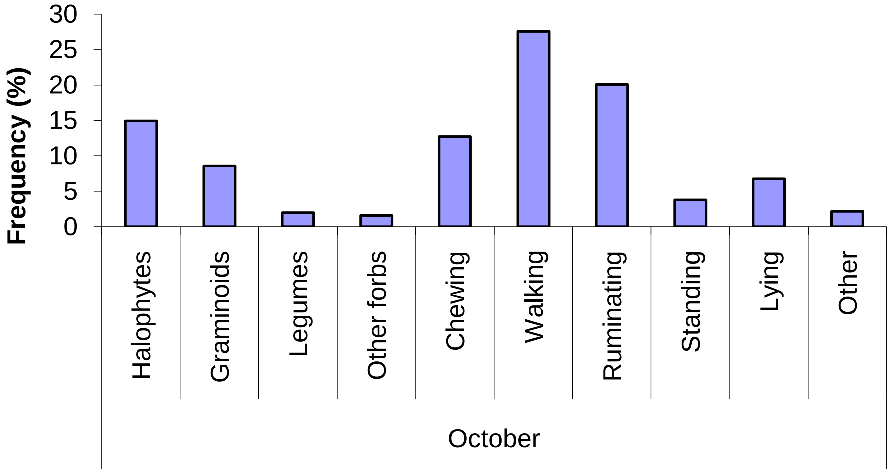

Figure 7. Frequency (%) of cattle activities during daytime in October.

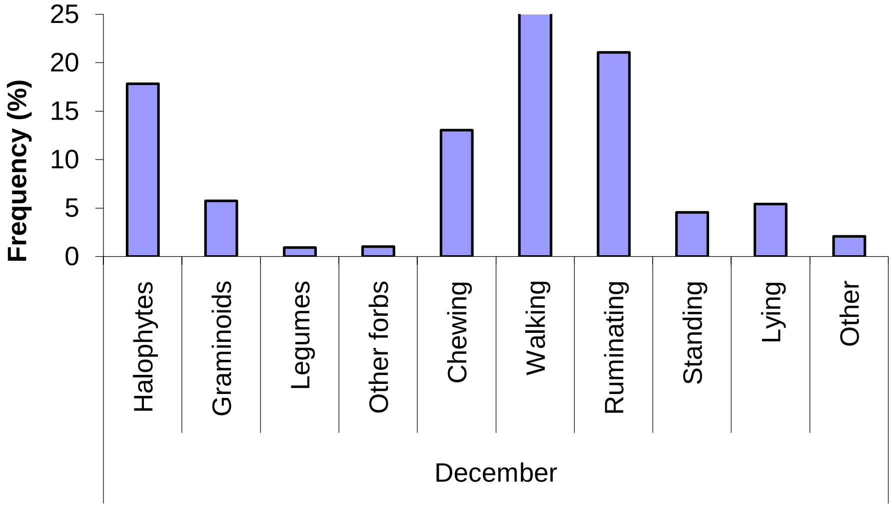

Figure 8. Frequency (%) of cattle activities during daytime in December.

Food nutritive value

Crude protein content (CP, %) of herbage (i.e. grasses, legumes and other forbs) was higher than the respective percentage of the halophytes *Halimione portulacoides* and *Salicornia fruticosa* in March and May (Figure 9). *Halimione portulacoides* and *Salicornia fruticosa* constitute the main halophytic dietary items of livestock and wild goose species at Evros Delta, while *Limonium* spp. is avoided by all herbivores. However, the value of CP content of *Limonium* spp. in March was very close with that of herbage (191.2 g/kg and 203.8 g/kg respectively). From summer (July) onwards, CP content of all the tested food resources was lower than early (March) and late spring (May). The differences of CP content among the three halophytic species and the herbage was further reduced in October and December, as all estimated values ranging from 92.2% (*Halimione portulacoides*) to 112.6% (herbage). Neutral detergent fiber (NDF: %, Figure 10), acid detergent fiber (ADF: %, Figure 11) and acid detergent lignin (ADL: %, Figure 12) for all food resources followed a more or less common trend with higher values in October and especially in December and lower values in March and May and July. These results lead to the conclusion that the nutrient content (CP, NDF, ADF, ADL) of the dominant halophytic species and the herbage are more or less similar with a few differences throughout the year.

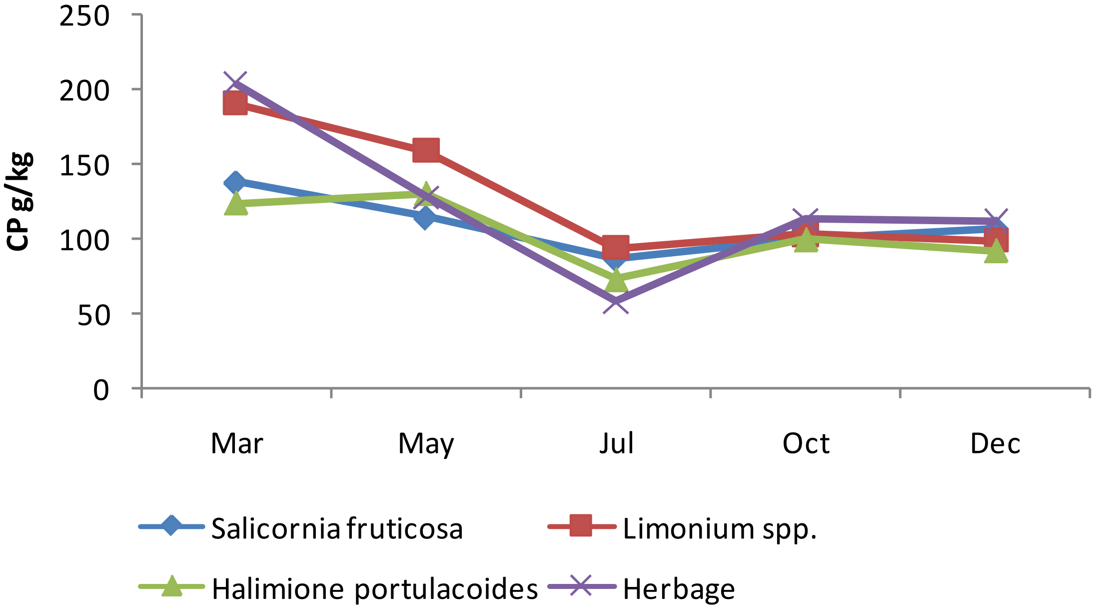

Figure 9. Crude protein content (CP, g/kg) of halophytes (*Salicornia fruticosa*, *Limonium* spp. and *Halimione portulacoides*) and of herbage (mix of available grasses, legumes and other forbs) at Evros Delta.

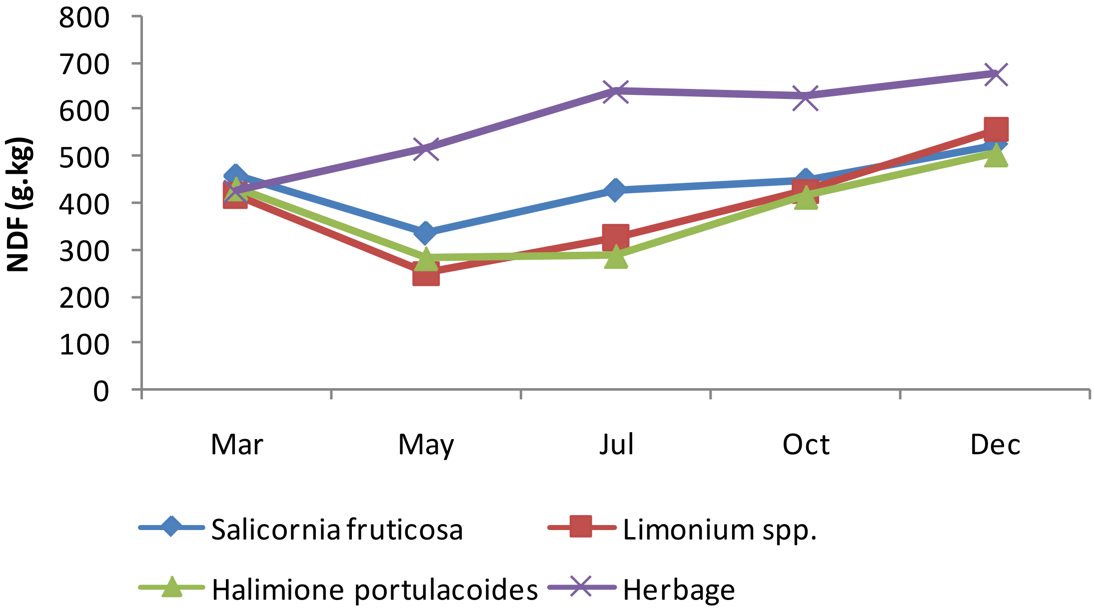

Figure 10. Neutral detergent fiber (NDF, g/kg) of halophytes (*Salicornia fruticosa*, *Limonium* spp and *Halimione portulacoides*) and of herbage (mix of available grasses, legumes and other forbs) at Evros Delta.

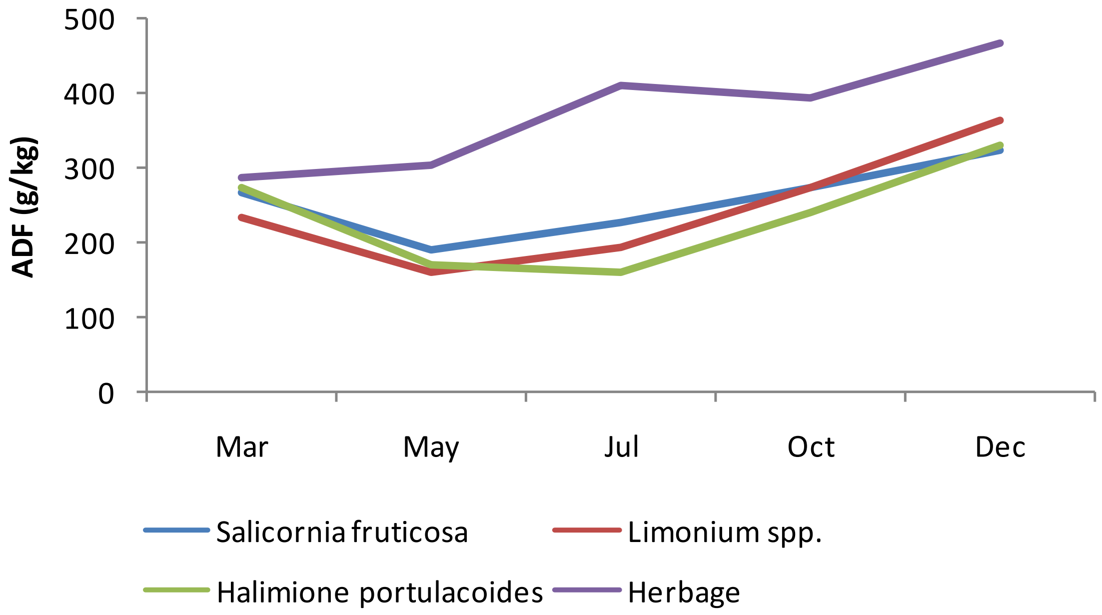

Figure 11. Acid detergent fiber (ADF, g/kg) of halophytes (*Salicornia fruticosa*, *Limonium* spp. and *Halimione portulacoides*) and of herbage (mix of available grasses, legumes and other forbs) at Evros Delta.

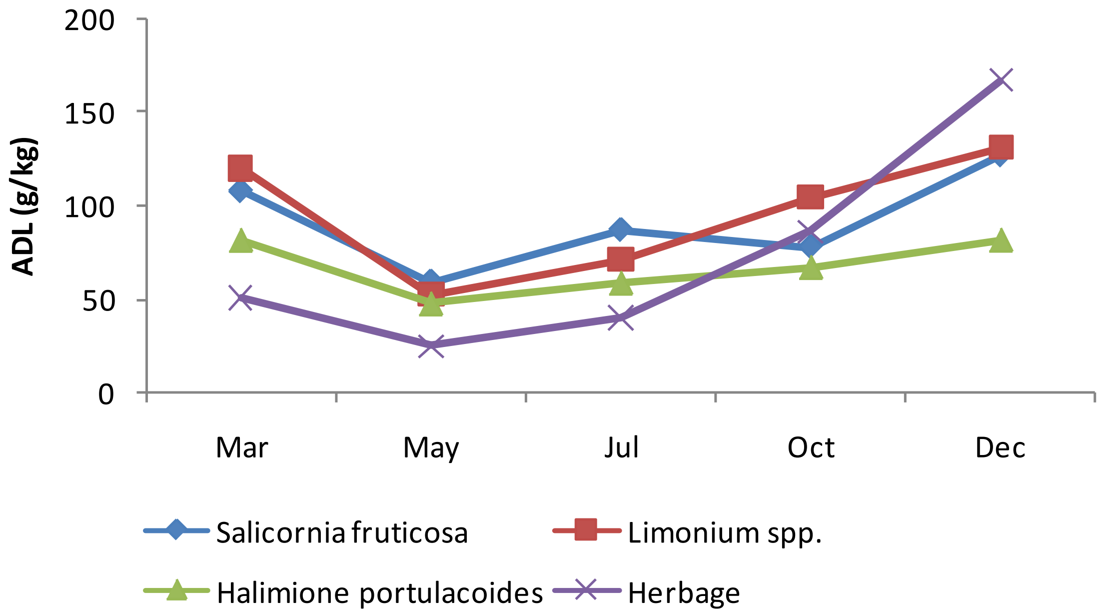

Figure 12. Acid detergent lignin (ADL, g/kg) of halophytes (*Salicornia fruticosa*, *Limonium* spp and *Halimione portulacoides*) and of herbage (mix of available grasses, legumes and other forbs) at Evros Delta.

Conclusions, Management Implications and Future Research

Management practices focusing at the increasing of the availability of grasses, legumes and other forbs constitute a promising conservation tool of this ecosystem and its primary consumers. From this perspective, a higher grazing capacity can be achieved in this area (van der Wal et al. 2000) which will contribute to a more even balance between herbivores' numbers and food resources. The applied management practice, i.e. light ploughing and subsequently seeding a mix of two grass species (*Dactylis glomerata, Lollium perenne*) and one legume (*Trifolium repens*), can be considered successful as the graminoids' coverage was about 6-fold higher in the seeded and protected from cattle grazing sites than that in the natural halophytes patches (control group). However, natural graminoids contributed the majority of this increment three years after seeding. These results suggest that light ploughing without seeding also seems to benefit grasses and contributes to the substantial reduction of the halophytic dominance. This is further supported by the fact that geese usually thrive in habitats where livestock grazing, fire and other factors, such as light ploughing, keep the vegetation in earlier stages of succession and avoid habitats at advanced succession stages of vegetation. Future research should investigate the potential positive effects on the vegetation composition and structure, the responses of tame and wild herbivores and the ways that light ploughing could be applied in specific parts of the study area in favour of geese and the other herbivores.

No protection at all from cattle grazing had poor benefits and resulted to a great increase of the cover proportions of bare soil during the first year after light ploughing and seeding. However, this negative effect (the great increase of bare soil's coverage) was less pronounced two years after the implementation of habitat improvement techniques and it was diminished three years later. Obviously, cattle activities (grazing, trampling, etc.) had a temporarily negative effect on the re-establishment not only of the graminoids but also of the vegetation in total as this treatment resulted to a large increase of the bare with no vegetation soil surface. On the contrary, protection from cattle grazing either for one or two years increased the cover of graminoids and legumes (preferred forage for herbivores), had no effect on forbs and reduced halophytic dominance. In addition, LWfG along with other goose species (mainly GWfG) used the treated sites in the Dimitriadis grassland more intensively than the control group (natural halophytic dominant sites) even from the next wintering period after seeding. The same trend was also followed by other goose species, besides the LWfG which stay at

Kerkini Lake almost the entire wintering period during the second and the third wintering period (2015-2016 and 2016-2017) after light ploughing and seeding (www.piskulka.net).

Conclusively, protection from cattle grazing for one year after the implementation of light ploughing and seeding is a management practice which increased the relative cover and the availability of the preferred forage for geese and reduced the respective percentages of the halophytic species. Additionally, seeding and protection from cattle grazing increased the use of these sites by the geese as feeding places. Protection from cattle grazing seems essential in order to improve this grazing land during the first year after seeding, but had no significant benefits concerning the coverage of the available food categories for herbivores when this regime is maintained for another one year. Under this aspect, and based on the fact that cattle usually graze in the Dimitriadis grassland for about eight to nine months per year, protection from grazing should be hold during the first grazing period after the implementation of light ploughing and seeding (i.e. from March – April to late November – early December) and after that time cattle grazing should be allowed.

Seeding *Bromus inermis* by hand without any preparation of the soil before was failed. Only a few small patches of individuals of this species were found in the seeded area one year after seeding. Obviously, the lack of light ploughing and particularly the non-covering of seeds with soil after seeding are considered the major factors contributed to the failure of establishment of *Bromus inermis*. Towards this, the relatively high number of small-sized, seed-eaters, passerine species, such as the Eurasian skylark (*Alauda arvensis*) and the crested lark (*Galerida cristata*), as well as Starlings (*Sturnus vulgaris*) present in the area may have also contributed to this failure through the direct consumption of the seeds on the soil surface by the birds.

The nutrient content (CP, NDF, ADF, ADL) of the dominant halophytic species and the herbage were more or less similar with a few differences throughout the year. Hence, other characteristics of halophytic biomass, which presently is an underutilized forage resource under the existing management practice at Evros Delta, such as oxalate, mineral imbalances, toxins etc., potentially have adverse effects on herbivores and are responsible for the selection of habitats and foods by cattle and geese at Evros Delta. Future research should focus on the possible factors affecting the utilization of halophytic biomass by herbivores and on the possible ways to improve the productivity of saline systems by increasing halophyte feeding value.

Cattle seem to respond to temporal changes in quality and availability of forage by changing their activities throughout the year. The higher frequency of grazing in May and especially in December in relation to the other periods is probably an effect of both the higher availability and quality of forage in May. The higher availability of halophytes and graminoids in relation to that of legumes and other forbs throughout the year is also reflected to the higher frequency of cattle grazing upon halophytes and graminoids. Concerning graminoids, the only forage category which were highly selected by both geese and cattle, frequency of cattle grazing was high during the periods of high availability and quality (March, May and July) and low in October and December when both availability and quality of graminoids was reduced. On the contrary, the availability of halophytes was high in October and December and low during the other periods and this was also reflected to cattle activities. The high availability and quality of forage in spring (March and May) reflected to reduced frequency of walking and ruminating by cattle in relation to the other periods (i.e. July, October, December).

Natural grassland patches constitute the main feeding habitat for herbivores in the Evros Delta whereas the use of the natural halophytic patches is quite lower than the former ones (Karmiris et al. 2008). In addition, graminoids (i.e. mainly grasses and a few grass-likes) constituted the preferred forage category for geese in this coastal land (Karmiris et al. 2011). However, halophytes were the dominant available forage category since they constituted almost 3/5 of the total available food resources in the study area. Obviously, halophytic dominance in this area is a result of increasing soil salinity which usually is the crucial factor defining the outcome of the competition between halophytic and non-halophytic plant species in coastal areas. In essence, an inverse relationship between competitive ability and stress tolerance is a common finding in many empirical studies (Pennings & Callaway 1992, Pennings et al. 2005). According to this relationship, the competitively superior plant species occupy the least stressful zones of the coastal areas and displace competitively inferior plants to more stressful zones. It is highly probable that this is also holding in Dimitriadis grassland where despite the relatively flat character of the range surface, there are several slightly elevated zones than others (no more than 25-30 cm elevated difference). Even such limited elevated differences may be crucial for the competitive ability and the ultimate domination of halophytic and non-halophytic species (Davy et al. 2011). The high elevated zones are usually dominated by grass-legume-forb communities and the low ones by halophytes. The creation of several technical slightly elevated zones dispersed throughout the study area may contribute to the local reduction of the soil salinity and may lower both the competitive ability of halophytes and the stress to non-halophytes (grasses, legumes, forbs), which are usually less tolerant of salinity than halophytes (Alexander & Dunton 2006). Towards this goal, controlled freshwater inundation of this area is another management practice which may help in a complementary way to the deterioration of current halophytic expansion. Specific research should verify the above assumptions in order to manipulate the vegetation characteristics (cover, composition, availability, structure, etc.) in a desirable way, i.e. to favour mainly the grass-legume-forb communities at the expense of halophytic ones.

Halophytes, despite their insubstantial value as forage for herbivores, might provide cover which could be of particular importance to vulnerable species, such as geese and hares (Karmiris et al. 2011)., Halophytic patches at Dimitriadis grassland were used as roosting sites and as a shelter for geese and hares respectively. These observations suggest that halophytes are probably not important as a feeding resource for geese and the other herbivores, but they may be of prime importance for their survival ability and the protection against predators and humans. For vulnerable herbivores therefore, such as the LWfG, both available cover and food must be considered in conservational plans. At the moment, the role and the importance of halophytes in the ecology of geese and other herbivores in Dimitriadis grassland still remains unclear. Hence, the investigation of the role of the halophytic community in wildlife ecology will also contribute to the sustainable multiple use of coastal grazing lands of the Evros Delta.

Several studies have shown that cattle grazing benefits species of *Anseriformes* on the northwestern European coast, by retarding vegetation succession and maintaining a low vegetation height (van der Graaf et al. 2002, Bos et al. 2005). Geese, other waterfowl along with hares have also been recorded to use the grass-legume-forb patches with a low vegetation height more than the halophytic ones with much taller vegetation in the Evros Delta (Karmiris et al. 2008). Cattle also follow the same pattern and use grasses more intensively in the end of the growing season (i.e. end of spring) and halophytes in winter (Grigoriadis 2014). As long as forage and habitat resources for domestic and wild herbivores are not depleted, then livestock grazing is a valuable 'tool' in manipulating wildlife habitats (Vickery & Gill 1999). Livestock grazing seems to be vital for geese and the other herbivores in Evros Delta by deteriorating density and height of vegetation. When forage availability is limited, as probably happens in years with high numbers of wild herbivores, cattle stocking rates should be kept at a relatively low level and livestock raisers should provide increased quantities of supplementary food. Placement of supplements at halophytic dominant patches throughout the study area, instead of the grass dominant sites where the extra food is mostly placed today, is expected to improve the distribution of herbivores in a more uniform way.. For that purpose, regular estimation of both the availability of natural food and the number of herbivores during the cattle and the geese grazing periods (May – November and December – March respectively) is necessary. However, a more uniform grassing pressure by herbivores throughout the available grazing lands, which can be improved implying a more optimal placement of supplementary food, is considered capable to alleviate of the potential imbalance problem between forage availability and herbivores' numbers. In addition, the main and highly selected food for geese in the study area is C3 grasses (*Poa* spp., *Bromus* spp., *Hordeum* spp., etc.) which usually sprout in November. During the remaining wintering period (i.e. until next March) geese consume the green biomass of these species. Because of the relatively limited availability of these species, cattle grazing and trampling should be stopped at least by the end of November in order to protect the preferred food resource for geese during the rest of the wintering period. This rule should be strictly followed and it is more or less holding in this area in a traditional way because the availability of natural forage for cattle is usually very low from December to March. Hence, cattle usually are kept indoors for that period. Furthermore, placement of supplement by the farmers in halophytic dominant patches throughout the study area is expected to attract cattle and to improve their distribution and the grazing pressure in a more evenly way. Towards this goal, target grazing by cattle (or other tame herbivores) on halophytes especially during late summer and autumn may further contribute to the reduction of halophytic dominance and height the next winter in favour of geese and other wild herbivores. In that case, a herder and / or temporary fencing are needed to direct grazing pressure in a desirable way under an intensive rotational grazing system. Specific research is needed on the effects of cattle grazing and especially target grazing on vegetation composition and structure and if these effects directly or indirectly influence the behaviour of geese. However, because the feeding and movement behaviour of herbivores are influenced by multifactor systems, future research should also focus on the effects of the other human disturbances at the Evros Delta, except livestock grazing, mainly the touristic and fishing activities including the effects of the road network and the traffic volume.

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APPENDICES

A. Timetable of management implications and data collection at Evros Delta within the framework of C3 action.

B. Statistical analysis of vegetation data and descriptive statistics of chemical analysis data (S.P.S.S., ver. 13.0)

C. Location Map of the Evros Delta in Greece (inset small map at the right) and the Drana, Dimitriadis and Paloukia restored grasslands

D. Map of the Dimitriadis grassland

E. Photos

APPENDIX A. Timetable of management implications and data collection at Evros Delta grasslands within the framework of C3 action.

Actions	Oct-Nov 2013	Feb-Mar 2014	May 2014	Nov-Dec 2014	Feb 2015	May 2015	Oct-Nov 2015	Mar-Feb 2016	May 2016	July 2016	Oct 2016	Dec 2016	Feb-Mar 2017
Light ploughing	✓												
Mix seeding	✓												
Fencing half of seeding sites	✓												
Unfencing a quarter of fenced areas						✓							
Seeding *Bromus inermis*						✓							
Cutting halophytic vegetation	✓												
Total removal of fences									✓				
Estimation of vegetation characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Laboratory chemical analysis	✓	✓	✓	✓		✓				✓	✓	✓	✓
Habitat use by geese					✓			✓					✓
Cattle grazing effects on vegetation				✓			✓				✓	✓	
Cattle activities				✓		✓	✓	✓	✓	✓	✓	✓	

APPENDIX B. Statistical analysis of vegetation data and descriptive statistics of chemical analysis data (S.P.S.S., ver. 13.0)

NPar Tests

Forage category: Graminoids

Kruskal-Wallis Test

Ranks[a]

	Treatment	N	Mean Rank
Cover	3 Years Protection	75	141,03
	Grass-Forb Patches	75	262,17
	Halophytic Patches	75	48,75
	1-2 Years Protection	75	150,05
	Total	300	

a. CoverCateg = Graminoids

Test Statistics[a,b,c]

	Cover
Chi-Square	229,375
df	3
Asymp. Sig.	,000

a. Kruskal Wallis Test

b. Grouping Variable: Treatment

c. CoverCateg = Graminoids

Forage category: Legumes

Kruskal-Wallis Test

Ranks[a]

	Treatment	N	Mean Rank
Cover	3 Years Protection	75	163,88
	Grass-Forb Patches	75	184,15
	Halophytic Patches	75	107,77
	1-2 Years Protection	75	146,20
	Total	300	

a. CoverCateg = Legumes

Test Statistics[a,b,c]

	Cover
Chi-Square	39,628
df	3
Asymp. Sig.	,000

a. Kruskal Wallis Test

b. Grouping Variable: Treatment

c. CoverCateg = Legumes

Forage category: Other Forbs

Kruskal-Wallis Test

Ranks[a]

	Treatment	N	Mean Rank
Cover	3 Years Protection	75	161,23
	Grass-Forb Patches	75	172,44
	Halophytic Patches	75	115,92
	1-2 Years Protection	75	152,41
	Total	300	

a. CoverCateg = Other Forbs

Test Statistics[a,b,c]

	Cover
Chi-Square	25,717
df	3
Asymp. Sig.	,000

a. Kruskal Wallis Test

b. Grouping Variable: Treatment

c. CoverCateg = Other Forbs

Forage category: Halophytes

Kruskal-Wallis Test

Ranks[a]

	Treatment	N	Mean Rank
Cover	3 Years Protection	75	173,63
	Grass-Forb Patches	75	38,69
	Halophytic Patches	75	233,33
	1-2 Years Protection	75	156,35
	Total	300	

a. CoverCateg = Halophytes

Test Statistics[a,b,c]

	Cover
Chi-Square	199,769
df	3
Asymp. Sig.	,000

a. Kruskal Wallis Test

b. Grouping Variable: Treatment

c. CoverCateg = Halophytes

Bare soil

Kruskal-Wallis Test

Ranks[a]

	Treatment	N	Mean Rank
Cover	3 Years Protection	75	120,71
	Grass-Forb Patches	75	124,13
	Halophytic Patches	75	210,36
	1-2 Years Protection	75	146,79
	Total	300	

a. CoverCateg = Soil

Test Statistics[a,b,c]

	Cover
Chi-Square	55,252
df	3
Asymp. Sig.	,000

a. Kruskal Wallis Test

b. Grouping Variable: Treatment

c. CoverCateg = Soil

Dependent Variable: CP (g/kg)

Plant species - Forage category	Period	Mean	Std. Deviation	N
Salicornia fruticosa	**Mar**	137,8	23,70	4
	May	114,4	4,99	4
	Jul	86,9	4,02	4
	Oct	100,7	26,05	4
	Dec	107,2	11,66	4
	Total	109,4	22,86	20
***Limonium* spp.**	**Mar**	191,2	60,86	4
	May	158,9	15,94	4
	Jul	94,1	9,56	4
	Oct	103,3	12,59	4
	Dec	98,4	14,81	4
	Total	129,2	47,89	20
Halimione portulacoides	**Mar**	123,9	5,77	4
	May	130,1	15,57	4
	Jul	73,0	5,60	4
	Oct	99,4	27,95	4
	Dec	92,2	7,56	4
	Total	103,7	25,37	20
Herbage	**Mar**	203,8	23,45	4
	May	127,7	9,74	4
	Jul	57,8	10,70	4
	Oct	112,6	51,18	4
	Dec	111,9	30,30	4
	Total	122,8	54,77	20

Dependent Variable: NDF (g/kg)

Plant species - Forage category	Period	Mean	Std. Deviation	N
Salicornia fruticosa	**Mar**	459,3	7,85	4
	May	336,8	6,27	4
	Jul	428,6	29,47	4
	Oct	450,1	30,02	4
	Dec	525,7	18,42	4
	Total	440,1	65,31	20
***Limonium* spp.**	**Mar**	417,3	22,82	4
	May	251,7	16,37	4
	Jul	327,2	21,26	4
	Oct	425,2	31,39	4
	Dec	555,0	74,30	4
	Total	395,3	110,44	20
Halimione portulacoides	**Mar**	432,1	52,26	4
	May	281,6	24,07	4
	Jul	286,6	12,77	4
	Oct	414,0	28,07	4
	Dec	505,3	28,25	4
	Total	383,9	93,68	20
Herbage	**Mar**	425,5	16,19	4
	May	515,3	15,46	4
	Jul	639,3	6,49	4
	Oct	626,1	70,78	4
	Dec	676,7	77,29	4
	Total	576,6	104,26	20

Dependent Variable: ADF (g/kg)

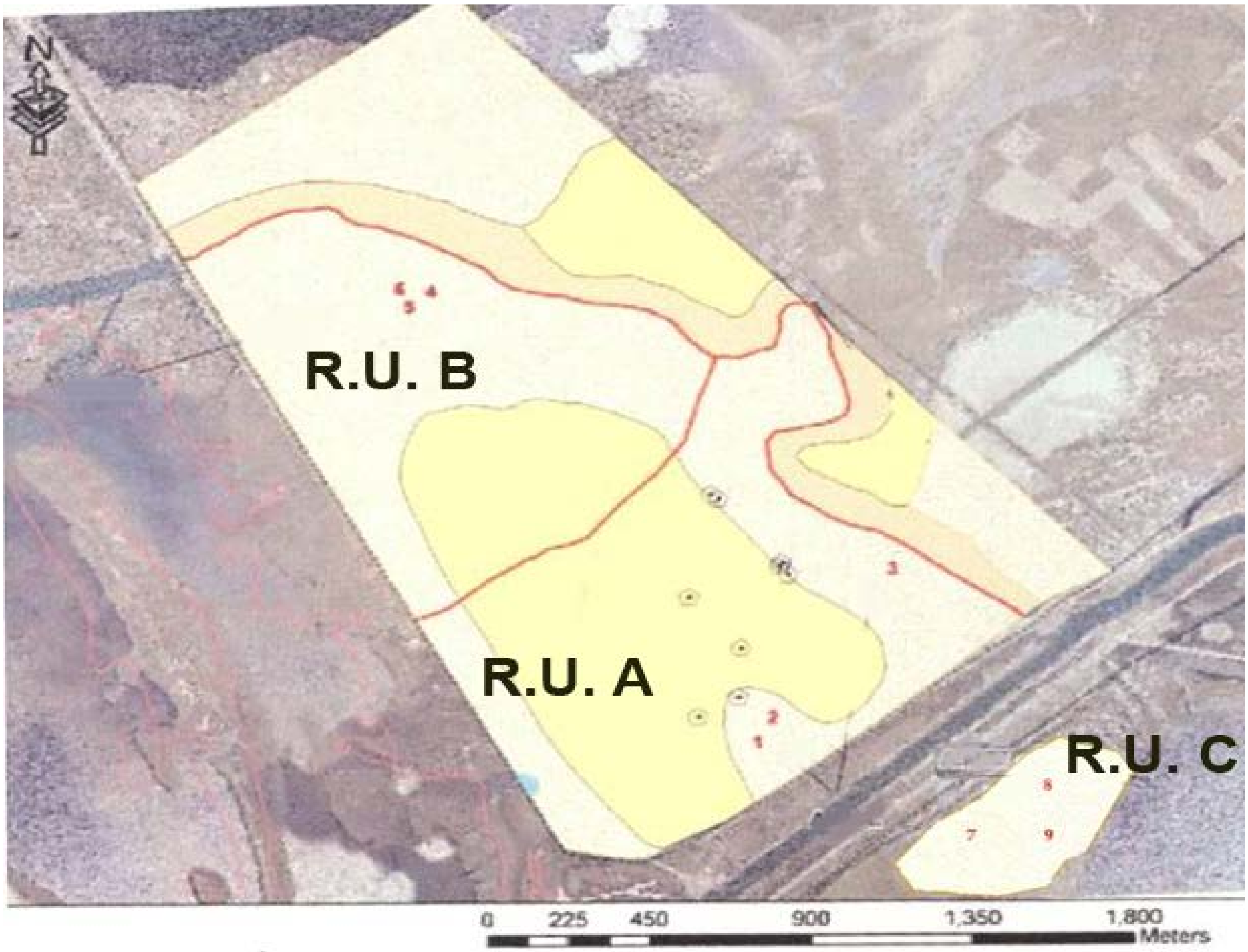
Plant species - Forage category	Period	Mean	Std. Deviation	N
Salicornia fruticosa	**Mar**	268,9	17,15	4
	May	189,0	20,64	4
	Jul	226,8	12,81	4
	Oct	276,0	22,85	4
	Dec	325,5	19,03	4
	Total	257,2	50,37	20
***Limonium* spp.**	**Mar**	233,4	56,41	4
	May	161,1	4,99	4
	Jul	195,0	6,50	4
	Oct	274,7	14,33	4
	Dec	363,6	23,36	4
	Total	245,6	76,27	20
Halimione portulacoides	**Mar**	273,8	27,66	4
	May	171,1	12,89	4
	Jul	161,2	10,45	4
	Oct	242,7	14,36	4
	Dec	331,2	16,85	4
	Total	236,0	67,27	20
Herbage	**Mar**	286,7	31,46	4
	May	302,5	5,52	4
	Jul	409,6	20,75	4
	Oct	394,2	31,52	4
	Dec	467,1	54,68	4
	Total	372,0	75,59	20

Dependent Variable: ADL (g/kg)

Plant species - Forage category	Period	Mean	Std. Deviation	N
Salicornia fruticosa	**Mar**	107,7	13,46	4
	May	59,4	5,45	4
	Jul	86,9	7,65	4
	Oct	77,9	15,59	4
	Dec	126,8	11,21	4
	Total	91,7	26,06	20
***Limonium* spp.**	**Mar**	119,7	35,54	4
	May	52,6	3,54	4
	Jul	70,8	6,37	4
	Oct	104,5	13,58	4
	Dec	130,8	6,82	4
	Total	95,7	34,09	20
Halimione portulacoides	**Mar**	81,7	3,95	4
	May	47,9	2,49	4
	Jul	58,9	0,98	4
	Oct	67,2	4,07	4
	Dec	81,8	10,73	4
	Total	67,5	14,37	20
Herbage	**Mar**	50,9	9,12	4
	May	25,4	4,38	4
	Jul	40,2	9,73	4
	Oct	86,2	8,42	4
	Dec	166,8	36,03	4
	Total	73,9	54,26	20

APPENDIX C. Location Map of the Evros Delta in Greece (inset small map at the right) and the Drana, Dimitriadis and Paloukia restored areas

APPENDIX D**.** Map of the Dimitriadis grassland with the three identified Range Units (R.U.)



APPENDIX E. Photos

November 2013 – Light ploughing

November 2013 – Seeding a mix of *Lollium perenne*, *Dactylis glomerata* and *Trifolium repens*

November 2013 – Fencing part of seeded sites

December 2013 – Newly sprouted seeded plants

November 2013 – Cutting halophytic vegetation

November 2013 – Low vegetation height after cutting halophytes


May 2014 – Herbage production


March 2015 – Estimating vegetation parameters


February 2015 – Grass dominance in seeded sites used by geese


February 2015 – Counting geese droppings

May 2014 – Freely grazed seeded site (at the left) and protected from cattle grazing fenced site (at the right)

March 2016 – No protection (at the right), 1-year protection (at the left) and 2-years protection (fenced area) from cattle grazing

February 2015 – Geese in grasses

February 2016 – Geese in halophytes

February 2015 – Geese use the treated sites both inside and outside the fenced plot


May 2014 – Cattle grazing on grasses at Dimitriadis grassland, Evros Delta


October 2016 – Cattle grazing on halophytes at Dimitriadis grassland, Evros Delta