The Samothraki Seeding Project

Report 2019

Photo: Felix Bousies

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INTRODUCTION

In September 2015, we were invited as consultants of Terraprima Environmental Services to participate in a project on the Greek island of Samothraki, led by Marina Fischer-Kowalski from the Institute of Social Ecology of Vienna. This project aims to:

- establish, in Samothraki, a series of trials with sown biodiverse pastures in various places, using different seed mixtures;
- observe and monitor the establishment and development of these mixtures, species and forage varieties in Samothraki;
- transfer knowledge, involving local technicians and farmers, regarding the practices and methodologies associated with the seeding and management of sown biodiverse pastures;

MATERIAL AND METHODS

To demonstrate the applicability of the concept of sown biodiverse pastures on the island of Samothraki, several farmers and several sites were selected to test different forage mixtures, linked to the concept of biodiversity and supported by the high presence of legumes in the seed mixtures.

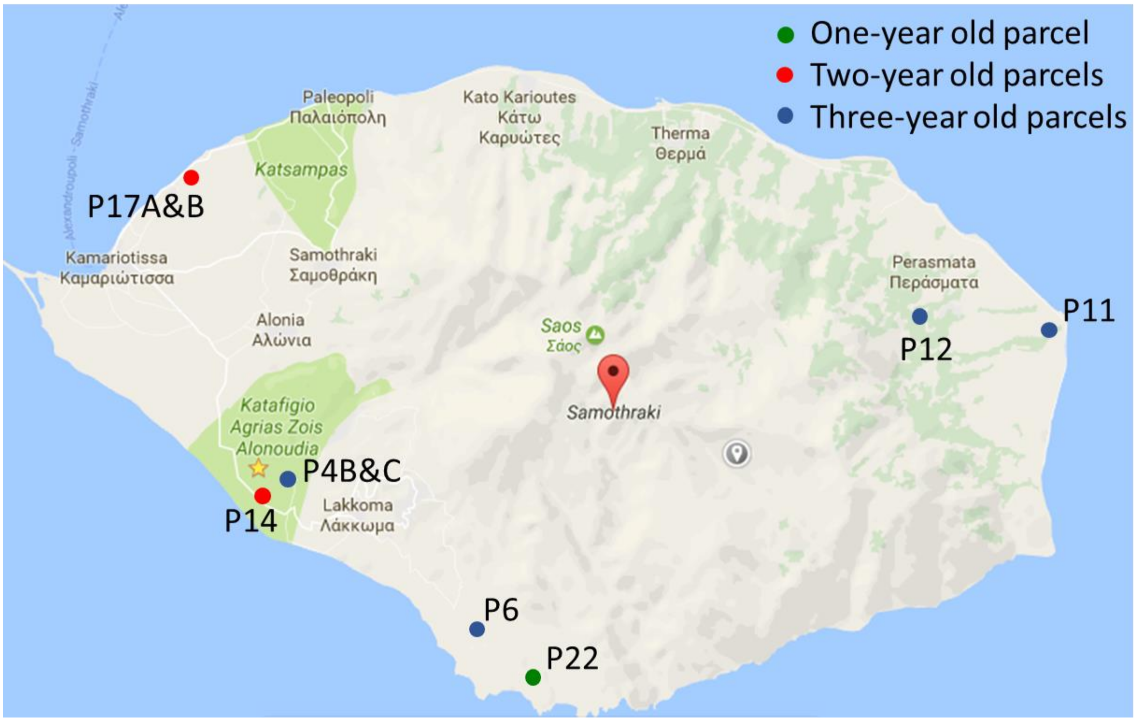
In June 2019, a quantitative assessment of the effects of implementing sown biodiverse pastures on aboveground productivity and species composition took place, with this work being done by Marjan Jongen.
Assessment took place in 5 parcels / plots that were sown between November 2016 and March 2017, i.e. three-year old parcels. In addition, assessment took place in 3 parcels / plots that were sown in February-March 2018, i.e. two-year old parcels, and in 1 parcel / plot that was sown in October 2018, i.e. one-year old parcel.
In each parcel the aim was to achieve the following tasks:

- Observations along 200 m line transects, using the step-point method (at intervals of 1 m), giving measurements of cover for individual species, total cover, and species composition by cover. Collected data will enable calculation of diversity (species richness, Shannon-Wiener diversity index, Simpson´s diversity index, Evenness) and similarity indexes (comparison of species similarity between sown and natural parcels, through calculation of the Renkonen similarity index).
- Assessment of aboveground productivity, by harvesting all plant material in replicate 30×30 cm quadrats. Sorting of harvested plant material into the functional groups (grasses, legumes, forbs) and prominent individual species. In most of the three-year old parcels, Giorgos Maskalides installed exclosure cages in November 2017, to exclude the presence of livestock and enable calculation of productivity and forage intake through grazing. Two cages were installed in plot 4B and plot 4C, and three cages were installed in plot 6, plot 11 and plot 12. Within each of the cages one or two 30×30 cm quadrats were cut for productivity assessment.
- Soil sampling, for determination of soil texture, soil organic matter and other relevant components, by taking multiple soil cores to a depth of 20 cm.

However, due to the vegetation in an advanced senescent state, not all of the above activities could be performed in all parcels.

Table 1: Overview of the parcels / plots in Samothraki that were monitored in June 2019.

Plot number	Owner	Location	Size (ha)	Seed mixture
4B	V. Panagiotis	1 km W of Makrylies	0.4	NEU550
4C	V. Panagiotis	1 km W of Makrylies	0.4	AL550
6	K. Kostas	1 km SE of Dhaphnes	0.5	AC500
11	C.Panagiotis	Agistros	0.5	AL 550
12	F. Giannis	Ano Meria	1.0	NEU 550
14	V. Panagiotis	1 km W of Makrylies	1	AC 500
17A	A. Petros	Limnidi	0.1	NEU 550
17B	A. Petros	Limnidi	0.9	AC 500
22	F. Bousies	Near Pachia Ammos	0.8	NEU 550



Map 1: Location of the parcels / plots in Samothraki that were monitored in June 2019. Blue dots represent parcels sown between November 2016 and March 2017 (i.e. three-year old parcels), red dots represent parcels sown in February / March 2018 (i.e. two-year old parcels), and the green dot represents the parcel sown in October 2018 (i.e. one-year old parcel).

Note: Unfortunately, several parcels that were sown in 2017 or 2018 were destroyed, and sown with an annual crop. Among this plot 11. However, in November 2017 three cages were installed in this parcel, and the cages and immediate surroundings were not sown with the annual crop.

Plot	Owner	Location	Size (ha)	Seed mixture
9	K. Chrysostomos	Ag. Georgios	0.4	NEU 550
11	C.Panagiotis	Agistros	0.5	AL 550
15	A. Petros	Limnidi	0.8	AC 500
16A	A. Petros	Limnidi	0.7	AC 500
16B	A. Petros	Limnidi	0.3	AC 500

Information on mixtures:
Seed mixtures were chosen according to soil conditions. Three types of mixtures / compositions were selected:
1. AC 500
2. NEU 550
3. AL 550

Table 2: Composition of the permanent mixtures used in Samothraki. The reference AC corresponds to acidic soils, the reference NEU to neutral soils and AL to alkaline soils. The numeric reference corresponds to the annual average precipitation for which the mixture is designed, with its respective error margin.

NEU 550 & AL 550
LEGUMES
Trifolium subterraneum
Trifolium michelianum
Trifolium resupinatum
Trifolium isthmocarpum
Trifolium vesiculosum
Medicago truncantula
Hedysarum coronarium
Onobrychis vicifolia
GRASSES
Lolium multiflorum
Dactylis glomerata

AC 500
LEGUMES
Trifolium subterraneum
Trifolium michelianum
Trifolium resupinatum
Trifolium isthmocarpum
Trifolium vesiculosum
Trifolium incarnatum
Ornithopus sativus
GRASSES
Lolium multiflorum
Dactylis glomerata

Preliminary RESULTS 2019

PLOT 4 (B and C)
Permanent pastures
Coordinates: N40.437 E25.505

Assessment:
12-06-2019 (Marjan Jongen)
25-06-2019 (Students M4 Summer School)
No transects were done in plot 4B nor in plot 4C due to vegetation being in advanced senescent state, and parcel being thoroughly grazed. On June 12, one 30×30 cm quadrat was cut in each cage and one 30×30 cm quadrat was cut in the immediate surroundings of each cage. On June 25, one 30×30 cm quadrat was cut in each cage.
Biomass cuttings in the cages represent primary productivity, and these samples were sorted in functional groups (grasses, legumes, forbs). Cutting outside the cages represent standing biomass, and these samples were not sorted.
On June 12, soil samples were taken in both plots.

Location cages:

SAM P4B_cage 1	N 40.437996° E 25.505136°
SAM P4B_cage 2	N 40.437985° E 25.505707°
SAM P4C_cage 1	N 40.437425° E 25.505172°
SAM P4C_cage 2	N 40.437587° E 25.505698°

Map 2: Parcel / plot 4B and 4C, indicating plot boundaries and location of the cages.

Resume:
Plot 4B and 4C were sown in November 2015, plot 4B with the mixture NEU 550, and plot 4C with AL550. These two plots have been well managed. In November 2017 two exclosure cages were installed in each of the plots, to exclude the presence of livestock and enable calculation of productivity and forage intake through grazing. In May 2018, both plots had an extremely high productivity, averaging 8302 kg ha^{-1} in 4B and 9991 kg ha^{-1} in 4C (Fig. 1).

Prior to the field-visit in June 2019, plots were intensively grazed, and standing biomass at time of field-visit was low, with the majority of vegetation present being senescent.
On 12 June 2019, both plots had a very high productivity, averaging 8958 kg ha^{-1} in 4B and 12171 kg ha^{-1} in 4C (Fig. 2). Standing biomass outside the cages averaged 1886 kg ha^{-1} in plot 4B and 2165 kg ha^{-1} in plot 4C (Fig. 3). The difference in forage quantity inside and outside the cages indicates the effect of grazing, with the animals having browsed between 7 to 10 tons ha^{-1}. Productivity, as assessed by the M4 students on 25 June 2019, was 6134 kg ha^{-1} in 4B and 7227 kg ha^{-1} in 4C, these values being substantially lower as compared to the data from 12 June. This difference is probably caused by seed dispersal and loss of senescent material due to wind, although some of the disparity can be due to sampling techniques. Sowing practice in these parcels has proven to be very successful, as demonstrated by the high productivity and the vast quantity of seeds produced by the various species sown. The good management practices, undertaken in relation to these two plots, will guarantee their future.

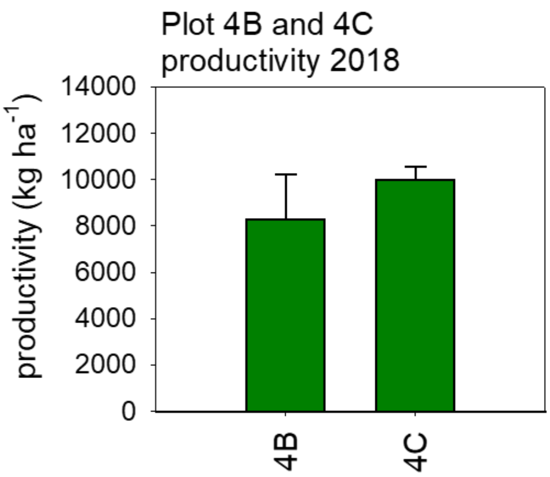


Figure 1: Aboveground productivity ± SE in the cages in plot 4B and 4C on 28 May 2018.

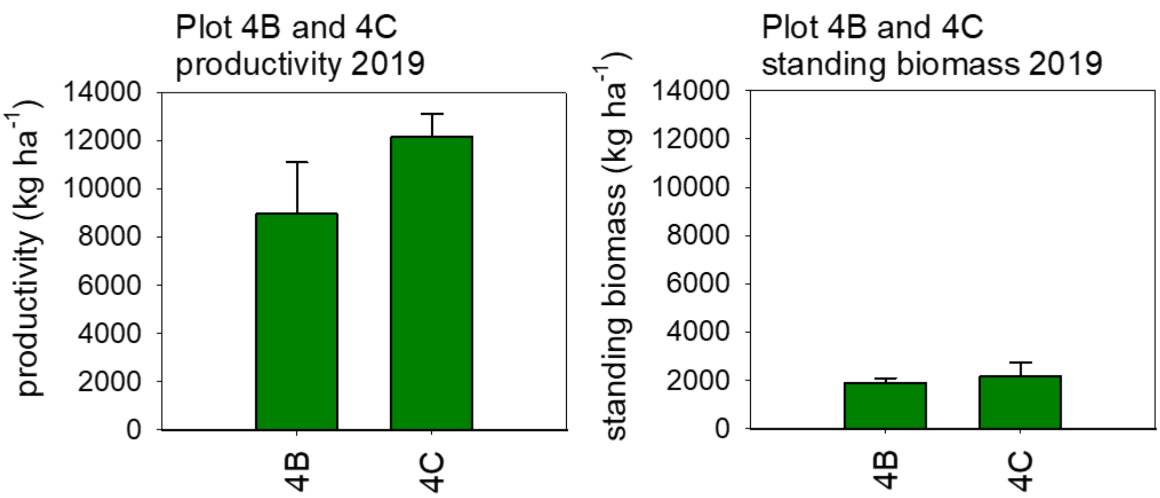


Figure 2: Aboveground productivity ± SE in the cages, and standing biomass ± SE outside the cages in plot 4B and 4C on 12 June 2019.

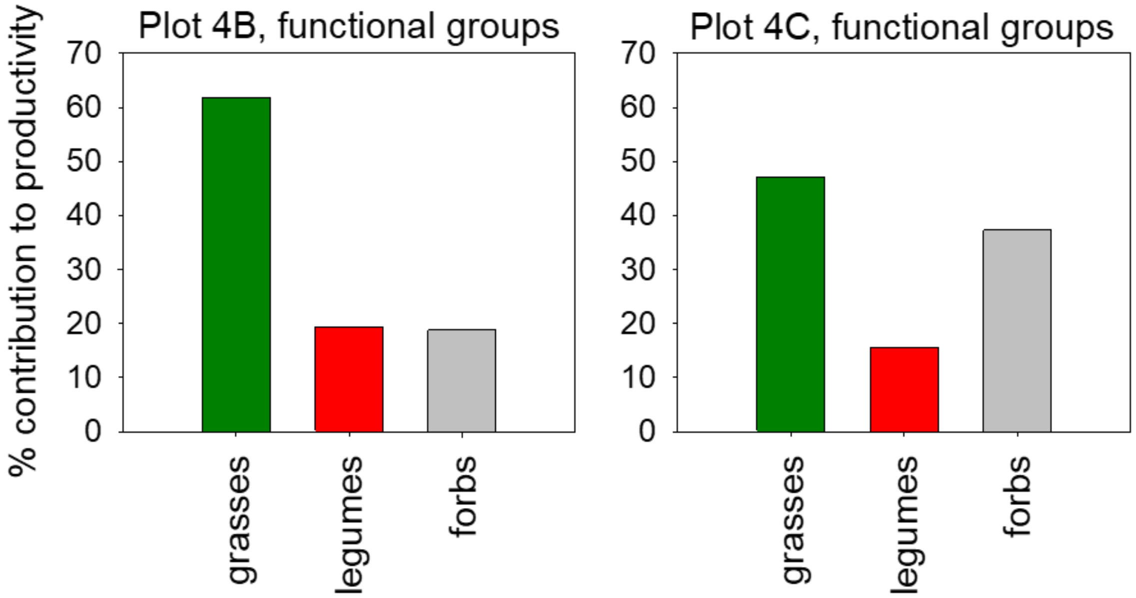


Figure 3: Functional group relative abundance (% contribution to aboveground productivity) in the cages in plot 4B and 4C on 12 June 2019.

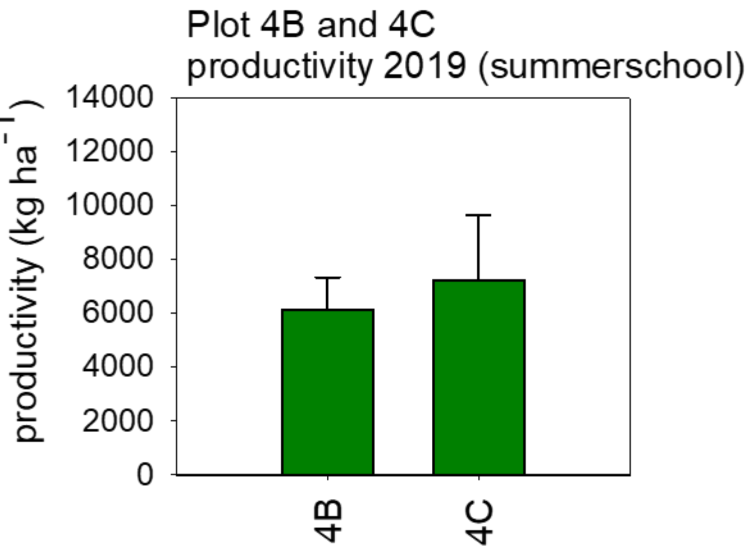


Figure 4: Aboveground productivity ± SE in the cages in plot 4B and 4C on 25 June 2019.

Plot 4B, June 2019

Plot 4B cage 2, June 2019

Plot 4B standing biomass, June 2019

Plot 4B, traces *Trifolium* seeds, June 2019

Plot 4C, June 2019

Plot 4C cage 1, June 2019

Plot 4C standing biomass, June 2019

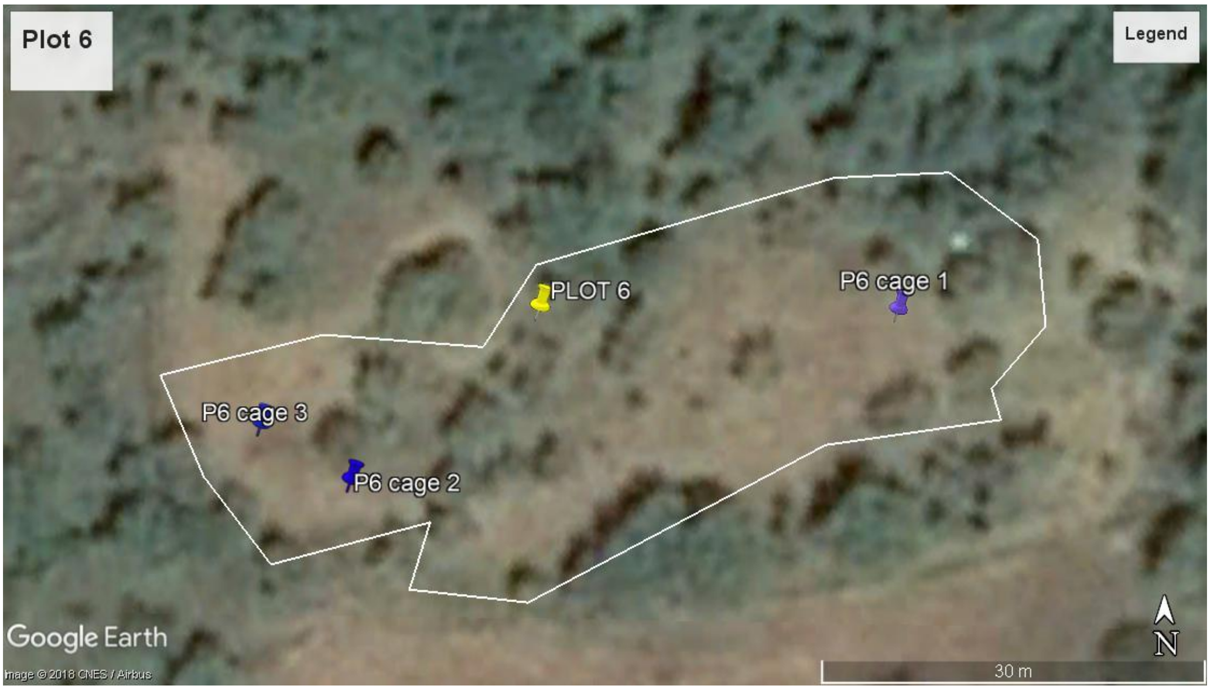
PLOT 6

Permanent pasture
Coordinates: N40.4141 E25.5507

Assessment:
14-06-2019
No transects were done in plot 6 due to vegetation being in advanced senescent state. One 30×30 cm quadrats was cut in each of the three cages. Biomass was sorted in species or functional groups (grasses, legumes, forbs). Standing biomass was high, approximately equal to productivity within the cages, as plot had not been grazed.
On June 14, soil samples were taken.

Location cages:

SAM P6_cage 1	N 40.414115° E 25.551056°
SAM P6_cage 2	N 40.413999° E 25.550527°
SAM P6_cage 3	N 40.414041° E 25.550435°



Map 3: Parcel / plot 6, indicating plot boundaries and location of the cages.

Resume:
Plot 6 was sown in November 2016 with the permanent mixture AC 500, in the undercover of an olive grove with a fairly steep slope. Although soil preparatory work was not optimal, due to slope, the germination and vegetative development in spring 2017 was excellent, with high biodiversity and ample evidence of the species from the seed mixture.
Sowing practice in this parcel has proven to be successful. In May 2018 productivity was high, averaging 5000 kg ha^{-1} (Fig. 5). In June 2019, productivity was even higher, averaging 6841 kg ha^{-1} (Fig. 5). There was ample evidence of leguminous species from the seed mixture accompanied by a vast seed production (especially *Trifolium michelianum*, *T. resupinatum* and *T. vesiculosum*). To guarantee this plot's future, an intensive grazing is recommended, to ensure total removal of the pasture produced.

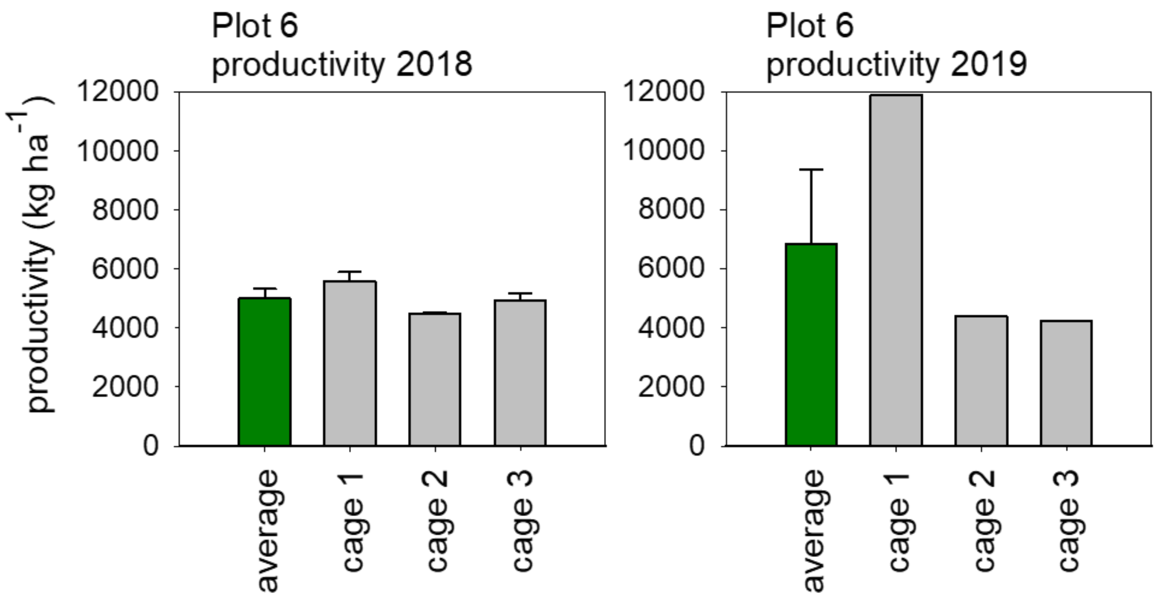


Figure 5: Aboveground productivity ± SE in the cages in plot 6 on 29 May 2018 and 14 June 2019.

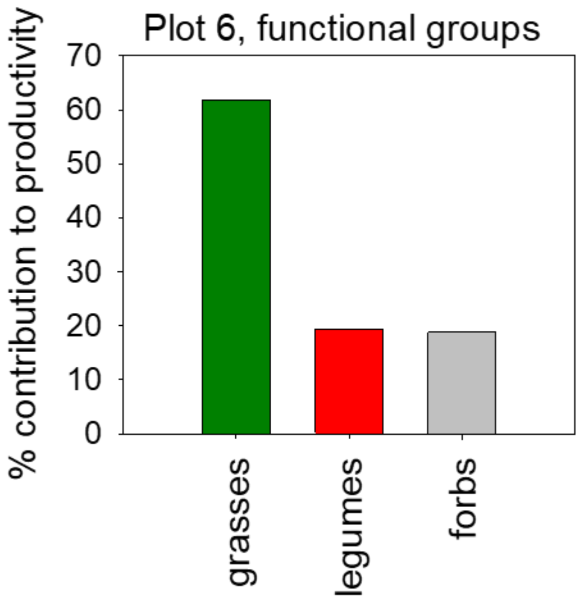


Figure 6: Functional group relative abundance (% contribution to aboveground productivity) in the cages in plot 6 on 14 June 2019.


Plot 6, June 2019


Plot 6 cage 1, June 2019


Plot 6 cage 2, June 2019

Plot 6 shrub encroachment, June 2019

Plot 6 *Trifolium* sp.

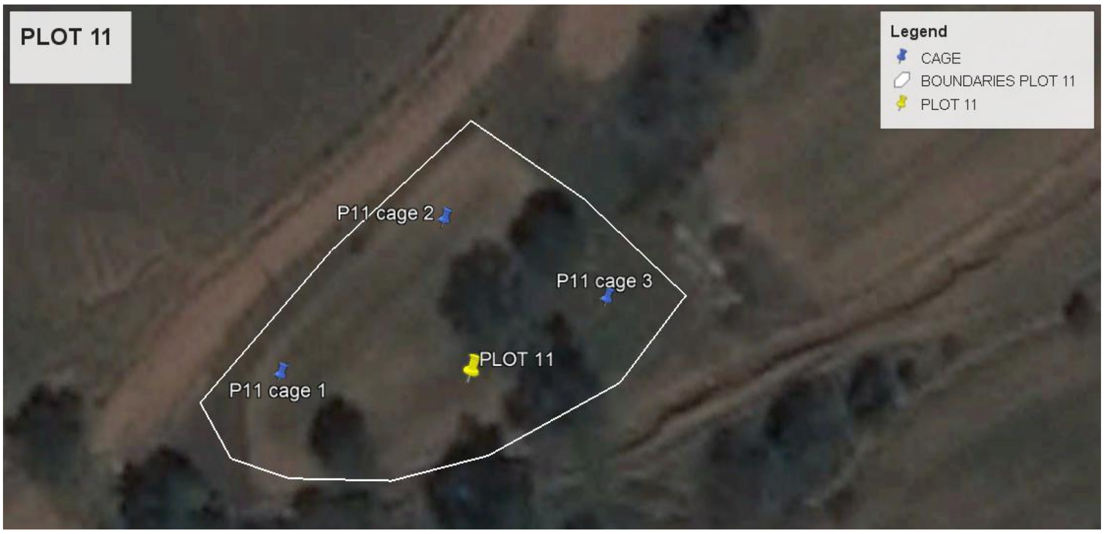
PLOT 11

Permanent pasture / annual crop (Hordeum)
Coordinates: N40.4644 E25.6956

Assessment:
24-06-2019 ((Students M4 Summer School)
In 2019 plot 11 was sown with barley (*Hordeum*). However, the cages and immediate surroundings were not sown with the annual crop.
In June 2019, two 30×30 cm quadrats were cut in each of the three cages. In addition, three 40×40 cm quadrats were cut outside the cages, i.e. the barley crop. Biomass cuttings were sorted in species or functional groups (grasses, legumes and forbs).
On June 24, soil samples were taken near the cages (representing the sown biodiverse parcel) and in the barley crop.

Location cages:

SAM P11_cage 1	N 40.464400° E 25.695271°
SAM P11_cage 2	N 40.464606° E 25.695554°
SAM P11_cage 3	N 40.464500° E 25.695840°



Map 4: Parcel / plot 11, indicating plot boundaries and location of the cages.

Resume:
Plot 11 was sown in March 2017 with the mixture NEU 550. No data is available regarding productivity in 2017, as plot had been grazed prior to field-visit in May 2017. Nevertheless, transect data at that time looked promising, with 62% of hits representing species from the seed mixture. On 1 June 2018, averaged aboveground productivity in the cages was 7041 kg ha^{-1} (Fig. 7). On 24 June 2019, averaged aboveground productivity in the cages was 4919 kg ha^{-1} (Fig. 8). Legumes represented 27% of biomass in the cages (Table 6), while forbs accounted for the majority of biomass (50%). With the exception of the cages and their immediate surroundings, plot 11 was sown with barley in 2019. Aboveground productivity of this annual crop was 3532 kg ha^{-1} (Fig. 8). Thus, even though the establishment of a sown biodiverse pasture in this parcel was not particularly successful, mostly due to intensive grazing during less favourable times (i.e. during seed production in spring), productivity of the annual crop in 2019 was still lower as compared with the sown biodiverse pasture.

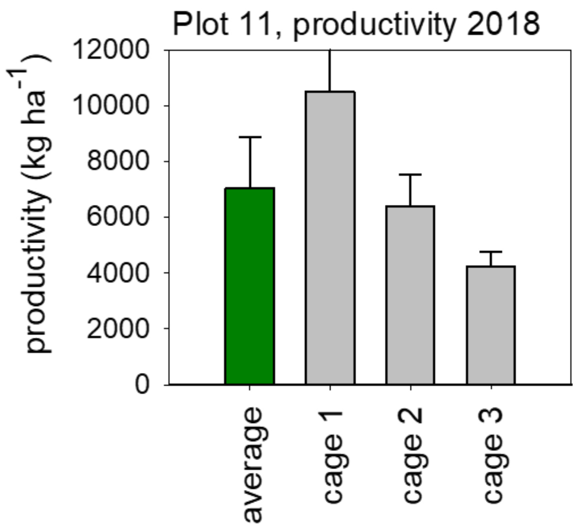


Figure 7: Aboveground productivity ± SE in the cages in plot 11 on 1 June 2018.

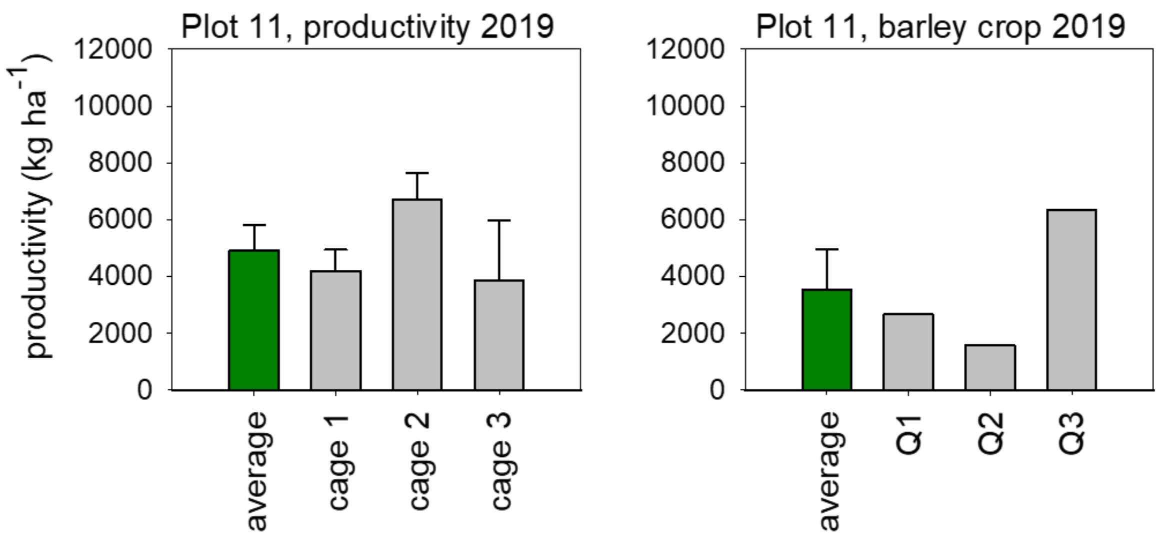


Figure 8: Aboveground productivity ± SE in the cages, and outside the cages (barley crop) in plot 11 on 24 June 2019.

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Plot 11, June 2019

Plot 11 cage 1, June 2019


Plot 11 cage 2, June 2019


Plot 11 cage 3, June 2019

Plot 11 barley crop, quadrat 1

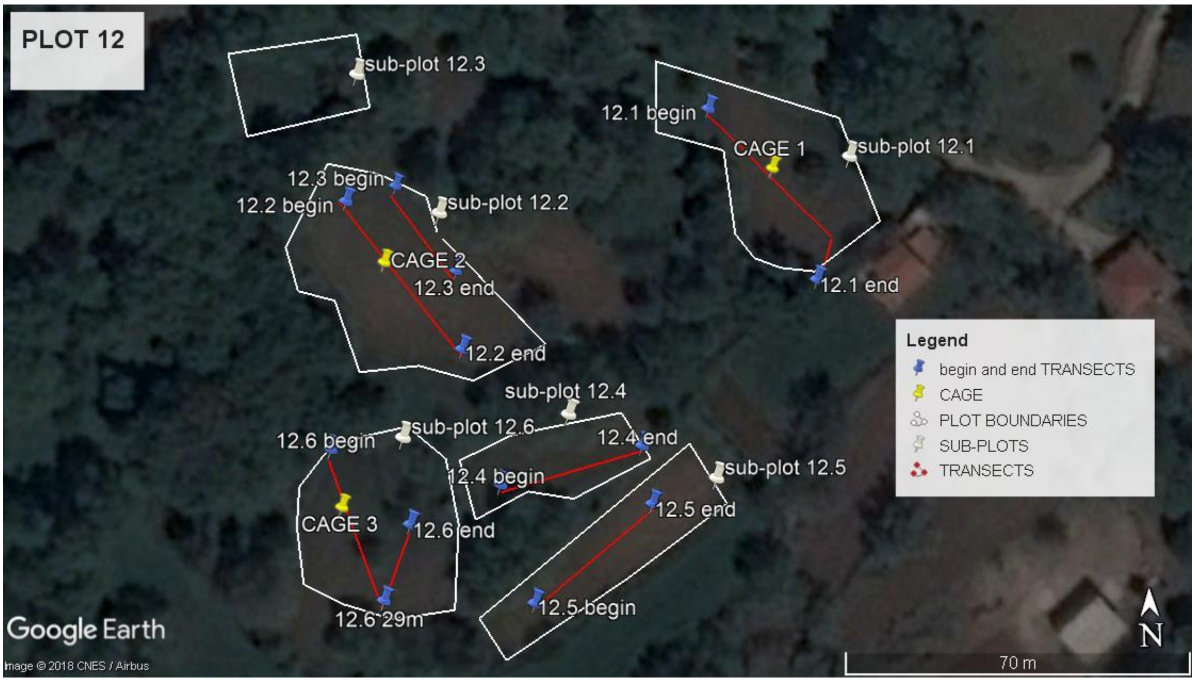
PLOT 12

Permanent pasture
Coordinates: N40.4655 E25.6681

Assessment:
11-06-2019 (Marjan Jongen)
24-06-2019 (Students M4 Summer School)
Although vegetation was in a senescent state, and parcel being grazed, two transects (41 m and 51 m) were done in plot 12 on June 11, one transect in sub-plot 12.1 and one transect in sub-plot 12.2. On June 11, two 30×30 cm quadrats were cut in cage 1, and one 30×30 cm quadrat in cage 2 and cage 3. In addition, one 30×30 cm quadrat was cut in the immediate surroundings of each cage. On June 24, one 30×30 cm quadrat was cut in cage 1 and cage 2, and one 40×40 cm quadrat was cut in cage 3.
Biomass cuttings in the cages represent primary productivity, and these samples were sorted in functional groups (grasses, legumes, forbs). Cutting outside the cages represent standing biomass, and these samples were not sorted.
On June 11, one composite soil sample was taken, comprised of soil cores in all the sub-parcels.

Location cages:

SAM P12_cage 1	N 40.465780° E 25.668861°
SAM P12_cage 2	N 40.465627° E 25.667959°
SAM P12_cage 3	N 40.465209° E 25.667857°



Map 5: Parcel / plot 12, indicating plot boundaries, transects and location of the cages.

Resume:
Plot 12 was sown in March 2017 with a permanent mixtures NEU 550 and AL 550. In spring 2017 the pasture had an excellent vegetative development, and the various species from the seed mixture were clearly visible. In 2017, data on functional group abundance in the transects gave 33% grasses, 60% legumes and a mere 7% forbs.

In May 2018, aboveground productivity in this parcel was extremely high, averaging 8003 kg ha^{-1} (Fig. 9). Data on functional group abundance in 2018 indicated that legume abundance was 39%, which is considerably lower as compared to legume abundance in 2017 (60%). However, in 2018, 61% of hits still represented species from the seed mixture. In 2019, legume abundance decreased to 35% (Fig. 12), with 43% of hits representing species from the seed mixture (Table 4). Prominent legume species in 2019 were *Trifolium subterraneum* and *Trifolium michelianum*, while *Hordeum* (and not *Lolium*) was the prominent grass (Fig. 12). Although this data indicates a continued decrease in the species from the seed mixture, this is partly due to vegetation in 2018 and 2019 in advanced senescence at the time of monitoring.

The excellent performance of this parcel is evident from the aboveground productivity in June 2019, which was still very high, averaging 7609 kg ha-1 (Fig. 10). Standing biomass was 4729 kg ha^{-1}, indicating the effect of grazing, with the animals having browsed 2880 kg ha^{-1}. Productivity, as assessed by the M4 students on 24 June 2019, was 5727 kg ha^{-1} (Fig. 11), this value being lower as compared to the data from 11 June. This difference is probably caused by seed dispersal and loss of senescent material due to wind, although some of the disparity can be due to sampling techniques.

Altogether, sowing practice in this parcel has proven to be successful, as demonstrated by the high productivity and the continued presence of species from the seed mixture.

Although stones are abundant in some areas, which is indicative of the degree of soil degradation, the biodiverse pasture shows it full potential and thrived among the rocks. However, the high abundance of thistles in 2019 (see photos) is not favourable and reason for concern.

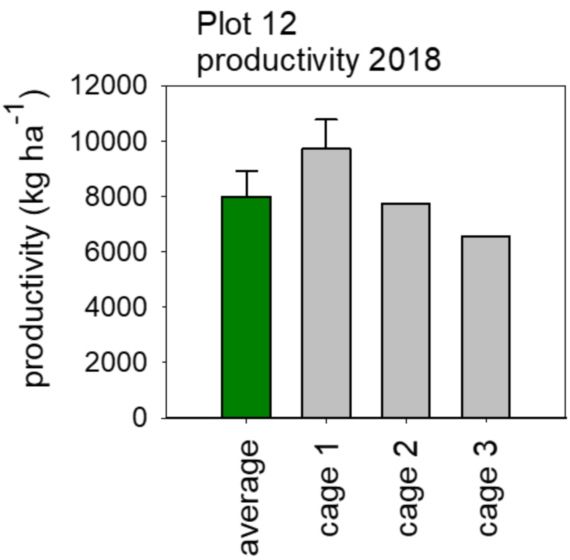


Figure 9: Aboveground productivity ± SE in the cages in plot 12 on 25 May 2018.

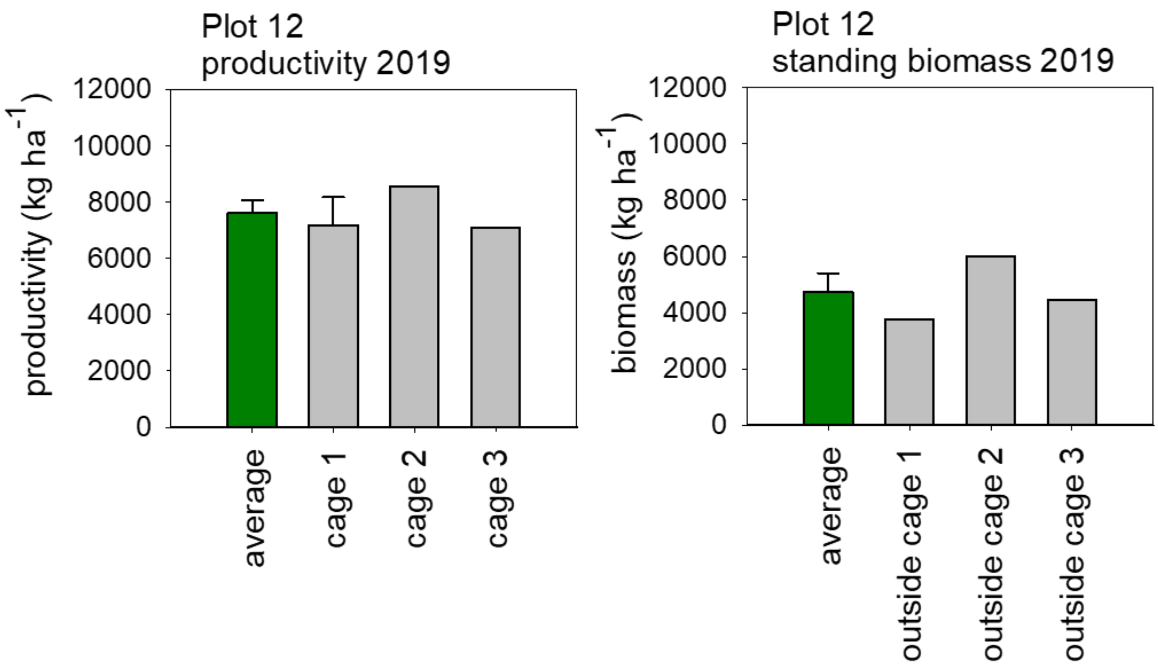


Figure 10: Aboveground productivity ± SE in the cages and standing biomass ± SE outside the cages in plot 12 on 11 June 2019.

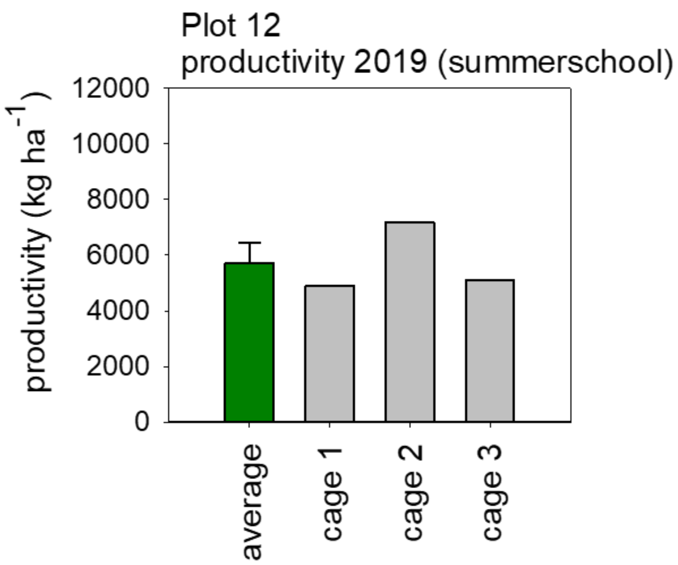


Figure 11: Aboveground productivity ± SE in the cages in plot 12 on 24 June 2019.

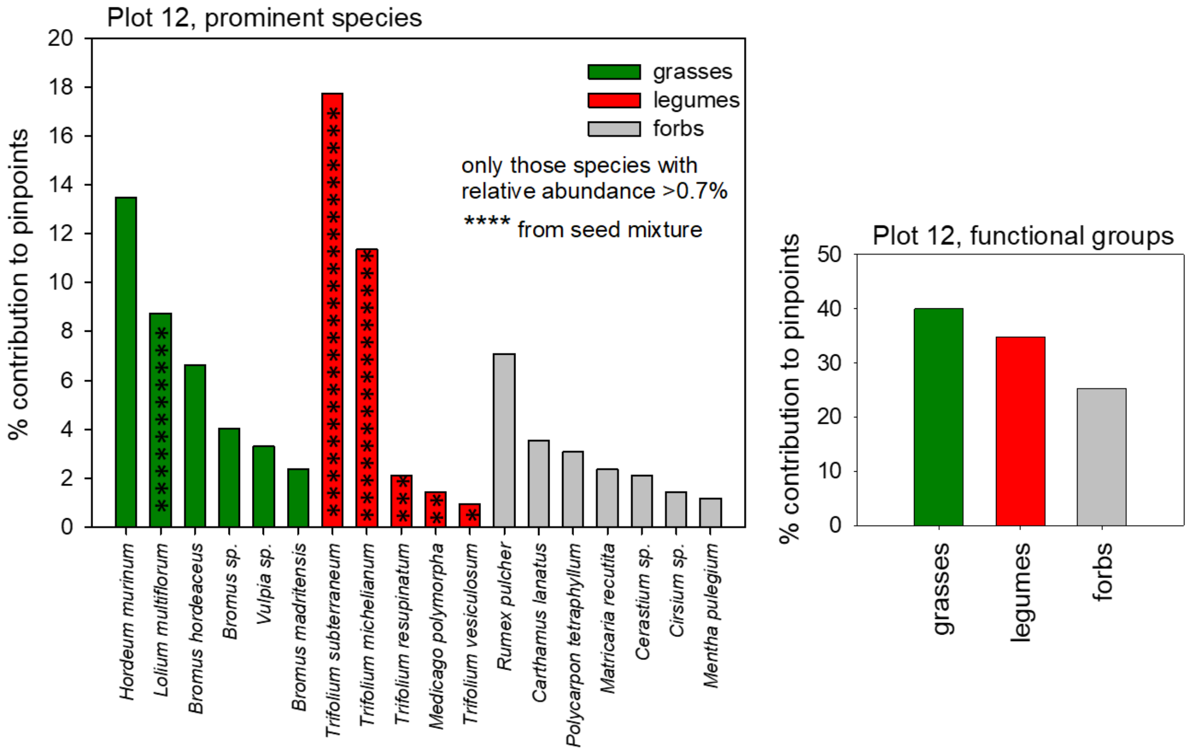


Figure 12: Relative abundance of the prominent species, and the functional groups in plot 12 on 11 June 2019.

Plot 12.1 cage 1, June 2019

Plot 12.2 cage 2, June 2019

Plot 12 legume presence, June 2019

Plot 12 legume presence, June 2019

Plot 12.1 transect 1, June 2019

Plot 12.2 transect 2, June 2019

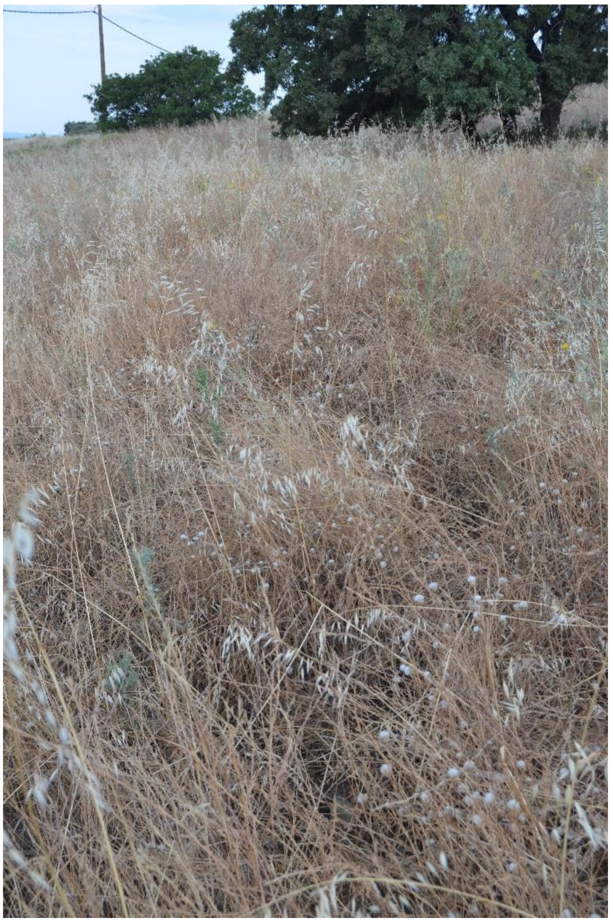
PLOT 14

Permanent pasture
Coordinates: N40.4360 E25.5029

Assessment:
In June 2019 monitoring in plot 14 was not possible, due to the vegetation being senescent. Especially regarding any legumes, any monitoring would have given unreliable results. Only a visual assessment was done.

Map 6: Parcel / plot 14, indicating plot boundaries.

Resume:
Plot 14 was sown in March 2018 with the permanent mixture AC500. In 2018, monitoring of this parcel indicated a prominent presence of *Vicia sativa*, a legume species that is not present in the seed mixture. Species from the seed mixture only represented 38% of hits in 2018. The plants were all very small, although a lot of the specimens did have flowers and/or seedpods (especially for *Trifolium resupinatum* and *Trifolium michelianum*).
In 2019, visual assessment showed high productivity, and a high abundance of the legume species from the seed mixture (see photos). In addition, there was little evidence of the presence of *Vicia sativa*. This is promising, and data collection in spring 2020 will have to provide additional information.


Plot 14, June 2019

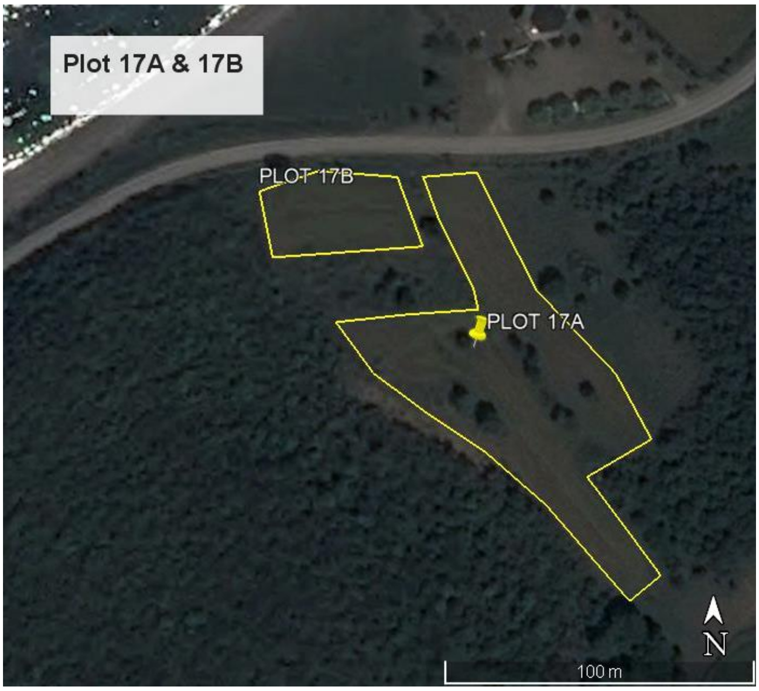

Plot 14 legume presence, June 2019


Plot 14 legume presence, June 2019

PLOT 17A and 17B

Permanent pastures
Coordinates 17A: N40.4926 E25.4942
Coordinates 17B: N40.4930 E25.4936

Assessment:
In June 2019 monitoring in plot 17A and 17B was not possible, due to the vegetation being senescent. Especially regarding any legumes, any monitoring would have given unreliable results. Only a visual assessment was done.



Map 7: Parcels / plots 17A and 17B, indicating plot boundaries.

Resume:
Both plot 17A and 17B were sown in February 2018. Plot 17A was sown with the permanent mixture NEU550, plot 17B with the permanent mixture AC500. Results from the monitoring in May 2018 looked promising. In plot 17A, data on functional group abundance in the transects gave a legume abundance of 38%, with 51% of hits representing species from the seed mixture. In plot 17B, legume abundance was 35%, with 46% of hits representing species from the seed mixture. In 2018, prominent species in both plots were *Lolium multiflorum* and *Trifolium subterraneum*. And although legume specimens were small, especially as compared to the 'big' forbs in these plots, there was ample evidence of seed / seedpods from the legume species from the seed mixture.
In 2019, visual assessment showed a high productivity, although the high abundance of thistles is worrying. Legume abundance was high, with ample evidence of seed / seedpods from the legume species from the seed mixture (see photos). This is promising, and data collection in spring 2020 will have to provide additional information.


Plot 17A, June 2019


Plot 17B, June 2019


Plot 17 legume presence, June 2019

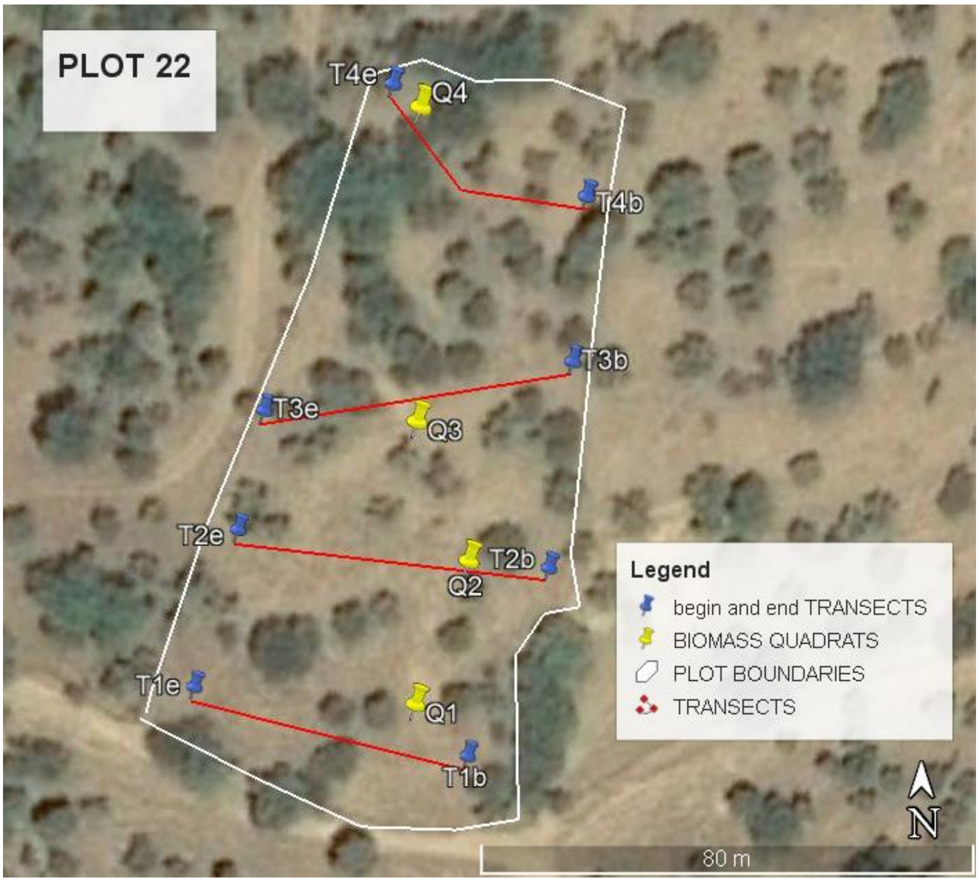

Plot 17 legume presence, June 2019


Plot 17 legume presence, June 2019

PLOT 22

Permanent pasture
Coordinates: N40.4013 E25.5694

Assessment:
13-06-2019 (Marjan Jongen)
25-06-2019 (Students M4 Summer School)
On June 13 observations along four line transects were made (40 m, 49 m, 45 m, 33 m), using the step-point method, at intervals of 1 m. In addition, four 30×30 cm quadrats were cut for productivity assessment. All biomass cuttings were sorted in species or functional groups. On June 25, four 30×30 cm quadrats were cut for productivity assessment.
On June 13, soil samples were taken.



Map 8: Parcel / plot 22, indicating plot boundaries, transects and location of biomass quadrats.

Resume:
Plot 22 was sown in October 2018 with the permanent mixture NEU550. In spring 2019 the pasture had an excellent vegetative development, and the various species from the seed mixture were clearly visible. Data on functional group abundance in the transects gave 53% legumes, 25% grasses and 21% forbs (Fig. 14), with 64% of hits representing species from the seed mixture (Table 4). Prominent species were *Lolium multiflorum*, *Trifolium subterraneum* and *Trifolium michelianu*m (Fig. 14). On 13 June 2019, aboveground productivity in this parcel was moderate to high, averaging 4231 kg ha^{-1} (Fig. 13), with legumes accounting for 75% of biomass (Table 5).

Productivity, as assessed by the M4 students on 25 June 2019, was 3345 kg ha^{-1}, these values being slightly lower as compared to the data from 13 June. This difference is probably caused by seed dispersal and loss of senescent material due to wind, although some of the disparity can be due to sampling techniques.
Sowing practice in this parcel has proven to be very successful, as demonstrated by the high legume abundance, both from transect data as from biomass cuttings. The good management practices, undertaken in relation to this plot, will guarantee its future.

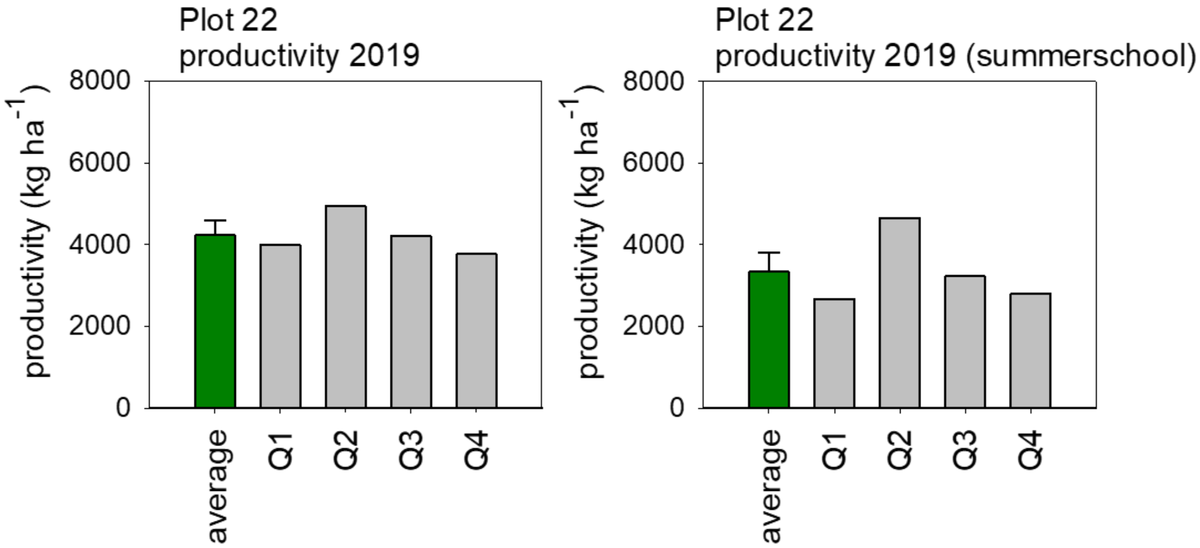


Figure 13: Aboveground productivity ± SE in plot 12 on 13 June 2019 (left) and 25 June 2019 (right).

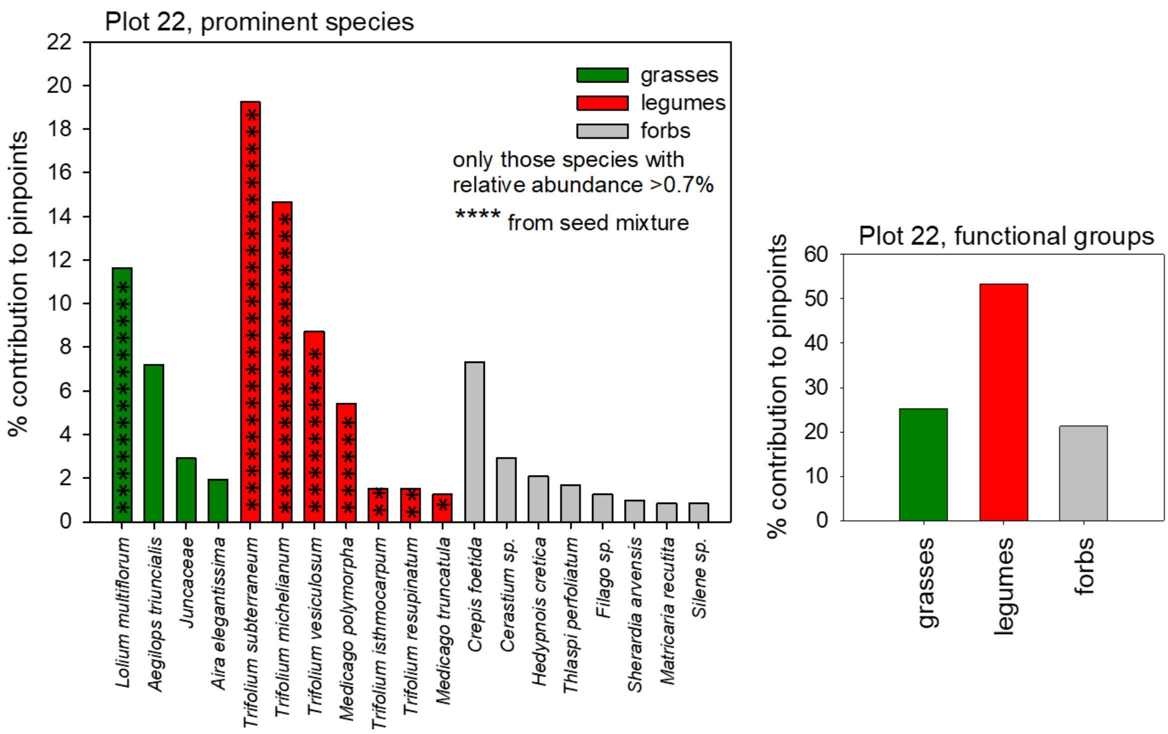


Figure 14: Relative abundance of the prominent species, and the functional groups in plot 22 on 13 June 2019.


Plot 22, June 2019


Plot 22, June 2019

Plot 22 transect 1, June 2019

Plot 22 transect 2, June 2019

Plot 22 quadrat 1, June 2019

Plot 22 quadrat 2, June 2019


Plot 22 versus natural pasture.


Plot 22 versus natural pasture.

Table 3: Soil parameters in monitored plots in Samothraki in 2019.

June 2019	P4B	P4C	P6	P12	P11 SBP	P11 CP	P22
Phosphorus (P) P_2O_5 mg/kg	74	95	90	91	23	29	118
Potassium (K) K_2O mg/kg	180	262	110	180	106	113	161
Magnesium (Mg) mg/kg	>220	>220	>220	153	>220	>220	>220
Nitrogen (mineral-N) mg/kg	29	23	29	18	26	18	18
pH (H_2O)	6.4	6.5	5.8	5.8	5.3	5.4	5.9
Organic matter (%)	2.05	2.10	2.10	2.85	1.30	1.50	2.00
Texture: sand (%) silt (%) clay (%) Classification:							68.7 15 16.3 FA
Recommendation of fertilization for a production of 5 t/ha: Organic concealer t/ha Lime ($CaCO_3$) t/ha Nitrogen (N) kg/ha Phosphorus (P_2O_5) kg/ha Potassium (K_2O) kg/ha Magnesium (Mg) kg/ha Boron (B) kg/ha	 0 0 0 50 0 0 1	 0 0 0 30 0 0 1	 0 0 0 30 60 0 1	 0 0 0 30 0 0 1	 0 4.5 0 100 60 0 1	 0 4.5 0 75 25 0 -	 0 0 0 30 40 0 1

Análise Granulométrica: FA (franco-arenoso) = sandy loam

Figure 15: Determination of the soil class by use of the textural triangle, indicating the soil classification of plot 22 within the soil texture triangle. Soil texture refers to the relative proportion of sand, silt and clay.

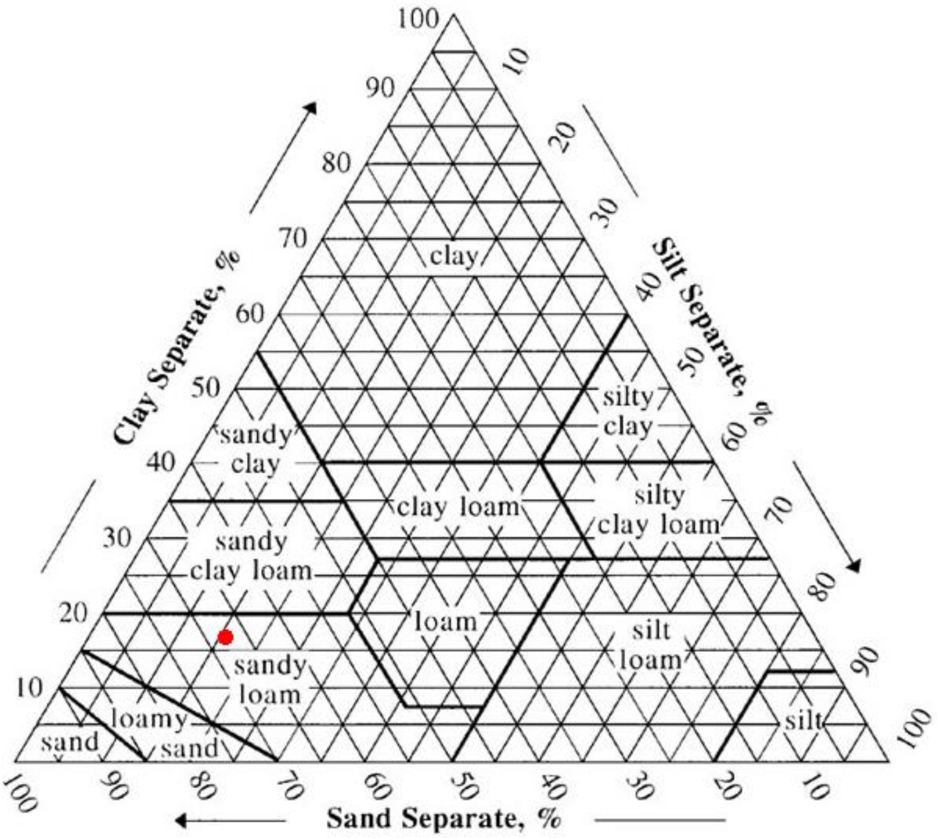


Table 4: Overview of the transect data in monitored plots in Samothraki in 2019.

	TRANSECT DATA								
PLOT	number of species	Shannon index	Simpson	Evenness	Hmax	grasses (%)	legumes (%)	forbs (%)	species seed mixture (%)
4B									
4C									
6									
11									
12	37	2.82	11.44	0.78	3.61	39.95	34.75	25.30	42.79
14									
17A									
17B									
22	43	2.75	10.31	0.73	3.76	25.31	53.39	21.30	64.32

Table 5: Overview of the quadrat data in monitored plots in Samothraki in 2019.

		QUADRAT DATA (average ± SD) CAGES IN					QUADRAT DATA (average ± SD) CAGES OUT / NO CAGES PRESENT			
PLOT		productivity (kg ha-1)	grasses (%)	legumes (%)	forbs (%)		productivity (kg ha-1)	grasses (%)	legumes (%)	forbs (%)
4B	permanent	8958±3030.4	61.8±6.01	19.4±6.30	18.7±0.29		1886±297.1			
4C	permanent	12171±1364.8	47.2±14.22	15.6±4.81	37.2±19.03		2165±812.0			
6	permanent	6841±4368.3	48.4±31.42	21.7±22.59	29.9±30.56					
11	permanent									
12	permanent	7609±813.7	63.5±23.63	33.6±24.15	2.9±1.98		4729±1157.8			
14	permanent									
17A	permanent									
17B	permanent									
22	permanent						4231±510.6	21.7±4.87	75.4±6.79	2.9±2.40

Table 6: Overview of the quadrat data in monitored plots in Samothraki during the Summer School in 2019.

		QUADRAT DATA (average ± SD) CAGES IN					QUADRAT DATA (average ± SD) CAGES OUT / NO CAGES PRESENT			
PLOT		productivity (kg ha-1)	grasses (%)	legumes (%)	forbs (%)		productivity (kg ha-1)	grasses (%)	legumes (%)	forbs (%)
4B	permanent	6134±1668.8	70.2±6.61	14.9±4.13	14.9±2.48					
4C	permanent	7227±3394.9	45.1±23.64	16.4±5.37	38.5±29.02					
11	permanent	4919±2068.9	27.2±19.01	23.3±17.79	49.5±25.27		3532±2482.8	97.1±5.10	0	2.9±5.10
12	permanent	5727±1258.4	75.2±20.91	14.8±17.21	10.0±6.53					
22	permanent						3345±905.9			

CONCLUSIONS OF OBSERVATIONS

From field observations on the sown biodiverse permanent pastures, made during four consecutive years, we can confer the following conclusions:

1. Results obtained so far for those plots that were sown between November 2016 and March 2017, i.e. three-year old parcels (plot 4, 6, 11, 12), indicate a great potential regarding the implementation of sown biodiverse permanent pastures in Samothraki. Our results showed that these pastures had a high productivity, which justifies additional installations of sown biodiverse pastures on the island of Samothraki in the future. Unfortunately, plot 11 was rotavated and sown with an annual crop.

2. For those plots that were sown in February-March 2018, i.e. two-year old parcels, results obtained show that the late sowing led to a high abundance of forbs. Although *Lolium* established well in these plots, the legumes were underrepresented, especially in terms of biomass. Nevertheless, there was ample evidence of leguminous species from the seed mixture. Data collection in spring 2020 will have to provide additional information. Unfortunately, plot 15 and 16 were rotavated and sown with an annual crop.

3. Results obtained in plot 22, sown only in 2018 (i.e. one-year old parcel), in the understorey of an olive grove, were very promising. Data collection in 2020 will have to provide information on the persistence of the sown biodiverse pasture.

3. The existing machinery and equipment on the island, although not the most suitable for soil preparation and sowing of this type of mixtures (some of the sown species have a very small seed size, with 1 million seeds kg-1), do allow for successful operations if care is taken when soil is prepared and mixtures are sown.

4. The sowing dates were not always correct, with some plots sown in January, February and March, while it is recommended to sow in the autumn, preferably before the first rains and before the soil temperatures decrease.

5. The absence of fences or other methods of animal exclusion, coupled with the small size of each plot, does not allow a correct management of the sown biodiverse pastures. In some plots there is no control of entry and exit of the animals and due to the small production area, all existing pasture is quickly consumed. Subsequently, it is not possible to correctly assess the results achieved.

7. Some soils in the trial plots, due to their high fertility, benefit the grasses present in the mixtures at the expense of the legumes, which causes irreversible quantitative and qualitative imbalances in the fodder produced.

RECOMMENDATIONS

Taking into account the obtained results, we consider that the sown biodiverse **annual** pastures should, at this moment, not be the focus of action, although they may gain importance in the future. We should currently concentrate our efforts on the implementation of sown biodiverse **permanent** pastures, rich in legumes.

The island of Samothraki provides excellent conditions for the installation of sown biodiverse permanent pastures. They may be of crucial importance, not only for farmers' economic performance, but also for their role in biodiversity conservation, and their high ecological, cultural and aesthetic value.

As one of the most important traditional agricultural land use system, biodiverse permanent pastures present a valuable tool to mitigate the negative effects of those factors not controlled by man. These pastures provide a better use of water resources, by conserving soil moisture and by reducing thermal fluctuations at ground level. In addition, the organic matter produced is not degraded and thus the active ingredients in the soil are increasingly metabolized by the enhanced microbial activity in the soil. Furthermore, the biodiverse permanent pastures play an important role in soil protection against erosive processes and they reduce the fire risk.

In Samothaki, sown biodiverse permanent pastures can contribute to the maintenance and conservation of the biodiversity and its associated landscape, minimizing the fast advancing erosive processes, the latter not only due to adverse climatic conditions, but also to the observed high animal pressure, which increasingly determines the landscape. In addition, the sowing of these pastures will increase the island's forage production, thus allowing a reduction of grazing pressure in the most sensitive areas, such as mountain areas, and enabling a retreat of sheep and goats to less susceptible areas. These pastures can provide a two- to five-fold increase in production, as compared to natural pastures, without introducing new species, but rather cultivars of existing species, selected for their productive capacity, as we observed several native species that entered into the seed mixtures used.

Thus, the concept of SUSTAINABILITY, associated with sown permanent pastures, can be used for livestock products, such as meat, milk, cheese, wool, etc., which may be labelled as 'Sustainable Products', as a result of the good agricultural practices associated with this type of pasture. Also, other local agricultural products provided by the sown biodiverse permanent pastures may be associated with this concept of sustainability.

The agricultural activity which is directly associated with several excellent products of the island of Samothraki (for example the Samotracian goat, the lambs that provide several traditional dishes, the cheeses Mizithra, Kaskavali and other hard cheeses) made by local shepherds from sheep and goat milk take advantage of the natural pastures of the island. These products may be in the front line to be considered sustainable products, due to the good agricultural practices that are applied.

Olive groves, as well as vineyards and other orchards on the island, can also benefit from this concept of sustainability, if associated with good agricultural practices (e.g. integrated protection or biological production) regarding the understorey vegetation. The maintenance of an herbaceous cover, provided by the sown biodiverse permanent pastures, in the understorey of these permanent cultures is fundamental to minimize the erosive processes.

Providing a vegetal cover in olive groves, vineyards and/or orchards will be essential to avoid the soil loss that occurs in those areas with inclination.
This cover will not only protect the soil against erosion and improve its physical and chemical properties, but it will also lead to a gradual improvement of the soil organic matter. This will result in an increase in fertility, infiltration and water retention capacity. The produced vegetal cover should be left on the ground in order to protect the soil, not only reducing the impact of erosion (rain, wind, etc.), but also avoiding water loss through evaporation.

The establishment of sown biodiverse permanent pastures in the understorey of olive groves, vineyards or orchards, would mean that several locally produced products (e.g. olive oils, currently produced in a biological way, according to Greek ancestral methods) could benefit from the concept of sustainability. Another example is the autochthonous species of plum, called ‘Pragouoti’ by the locals, used to make traditional jams and liqueurs, much appreciated by the tourists. These products could, if associated with the agricultural practices mentioned, obtain the sustainable classification.

Another example is the honey. In conjunction with the local flora, the sown biodiverse permanent pastures, with their great variety of flowers during several months, could contribute to a differentiated product, of great quality and at the same time environment friendly. It is already common to sow the mixtures in the vicinity of the hives, to guarantee the quantity and quality of honey and its related products, taken into account that many of the species used in these mixtures are considered as melliferous species.

The Samothraki craft beer ‘Fonias’, produced in a family microbrewery, may also be associated with the concept of sustainability, through the establishment of sown biodiverse permanent pastures, provided that rotation of the cereal, in this case barley, allows for the sowing of these pastures. The sown pastures will subsequently provide nitrogen for the cereal crop, and simultaneously contribute to an improvement of the physical and chemical properties of the soil. In addition, the gradual increase in soil organic matter, will translate into an increase of its fertility, later to be utilized by the cereal culture.

We know that the individual farmers of Samothraki will not be able to develop a process that leads to the certification ‘Sustainable Products’, due to the size of their exploitation and their reduced financial resources. However, public or private entities, national or international, can play a key role in a project with this ambition.

We believe that a project that aims at the sustainability of the island of Samothraki, from its main tourist activity to the fisheries and its agriculture/livestock, will be beneficial. It will privilege the conservation and preservation of its biodiversity and emphasize the great ecological, cultural and landscape values that these activities represent on the island.

The certification of several local products as "Sustainable Samothraki" could be a factor of differentiation with third parties. Also, it will be a tourist attraction for the island to behave ‘environment friendly’, preserving increasingly rare values in the world’s economy, which is often more concerned with financial ratios than with the sustainability of the planet.

The initiative to implement this environmental tool (‘Sustainable Products’) to Samothraki, such as the sowing of biodiverse permanent pastures, will be associated with the higher values that the island represents. It can make Samothraki a world reference in the green economy, as a result of a policy directed towards the preservation of the ecosystem, simultaneously promoting sustainable economic growth.

Parallel to the establishment of sown biodiverse permanent pastures, a change of those procedures inherent to the agricultural activities on the island, should be considered, in particular, regarding the preparation of the soil:

- Soil mobilizations are carried out favourably to the slope, that is, perpendicular to the contour lines. This provides a superficial water runoff, which will carry a high amount of soil, especially in those plots with a marked slope. These mobilizations should be carried out following the elevation contour lines, so-called ‘contour plowing’, which will reduce the surface water runoff.

- An excessive soil mobilization system is observed, often using plows, with two and three irons (planters), which leads to a greater risk of soil loss due to erosion. In addition, this contributes to the appearance of so-called "callus", which creates a layer impermeable to the subsoil level. Therefore, these plows should only be used in specific cases, and, if possible, alternative ways of soil mobilization should be considered;

- The cereal monoculture system (oats, barley and/or wheat) should be kept to a minimum, especially in steep areas. Here, the permanent pastures with or without agroforestry systems will unequivocally contribute to soil protection. Sowing annual crops (cereals or other crops) should take place as early as possible, using early species and varieties. This will allow for rapid soil cover, before the onset of the period of heavy rains. In addition, using consociations, such as legumes with grasses, will contribute to the maintenance and conservation of the soil, as well as to species biodiversity (note that a fairly poor flora was observed in the lowlands, as a result of successive soil mobilizations and herbicide applications);

- Placing protectors for the natural regeneration of existing forest species will be fundamental to ensure their development and the creation of a stable arboreal cover. This as opposed to the current situation, with goats grazing disorderly, and the young trees are no more than shrub. The erosion risk, due to rains and intense winds, can be minimized if we create a forest, where the broad canopy of trees provides a protective soil cover, a situation observed in the recent past.