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# Conservation status assessment method for habitat types at Site of European Community Interest scale

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**ABSTRACT:** Most 92/43/EEC Directive (Natura 2000) Habitat Types are defined by vegetation, with reference to the phytosociological method. Habitat types' conservation status assessment is based partly on "Typical Species", structure, function and future trend of habitats. The 92/43/EEC Directive application guidance document does not mention a clear definition of "Typical Species". Furthermore, this Directive imposes for assessment to deal with Habitats types variants depending on local conditions. The method presented in this paper, is based on Frequency Analysis and is applied on the Site of Community Interest of the Volvi and Koronia lakes, in Greece. It defines firstly Typical Species using two species bond probability calculation and aggregation of the Species in vegetation units limited with probability thresholds, and secondly bonds probability calculation between species and environmental variable status for each species in the unit, presented in ecological profiles. This Phyto-ecological method not only defines Typical Species at site scale, using relative small number of plots (66), but also bonds Typical Species with habitat structure and function environmental variables such as grazing and edaphic ones at this scale. The information provided by this method helps short and middle term future trend prevision of Habitat and more "tuned" management on site scale than with global plots (relevés) treatment from all the country.

**KEYWORDS:** Habitat Types, Conservation Status, Typical Species, Frequency Analysis, Ecological Profiles, Site of community Interest Monitoring.

## 1 INTRODUCTION

In the frame of 92/43/EEC European Union Directive, habitat types are mostly defined by vegetation, with reference to the phytosociological method [3], and their conservation status is assessed through "parameters" such as area, range, structure, function, future prospects, pressures and threats. In this frame, the assessment of habitat structure and function requires checking the presence of Typical Species' (TS) from a given list.

There is no clear definition of what a is "Typical Species" in the guidance for the 92/43/EEC Directive application [7] and the Greek Explanatory Implementation Manual for the Conservation Degree Assessment of Habitat Types [6]. According to [6], TS may be not stable for the same habitat type along the sites in Europe or even in a country, and each habitat type is composed by vegetation units determined by ecological factor that may have not the same strength from a Site of Community Interest (SCI) to another. In this way, habitat types have variants depending on local conditions, and the 92/43/EEC Directive imposes this variability to be dealt with. The definition of structure in [7] and [6], due to the use of its TS completion list, is not much clear, although the structure of vegetation is well defined by many studies and is enough taken in account in the field data-recording database [13] (percentage of land cover by each vegetation strate). According to [7] and [6], the function of habitat, is leaved to "expert judgment".

The field data-recording database [13] created, for Habitat and Species assessment in Greece, includes lists of TS for each habitat type connected with phytosociological analysis [6] of the 15991 relevés (plots) from the initial phase records, concerning the whole country [14]. The analysis method uses the Tsiripidis et al. [15] algorithm and the Phi coefficient [5] that indicates the ability of a Species to separate a plant group from others. Nevertheless, for some reasons, including the difficulty to define the Phi threshold on which is based the decision to include or not a Species in the group of TS, the least choice of TS for the database is left to “expert judgement”.

The results that derived from this process include lists of 16 to 49 TS in the Greek assessment database [13] for each of the habitat types we focused in the study area: Local variant (association Salicetum albae) of the 92A0 (Salix alba and Populus alba galleries,), local variant (association Tamaricetum parviflorae) of 92D0 (Southern riparian galleries and thickets that corresponds to Nerio-Tamaricetea and Securinegion tinctoriae), local variant of 6420 (Mediterranean tall humid grasslands of the Molinio-Holoschoenion), a variant of 72A0 (Reed beds that corresponds to the association Phragmitetum), another variant of 72A0 (Reed beds that corresponds to the association Scirpetum lacustris) and the local variant of 3290 (Intermittently flowing Mediterranean rivers of the Paspalo-Agrostidion).

Because of the great number of TS for each habitat type in the [13] database, it would take at least the same time as for the initial phytosociological relevé, where every Species is noted, to check for presence and other parameters as abundance or vitality for each TS in a field plot. Also, besides the difficulty of assessing the habitat conservation status, looking whether some of the numerous TS are lacking or not, there maybe also difficulty in deciding to which habitat type belong some relevés, due to common TS. According to the [13] database, 10 common TS exist between 92A0 and 92D0, 9 between the two variants of 72A0 and 5 between 92A0 and at least one of the two variants of 72A0. Also 6 TS are common between 92A0 and 92D0 and at least one of the two variants of 72A0. This shows the possibility of evolution from one habitat type to another, with some probability that a station belongs to an intermediate form between two types inside the study area. This incertitude is maintained in spite of dealing with the habitats variants, which very often differentiate SCI [14].

Better knowledge of the factors that conduct the changes among habitat types and the TS that are the most sensible to these factors should be useful [10], but this is more efficient at local scale, in each SCI. In this way we should be able to indicate a few TS that are operational indicators, firstly, of a habitat type, and secondly, of the dynamics status of each habitat. For this purpose, we must dispose a processing method that gives satisfactory results with a small amount of relevés due to the restriction of the work area. This paper exposes this method, using a sub sample of 66 relevés, on geological substratum not older than tertiary deposits, from those, which have been gathered during the fieldwork for monitoring and assessing habitat conservation in the Greek Volvi and Koroni lake National Park, Thessaloniki Prefecture during 2013-2015 period [1], [2].

## 2 Material And Method

We used 66 vegetation and environmental variables field samples (relevés) on surfaces between 8 and 100 $m^2$, depending on habitat type and its richness in Species. The samples’ location has been chosen by stratified sampling method [10], using habitat type and geological substrata maps [1], [2]. In these samples the presence of each Species is noted, and also its abundance, its vitality and in which vegetation strata it is the most abundant. The status of 25 environmental variables was also noted on the plots. Only process of Species’ presence and four variables is presented here.

### 2.1 Phytosociological Processing Method With Frequency Analysis

In phytosociology the probability to find in the same relevé two or more plant Species is the basic principle on which, it could be mentioned, that a Species is characteristic of one vegetation unit. The Conservatoire Botanique National Alpin [9] has studied the problem of finding TS in France and reached to the definition that a TS has a large probability to be found with other Species which together characterize a habitat type in one or another phytosociological taxon. The process used by the upward authors is to calculate the exact probability of finding two Species together in a relevé, and not a statistic coefficient (as Phi or Chi2) or parameter that is supposed to represent a phenomenon in a large sample, that is not efficient in small samples. So, the above-mentioned method [9] adopted by us, is not inferential, and is called “Frequency Analysis”. The probability calculation is explained downwards.

***Table 1: Combination number of presence and absence of two Species in the relevés***

| **Frequencies** | | **2d Species** | | |
|---|---|---|---|---|
| | | **Presence** | **Absence** | **Total** |
| **1st Species** | **Presence** | a | b | a+b |
| | **Absence** | c | d | c+d |
| | **Total** | a+c | b+d | n |

Where: n = a+b+c+d

The probability (P) of the table is: $P = \frac{(a+b)!(c+d)!(a+c)!(b+d)!}{n!a!b!c!d!}$

The information quantity (I) that offers is: $I = \log_2 \frac{1}{P}$

The amount of information I (with sha as unit), from the Information Theory [4], [8], is used here as a practical bound between two Species, which can be visually represented as a distance where a short distance is a tight bound. This gives a dendrogram named "archipel"[9], [10], with an algorithm that starts with the two Species that have the highest I. The two first Species form a first vegetation unit that will be enlarged with a third Species that has the highest I with one of the Species ofthe unit and so on till a threshold I. The algorithm is reinitiated with the rest of the Species that are not in the first unit to form a second unit and so on. In our case, we chose the threshold I = 5 sha, that means a 97% probability to be wrong if we say that the two Species with this amount of mutual information quantity are not bounded. The fidelity of Species to a unit can be measured by this method.

To attribute each vegetation unit - resulting form the above-described process- to each habitat type, each vegetation unit is compared with the proposed TS composition of the habitat types in the [13] database. To precise correspondence between TS and local variants of Habitat types through phytosociological units, we used the results of the Twinspan method's phytosociological process [12], by which have been described a Northern Greece study area's habitats through 5238 relevés [14] and includes our study area. This method uses reciprocal averaging frequencies to define characteristic Species of habitat types, which is an additional inferential method to the one used throughout Greece [6].

Frequency analysis shows that when two Species are present only two times in the sample of 66 relevés, and when they are present both in the two same relevés, there is 99,95 % chance to be wrong if we suppose that they are not bounded. This is important information that counts, although more information on these two relevés is needed. The second part of the process, presented downwards can be used in order to gather this information. With this method, it is possible to exploit the information given by mutual presence of Species less than 5 and then exploit small number of relevés.

### 2.2 PHYTO-ECOLOGICAL PROCESSING METHOD WITH FREQUENCY ANALYSIS

The ecological meaning of the abovementioned bonds between Species need coded variables of the environment and the frequencies of Species in the variable classes. This process is called phyto-ecological process [11], [10].

***Table 2: Combination number of presences and absences of a Species and variable class in the relevés.***

| **Variable V** | | **Presence of class V(i)** | **Presence of all other classes of V** | **Total** |
|---|---|---|---|---|
| **Species S** | **Presence** | A | b | a+b |
| | **Absence** | C | d | c+d |
| | **Total** | a+c | b+d | n |

The probability of this table is calculated with the same formula as in table 1. It is reiterated the calculation for each class V(i) and establish the ecological profiles for each Species of groups of Species and for each variable to verify the effect on the plant Species' repartition.

Simultaneously the combinations between variables classes are calculated from variables pairs for detection of redundancies in variables or eventual bias in bonds interpretation.

***Table 3: Ecological profile of Species***

| Classes of variable V | V(1) | V(i) | … | V(n) | Total of relevés |
|---|---|---|---|---|---|
| **Presences of the class P(i)** | **P(1)** | **P(i)** | **…** | **P(n)** | **ΣP(i)** |
| **Name of the Species S** | **Presence of S in V(1)** | **Presence of S in V(i)** | **…** | **Presence of S in V(n)** | **Total presence of the Species S** |

In the same table cell for the presence of S in V(i), the significance of the probability to find the Species S in the variable class V(i) with the downwards signs is mentioned.

| | |
|---|---|
| + | Significative bond (probability <0,05) |
| ++ | Very significative bond (probability < 0,01) |
| +++ | Extremely significative bond (probability < 0,001) |
| - | Significative incompatibility (probability <0,05) |
| -- | Very significative incompatibility (probability <0,01) |
| --- | Extremely significative incompatibility (probability <0,001) |

The calculations have been processed through ECHO database' software of the Montpellier's Institut de Botanique that can be provided mailing to migodron@wanadoo.fr.

## 3 RESULTS AND DISCUSSION

The vegetation units and their correspondence to habitat types (presented in introduction) are presented bellow, with mention in parentheses of the mutual information (I) between the Species in sha.

- **Unit 1:** This unit combines the habitat type 6420, and especially the Trifolion resupinati Micevski 1957, characterized by *Juncus acutus* and *Scirpoides holoschoenus* (I=17), with the 92A0, and especially the Salicetum albae, characterized by *Salix alba* (I=11 with *Scirpoides holoschoenus*), *Populus alba* (I=10 with *Salix alba*), *Alnus glutinosa* (I=9 with *Populus alba*) and *Rubus ulmifolius* (I=7 with *Alnus glutinosa*).
- **Unit 2:** It combines the habitat type 92A0, and especially the Salicetum albae, with the 92D0, and especially the Tamaricetum parviflorae, and is characterized by *Aristolochia clematitis, Ballota nigra* (I=7), *Urtica dioica* (I=7 with *Ballota nigra*), *Phytolacca americana* (I=7 with *Urtica dioica*) and *Cornus mas* (I=6 with *Urtica dioica*).
- **Unit 3:** This unit is part of the 72A0 type, and especially the Scirpetum lacustris, characterized by *Cyperus longus, Lythrum salicaria* (I=13), *Pulicaria dysenterica* (I=9 with *Cyperus longus*) and *Schoenoplectus lacustris* (I=6 with *Cyperus longus*). *Agrostis stolonifera* (I=9 with *Cyperus longus*), which, according to the [11] database, is TS of all the mentioned habitat types but the 3290, is member of this group.
- **Unit 4:** This unit belongs to the 3290 type, and especially the Paspalo-Agrostidion semiverticillatae Br.-Bl. Roussine et nègre, characterized by *Cyperus fuscus, Echinochloa crus-galli* (I=16) and *Paspalum paspalodes* (I=11 with *Cyperus fuscus*), but *Paspalum paspalodes* and *Echinochloa crus-galli* are also TS of the 72A0, according to the [11] database.
- **Unit 5:** This unit, with *Cichorium intybus, Crepis setosa* (I=12), *Cynodon dactylon* (I=10 with *Cichorium intybus*) and *Plantago lanceolata* (I=6 with *Cichorium intybus*), due to the two last characteristics, belongs to the 6420 type, and especially to the Trifolion resupinati Micevski 1957, although *Crepis setosa* is characteristic of the Cirsion appendiculati Horvat, Pawlowski et Walas 1937, which have been classified in 2001 in the 6432 type (Eutrophic tall herbs).

The method does not distinguish a unit that would correspond well with the 92D0 type as characterized in the [13] database because this type has Species that live in different soil structure, as it can be seen bellow for *Vitex agn. castus* and *Tamarix parviflora.*

Bellow some ecological profiles of the group's Species are presented that can explain the reasons why the units are differentiated, using variables of structure and function of the habitats. The habitat types they characterize, according to [13] and [14] are in parenthesis.

*Table 4: Ecological profile of the group Species for the aquifer's depth in summer*

| Class of depth (cm) | 0-20 | 20-40 | 40-80 | 80-120 | >120 | Total of relevés |
|---|---|---|---|---|---|---|
| **Presences of the classes** | **4** | **8** | **14** | **18** | **22** | **66** |
| **Species** | **Presences of the Species** | | | | | **Total presences of the Species** |
| *Vitex agn. castus (92D0)* | 0 | 0 | 3 | 1 | 10<br>++ | **14** |
| *Rubus ulmifolius (92A0, 92D0)* | 0 | 0<br>- | 4 | 9<br>+ | 7 | **20** |
| *Cichorium intybus (6420)* | 0 | 1 | 2 | 8<br>+ | 7 | **18** |
| *Salix alba (92A0, 92D0)* | 1 | 0 | 3 | 4 | 0<br>- | **8** |
| *Scirpoides holoschoenus (92D0, 6420, 72A0)* | 0 | 2 | 6<br>+ | 5 | 1<br>- | **14** |
| *Agrostis stolonifera (92A0, 92D0, 6420, 72A0)* | 1 | 3 | 4 | 1 | 0<br>- | **9** |
| *Juncus acutus (92D0, 6420, 72A0)* | 1 | 2 | 6 | 6 | 0<br>--- | **15** |
| *Phragmites australis (92A0, 92D0, 72A0)* | 2 | 4 | 7 | 9 | 1<br>--- | **23** |
| *Pulicaria dysenterica (72A0)* | 2<br>+ | 1 | 2 | 2 | 0<br>- | **7** |
| *Echinochloa crus-galli (72A0)* | 2<br>++ | 1 | 0 | 0 | 0 | **3** |
| *Paspalum paspalodes (72A0, 3290)* | 3<br>++ | 2 | 1 | 0 | 0 | **6** |
| *Cyperus fuscus (3290)* | 2<br>++ | 1 | 0 | 0 | 0 | **3** |

The relations between potential TS and aquifer depth in summer can be locally verified using these ecological profiles:

- Unit 4, relied with 3290 type, is bounded with the moistest soils and the Species that forms it can be chosen as TS for this habitat type.
- 72A0 does not correspond precisely with soil moisture in our study area because a large population of its most TS, as reed (*Phragmites australis*), is on the Koronia lake's shore, which is subject of desiccation, and shows relative adaptation to this factor. The number of TS for 72A0 should be restrained to those of the unit 3 for our study area.
- *Vitex agnus castus*, which characterizes 92D0 habitat type in all the Natura 2000 web, is founded here mostly on the less moist soils upon newer geological deposits (not older than tertiary)

Ecological groups [11], [8], which are groups of Species that have the same profile for a variable, can differentiate habitat types or habitat variants, or contribute to several types, as vegetation units. In our case the salinity can explain one variant of 92D0.

*Table 5: Ecological profile of Species for the soil's reaction on HCl*

| Soil's reaction on HCl | No | Weak and brief | Weak and long | Strong and brief | Strong and long | No data | Total of relevés |
|---|---|---|---|---|---|---|---|
| **Presences of the classes** | **23** | **6** | **10** | **9** | **14** | **4** | **66** |
| **Species** | **Presences of the Species** | | | | | | **Total presences of the Species** |
| *Vitex agn. castus (92D0)* | 9<br>+ | 2 | 1 | 0 | 0<br>- | 2 | **14** |
| *Rubus ulmifolius (92A0, 92D0)* | 10 | 5<br>++ | 1 | 4 | 0<br>-- | 0 | **20** |
| *Scirpoides holoschoenus (92D0, 6420, 72A0)* | 6 | 2 | 1 | 3 | 0<br>- | 2 | **14** |
| *Tamarix parviflora (92D0)* | 5 | 3 | 2 | 5<br>+ | 2 | 0 | **17** |

*Tamarix parviflora* invades the argillic Koronia lake's bottom, that has been exposed when water level was restricted. Soil's salinity is explained by evaporation of alcalic water and concentration of salt on the soil's surface. Soils with more stable water dynamics, like the Volvi lake shores, support less resistant to salinity plants such as *Rubus ulmifolius*, characteristic of 92A0 and 92D0, according to the [13] database. *Vitex agn. castus* shows, in the abovementioned profiles that soil salinity can explain the existence of a 92D0 variant with this plant as characteristic. The following profiles completes the definition of this variant.

*Table 6: Ecological profile of Species for the geologic substrate*

| Geological substrate | New soil | Lacustrine sediments | Other quaternary deposits | Tertiary deposits | Total of relevés |
|---|---|---|---|---|---|
| **Presences of the classes** | **33** | **7** | **16** | **5** | **66** |
| **Species** | **Presences of the Species** | | | | **Total presences of the Species** |
| *Vitex agn. castus (92D0)* | 4<br>- | 1 | 5 | 4<br>+ | **14** |
| *Scirpoides holoschoenus (92D0, 6420, 72A0)* | 12<br>++ | 1 | 1 | 0 | **14** |
| *Tamarix parviflora (92D0)* | 13<br>++ | 1 | 3 | 0 | **17** |

New soil concerns either new exposed lake's bottom or new deposits from estuaries since the 1970' decade. The above ecological profiles confirm the need of a variant with *Vitex agn. castus* for 92D0.

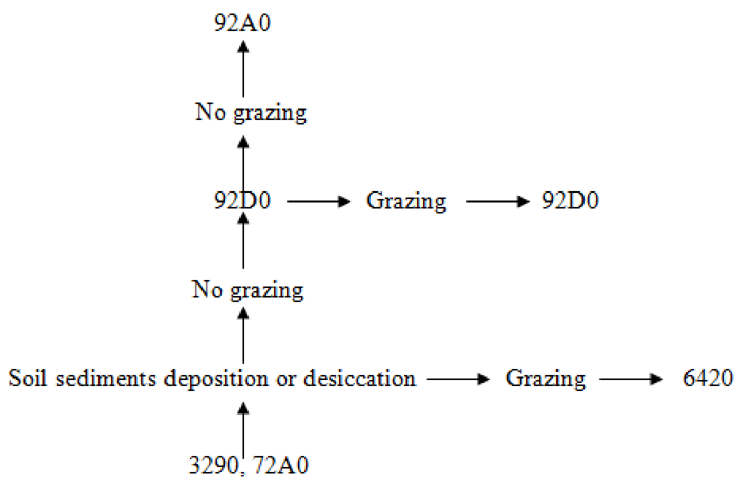
Another very important variable for the signification of vegetation units is the intensity of grazing estimated by its effect on the vegetation's structure.

*Table 7: Ecological profile of Species for the intensity of grazing*

| Intensity of grazing | No grazing | Not restrain veg. dynamics | Restrain without veg. structure change | Change veg. structure | Total of relevés |
|---|---|---|---|---|---|
| **Presences of the classes** | **16** | **27** | **21** | **2** | **66** |
| **Species** | **Presences of the Species** | | | | **Total presences of the Species** |
| *Cynodon dactylon (6420)* | 2<br>-- | 10 | 17<br>+++ | 1 | **30** |
| *Juncus acutus (92D0-6420-72A0)* | 3 | 4 | 8<br>+ | 0 | **15** |
| *Cichorium intybus (6420)* | 1<br>- | 8 | 8 | 1 | **18** |
| *Phragmites australis (92A0-92D0-72A0)* | 5 | 13<br>+ | 5 | 0 | **23** |
| *Aristolochia clematitis (92A0-92D0)* | 3<br>+ | 0 | 1 | 0 | **4** |
| *Urtica dioica (92A0)* | 7<br>+++ | 0<br>- | 1 | 0 | **8** |

The table above shows two types of profiles. *Aristolochia clematitis* and *Urtica dioica*, that grow under the shadow of the 92A0's trees or the 92D0's bushes, are significantly bonded with no evidence of grazing, when *Cynodon dactylon, Juncus acutus* and *Cichorium intybus*, characteristics of the 6420 habitat type, are significantly bonded with grazed meadows. We remark that *Phragmites australis* is bonded with a weak intensity of grazing. For the above-mentioned reasons, the TS proposed locally for 6420 (humid grasslands) are *Cynodon dactylon, Cichorium intybus,* and *Juncus acutus* because they indicate that grazing is going on. Grazing maintains the vegetation low, aborting trees or high shrubs' growth, that in turn maintains enough light for the grass. It is urged upon that *Cynodon dactylon* is significantly negatively bonded with more than 70% trees cover.

Better knowledge of the relationship between TS, structure and function of the habitats allowed us to propose an algorithm of habitat dynamics in the Volvi and Koroni lakes national Park [1], as follows. Under the hydrologic and edaphic dynamics of the study zone, grazing is the most important factor.




## 4 Conclusions

The phyto-ecological method allowed us to indicate a small amount of Typical Species for habitat types in order to check their population parameters in each field plot, based on local relationship, not only between the Species but also between the Species and habitats' structure and function variables. Using this method and these variables help tightening the relationship between the "parameters" of assessment, that are the Typical Species, the structure of the habitat, (which is not only based on vegetation in our method), and the functions where factors such as grazing or of soil dynamics are important. It looks good to have a small number of TS, given the known relationship between them and the Habitat's structure and function, for Habitat assessment efficiency and time saving.

Assessing habitat with locally efficient structure and function variables allows better knowledge on future prospects, pressure and threat and, at last, site monitoring.

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