PRELIMINARY RESULTS OF LIFE + FRAMME, ON FOREST FIRES IMPACTS

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1. Introduction

Present work was inspired by a rather unfavourable motivation, the 2008 forest fires in Greece. This catastrophe claimed in total 84 lives and burnt 268.834 hectares (ha), almost 5% of the country (1). Though Greek society was shocked, soon afterwards, a public discussion begun on reforestation and habitat's restoration efforts. First estimates, reported 10 to 15 years as the natural reforestation period (2).

Since forest fires are a common phenomenon, enhancement of natural reforestation is widely practiced in Greece. For that reason three main interventions are facilitated: Plantings, Anti-Erosion measures and Log-Cutting. A literature review on the efficiency and productivity of those interventions revealed significant knowledge gaps, or even adverse impacts (3,4,5,6,7,8,9,11), while at the same time critical fire impacts on soil remained untreated (12, 13, 14, 15, 16, 17, 18).

LIFE08 NAT/GR/000533 project (19), entitled "Fire RestorAtion Methodology for MEditerranean Forests – environmental safety & sustainability of 4 interventions in the Rhodes NATURA 2000 site FRAMME", was developed in order to fill those gaps. For this purpose two traditional interventions and two new innovative, implicating the re-use of municipal wastewater, were combined in a 4X4 experimental plan that questioned their safety, efficiency and sustainability (19).

Herbal indicators were chosen in order to monitor the interventions' efficiency and sustainability. The relevant review revealed extensive research of fire impacts on *fauna* biodiversity (20, 21, 22, 23, 24, 25), habitat restoration (3, 4, 10, 26) and productivity (27, 28), but rather scarce reports of fire impacts in *flora* biodiversity.

This paper presents the indicators definition and their accounting methodology, simultaneously with the first complete survey results. Those indicators are meant to define the alteration of the herbal biodiversity status, in the level of species, as a result of the Rhodes 2008 forest-fire. Therefore this current work communicates for the first time, the direct impact of an extensive forest fire on *flora* biodiversity.

2. Methodology

The total burnt Natura 2000 GR4210005 site, escalating to 2,900 ha (2), was defined as the area of interest. Cataloguing of the herbal biodiversity in this area was based in Carlstrom's work (29) and was crosschecked by other related flora's (30, 31). Identification of the potentially present *taxa*, was performed by overlapping the area of interest outline, with Calstrom's distribution maps. Confirmation of a *taxon* presence in the area of interest was secured by the inclusion of other ecological factors, such as habitat, endemism and scarcity in the island.

The first field survey was conducted during 2011, three years after the fire, in three consequent visits during spring, summer and autumn and covered at total 64 ha, almost 2,2% of the area of interest. The study area was fragmentised in 4 parcels, each including 16 plots of 1 ha, distributed evenly in the forest-fire perimeter zone. Field visits enumerated the following 3 indicators:

- Reforestation: This indicator investigates the reforestation dynamic and is expressed as the relevant forest-tree seedlings per ha. Randomized sampling within each plot performed the enumeration of this indicator. Sampling implicated the repetitive application of a, 1 m^2, rope frame and consequently counting of the seedlings. Estimation of each plot seedling density was based on those samplings escalating from 5 to 12 for each plot. Final indicator enumeration is provided by the following formula:

  $$\mathbf{R_I=a/b}$$

  a= Total number of seedlings in a given area
  b= Total ha of the given area
- Land Coverage: This indicator investigates the vegetative dynamics and is expressed as the percent of permanent vegetative land cover, within a given area. Randomized sampling within each plot performed the enumeration of this indicator. Sampling implicated the repetitive application of a, 1 m^2, rope frame and consequently counting of the small shrubs. Estimation of each plot's land coverage was based on those samplings, escalating from 5 to 12 for each plot, and original counting of the perimeter of the plantations. Final indicator enumeration is provided by the following formula:

  $$\mathbf{L_I=c+d}$$

  c= % of large shrubs land cover per ha
  d= % of large shrubs land cover per ha
  This indicator implicates the collection of additional data on height and perimeter of each large shrub and population density for each small shrub *taxon*, which are not discussed herein.
- Floral Biodiversity: This indicator investigates the biodiversity dynamics and is expressed as the absolute number of herbal *taxa* per ha. Extensive observation and collection within each plot performed the enumeration of this indicator. Photographs and herbaria were used complementary in order to document those observations. Enumeration of each plot's biodiversity indicator was based on those observations, which covered the total study area, thus 64 ha. Final indicator enumeration is provided by the following formula:

  $$\mathbf{H_I=e/f}$$

  e= Total number of *taxa* in a given area
  f= Total ha of the given area

The development of a remote sensing system utilizing satellite data is also on-going, in order to complement and organize field observations.

3. Preliminary Results & Discussion

The results presented herein are focussed in three issues, the biodiversity loss as a result of the 2008 fire, the reforestation dynamic in the same area and the efficiency of the restoration interventions.

3.1. Biodiversity Loss

Of critical importance for this subject is the pre-fire floral biodiversity wealth of the study area. FRAMME's Biodiversity Study (32) estimated the total potentially present *taxa* in the area of interest to 503. This number is strongly reduced to 379, when only the confirmed *taxa* are accounted. The additional exclusion of endemic and/or of limited distribution *taxa* further reduces this number to 261. This late number is considered a safe estimate of the total *taxa* present in the study area. The total number of *taxa* observed in the area was 105 (33).

Table 1: Pre & Post Fire Herbal Biodiversity Indicator

	Area of Interest	Area of study
H_{I1}	0.13	4.08
H_{I2}	0.03	1.64

H_{I1}: Herbal Biodiversity Indicator 2008
H_{I2}: Herbal Biodiversity Indicator 2011

Those results suggest that almost 72.3% of the preceding the 2008 fire biodiversity was lost, in the area of interest. When this indicator is corrected for reference to the area of study this loss is reduced to 59.8%, thus still accounting to more than half of the *taxa* originally grown in the area. Therefore a significant impact of Forest-fires is poorly described when impact evaluation is limited to the accounting of ha of habitats lost.

3.2. Reforestation Dynamic

Regeneration of Pine trees (*Pinus brutia)*, was the dominant figure for the enumeration of this indicator. Enumeration is presented for the four major experimental parcels for simplicity reasons.

Table 2: Post Fire Reforestation Indicator

	A	B	C	D
R_I	1,281.3	93.1	125.0	90.6

Those results suggest that while parcel B, C and D could be considered having homologous reforestation dynamics, parcel A presents significant difference. Indeed this difference exists, as parcel A is the only one in close contact with unburned forest islets.

The seedling densities observed dictate that plantation interventions are of immediate need in order to reach a safe number of seedlings. Such a number is not provided so far as previews research suggest seedling per ha varying from 500 to 5.000. Though those results also suggest that this need is greatly diminished for areas in close proximity to unburned forest islets.

3.3. Log-Barriers Efficiency

Construction of log-barriers was the only restoration intervention applied in the area of study, during the winter of years 2008-2009. This application being rather fragmentised allowed the comparative assessment of their efficiency in the terms of Reforestation Dynamics and Land Coverage. From this assessment is excluded parcel A due to its profound heterogeneity, previously highlighted.

Table 3: Log-barriers Efficiency

	B		C		D	
	1	2	1	2	1	2
R_I	102.5	83.8	142.5	107.5	83.8	97.5
L_I	66.5%	83.6%	89.9%	75.4%	80.4%	74.5%

1: Plots with Log-Barriers
2: Plots without Log-Barriers

Reforestation Indicator deviation in parcels B and C indicates a significant beneficiary impact on pine tree seedlings as those are increased by 22.3% and 32.6% respectively. But in parcel D the seedling in plots with log-barriers are decreased by 14.1%.

Land Coverage Indicator also presents controversial results. To be more specific this indicator documents the beneficiary impact of log-barriers for parcels C and D, were land coverage is increased by 14.5% and 5.9% respectively, but not for parcel B, were land coverage is decreased by 17.1% in plots with log-barriers. Those controversial results are not able to draw a clear conclusion on log-barriers restoration efficiency.

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More information available on the FRAMME project website: http://www.ellet.gr/framme

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