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Southern Aegean indicator values – Derivation, application and perspectives.

N. Böhling
Institute of Landscape and Plant Ecology, University of Hohenheim, Stuttgart, Germany

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ABSTRACT: Ecological indicator values have been derived for the vascular plants of the southern Aegean island arc comprising Kythira, Crete and the surrounding islets, the Karpathos archipelago and Rhodos (Greece). The derivation of these values follows a modified, more objective and more universal Ellenberg approach in evaluating the ecological amplitudes of plants. The evaluation concerns the climatic and edaphic eco-factors light, temperature, continentality, moisture, soil reaction, nutrient supply and salt tolerance. Details on indicator value quality are also given. 2442 taxa (species, subspecies and a few varieties) have been classified for the first time in this manner. The set of variables provides a compact ecological characterization of the floristic elements and brings ecological specialization of plants to an operational mode. Various methods of calculating average indicator values, indicator values spectra and other approaches in combination with plant or vegetation mapping would aid effective site and vegetation classification as well as environmental monitoring. Indicator values are valid only for the area they are defined for; with the exception of the S Aegean continentality values which are plant specific. Indicator values provide a useful tool for research in theoretical as well as in applied sciences.

1 ECOLOGICAL INDICATOR VALUES: A BRIEF OVERVIEW

Ecological indicator values (EIV) are a successful tool in ecological research and planning. The underlying basic principle is that the occurrence of plants as well as their distribution is determined by site factors, and not random. Plant taxa are not evenly spread over a spectrum of ecological conditions. They have "preferences" or show ecological presence ranges (Schubert 1985) for special site factors such as moisture or nutrient supply. The ecological amplitude varies from one plant species to another as well as from one site factor to another. Taxa with a very broad amplitude possess no indicator properties whereas those with a narrower range have better indicator properties. When such an indicator property is detected an indicator value can be assigned. Indicator value scales for indicator plants' behaviour range normally from 1 to 5 or from 1 to 9 (max. 12). The lower values represent low intensities of a site factor, for example, for plants of dry or nutrient-poor sites; the upper values higher expressions of this site factor, for example wet or nutrient-rich sites. Plants with a very broad amplitude are classified as "indifferent" indicated by "x" in the EIV tables. The ecological behaviour of plants is evaluated mainly for light (growing more or less in shade or sun), temperature (plants in cold to warmer sites), continentality (plants of eu-oceanic to eu-continental climate), moisture (plants of dry to wet and aquatic sites), reaction (plants of acid to

Table 1: EIV systems on vascular plants worldwide (references in Böhling et al. 2002).

Ellenberg (1950, 1952, 1974, 1979, 1991, 1992)	Central Europe
Zolyomi (1967), Borhidi (1993, 1995)	Hungary
Landolt (1977)	Switzerland
Kovacs (1979)	Romania
Zarzycki (1984)	Poland
Loopstra & van der Maarel (1984)	Netherlands
Vevle (1985)	Norway
Frank, Klotz & Westhus (1989, 1990)	former GDR (East Germany)
Klinka, Krajina, Ceska & Scagel (1989)	W British Columbia, Canada
Jurko (1990)	Czechoslovakia
Pülschen (1990)	Ethiopia
Karrer & al. (1990 – 1992), Karrer & Englisch (in prep.)	Austria
Böhling (1994, 1995)	Naxos, Greece
Mayor-Lopez (1996, 1999)	Asturias, Spain
Hill, Mountford, Roy & Bunce (1999)	Great Britain, Ireland
Böhling, Greuter & Raus (2002)	Southern Aegean, Greece
Godefroid (in prep.)	Spain

basic soils/waters), nutrient supply (plant species in nutrient-poor to nutrient-rich conditions) and salt tolerance (halophobic to eu-haline plants). Such EIV have been derived by ecological observations in the field and measurements of site factors. The plant taxa have been ordinated along ecological gradients: plants occurring (only or are centred) at the lowest intensity of a site factor have been given an EIV 1, the next group an EIV 2, the following an EIV 3 and so on, to for example a value of 9 (12) for a group of plants found at the highest intensity of a site factor. These are relative scales and the indicator values are relative numbers.

This method of deriving EIV was first applied by Heinz Ellenberg who was encouraged by Heinrich Walter to begin such a task. From 1950 onwards Ellenberg published several EIV lists for Central Europe comprising more and more plant groups and species. Parallel to or following Ellenberg's approach several EIV systems arose, particularly in Central Europe but also in some regions of North America and Africa (Table 1). They vary in the number of evaluated species, the size of the base area, the site factors considered and the extent of the EIV scales. With some exceptions they are individual systems valid for the flora of one particular area and the contents (definitions) of EIV figures cannot be used or transferred from one country to another. Nevertheless they have some scientific and practical value (see e.g., Böcker et al. 1983, Böhling et al. 2000).

Using EIV the empirical and experimental knowledge on the ecological behaviour of plants is transferred into a compact form, usually expressed as a data table or file. It can be used for calculations, e.g., for a relevé or a set of plants the mean EIV can be calculated by simple averaging of the EIV of all plants observed. Mean EIV reflect the ecological site conditions. One sample can be compared with others. The flora of one year can be compared with that of another. On the basis of a large number of samples with calculated mean EIV a mapping of site conditions is possible. Abundance values can be considered by calculating weighted means. EIV spectra showing the different rates of each EIV of a sample also allow comparative analysis (see examples in Ellenberg 1991, 1992).

For practical purposes some points have to be considered. "Ecological" IV stand for indicator values representing the behaviour of a species in nature, i.e., field conditions. This can be very different from the "physiological" behaviour exhibited after the exclusion of competitors (e.g., in pot cultivation under green-house conditions). Under conditions of cultivation many plants are able to grow at a broader spectrum of site qualities or show preferences for more moderate intensities. However, under natural conditions their broad physiological amplitudes are constricted and the centre could be displaced or divided by competitive species. Ellenberg (1991, 1992) had commented that the more saturated and balanced a plant community is, the better are the indicator functions of the plant set.

As competition plays a role for the design of the ecological amplitudes EIV are generally valid for the spatial unit they are derived for. Changes in competitor composition and abiotic site conditions (different climate or soils) might lead to a diverging ecological amplitude and thus to other EIV. Although most EIV are transferable to neighbouring regions judicious application is certainly necessary in applying them outside the base area.

The S Aegean indicator value (SAIV) system (Böhling et al. 2002) differs in some aspects from traditional systems.

2 INVESTIGATION AREA: THE SOUTHERN AEGEAN

The term "Southern Aegean" refers to the area of the southern Aegean island arc between the Greek Peloponnese in the west and the Turkish Marmaris peninsula to the east. It is a relict of an old land bridge between Europe and Asia, now broken up into several islands and islets. The Southern Aegean Indicator Values were prepared for the following islands and island groups: Kythira, Crete and surrounding islets, the Karpathos archipelago and Rhodos.

The investigated flora comprises 2442 taxa (including subspecies and a few varieties) of vascular plants belonging to the southeastern part of Europe which has one of the hottest and driest climates in the continent. Semi-arid elements are represented especially in SE Crete and SE Karpathos (*Lygeum spartum, Suaeda palaestina, Zygophyllum album*). Phrygana vegetation is widespread, with relicts of and secondary successions to *Olea-Pistacia lentiscus* and other evergreen broad-leaved vegetation, e.g., *Arbutus unedo, Quercus ilex, Q. coccifera* and *Phillyrea latifolia*. Scale- and needle-leaved evergreens are represented by *Juniperus phoenicea, J. oxycedrus* subsp. *oxycedrus* and *J. oxycedrus* subsp. *macrocarpa*, whereas deciduous trees are centred mainly in western Crete (*Fraxinus ornus, Quercus pubescens*). *Pinus halepensis* and *Cupressus sempervirens* as well as *Phoenix theophrasti, Platanus orientalis* and *Liquidambar orientalis* form scattered woodland. Above tree-line wind-swept *Astragalus* dwarf shrub vegetation dominates at temperatures similar to those in Central European mountains at moderate altitudes (e.g., in central Germany). Measured annual precipitation may exceed 2000 mm in special relief situations in the mountains of western Crete, and be less than 300 mm on the southern side. The Martonne humidity index varies between 10 and 82 (Böhling & al. 2002). As compared with this climatic diversity the diversity of soil conditions is relatively restricted. Calcareous and dolomitic substrates dominate whereas siliceous rocks are rare.

The southern Aegean has been investigated by the Berlin-Botanical-Museum work group (W. Greuter, Th. Raus and others) for nearly four decades. This particular project on derivation of indicator values was carried out between March 1997 and December 2000; it was mainly funded by the DFG (Deutsche Forschungsgemeinschaft) and supported by Heinz Ellenberg who passed away in spring 1997.

3 METHODS AND RESULTS

The Southern Aegean indicator value (SAIV, see Table 2) system follows Ellenberg's EIV (EEIV) system by evaluating the same eco-factors: light, temperature, continentality, moisture, reaction, nutrients and salt. Also the SAIV are relative numbers used on a relative scale. In a few cases the scale ranges for SAIV are nearly identical with those of the EEIV, in other cases the ranges had to

Table 2: Section of the SAIV Table comprising indicator values of the first 10 taxa (total 2442)

Species	L	T	K	F	R	N	S	Family
Abutilon theophrasti	6	8	6	5	7	8	1	Malv
Acantholimon androsaceum *[A. echinus subsp. creticum, A. ulicinum]*	9	2	4#	4	7	4	0	Plum
Acanthus spinosus	7	8°	5	4	x	7	0	Acan
Acer sempervirens *[A. creticum, A. orientale]*	(5)	x	4#	5	7	4	0	Acer
Aceras anthropophorum *[Orchis anthropophora]*	7	6°	3	4	7#	4	0	Orch
Achillea cretica	8	8	5#	3	8	6	3	Aste
Achillea ligustica	?	7	3#	?	5	?	0	Aste
Adiantum capillus-veneris	4	7°	3	8	7	2	0	Adia
Adonis annua subsp. cupaniana	8	8	6	4	7	6	0	Ranu
Adonis microcarpa subsp. cretica	8	8	5#	3	8	7	0	Ranu

be increased as there were site qualities in the Southern Aegean not occurring in Central Europe (e.g., temperature, aridity).

Special attention was paid to a more comprehensive definition of the indicator figures bearing in mind that Ellenberg's approach was consciously and deliberately for a greater part, a heuristic one. "Heuristic" is here used in the sense of not over-estimating the opportunities of technical measurement for ecological variables, but to trust in an ecological "sense" to obtain values from observations as well as realistic measurements. Many factors vary with time (e.g., precipitation, salt influence) and a period of study of only three years may not be representative. Some parameters such as seepage or water balance in deep substrate zones are not measurable in solid/karstic substrates at all. To adopt a laboratory approach rigorously would mean to install numerous and diverse sensors around numerous plants at different elevations and depths for a long period. This is obviously unrealistic. For practical use a reduction of all potential parameters for one factor on one simple key value (as an EIV) is usually adopted by many applied researchers. Ellenberg emphasized clearly that EIV are tools for orientation and do not replace measurements.

Much environmental data have been considered for the derivation of SAIV (for details see Böhling et al. 2002) to increase objectivity of the scales and indicator figures as well as of EIV assignments. 406 stands have been studied floristically and ecologically including soil sampling. At the LUFA (Landwirtschaftliche Untersuchungsanstalt), Karlsruhe, the samples were analysed in greater detail. Climatic data was obtained from the Greek Meteorological Service and the Agricultural Service of Crete. Phenological observations from three years in the field were integrated. More than 6000 plant specimens have been collected for later study, some proved new to science.

All data were registered in a computer database to allow easy access and further analysis especially to detect the width of the ecological amplitudes and the centres of ecological occurrence.

The choice of relevé locations followed a vegetation and site type approach rather than at random. Knowledge of the characteristics of a site/vegetation *type* permits an evaluation of similar sites by simple transfer of information. More than 125,000 plant data were correlated with soil data. In some cases species distribution maps and climatological maps were interpreted.

The term indicator "figure" is used for the abstract numbers characterizing the ecological behaviour in the definitions. Indicator "value" means a specific number for an individual taxon and an evaluated eco-factor.

Improvement in defining indicator figures involved specific parameters especially in the case of temperature figures (annual mean air temperature in 2 m above ground), continentality figures (plant distribution and humidity maps of Jäger (1968), moisture figures (a complex of water balance variables), reaction figures (pH($CaCl_2$) of the upper soil layer) and nutrient figures (C/N and C/P ratios and K availability).

In addition, characteristic *indicator ecological species groups* (IESG) were compiled to define indicator figures. These were important especially for the additional restriction of light figures and the salt figures where detailed measurements of variables have not been carried out or which proved unpractical. On the other hand, such IESG allow experienced phyto-ecologists to retrace the SAIV definitions, to comment on existing SAIV classifications (reliable or less reliable values) and to propose values for hitherto unevaluated taxa. The full lists of IESG are given in Böhling & al. (2002).

In several cases members of IESG are plants also occurring in Central Europe. When the *shared plants'* behaviour in the S Aegean was similar to that in C Europe they were used for connecting the scales of EEIV with SAIV. Besides Ellenberg's values (1991, 1992) those of Hill & al. (1999) and Borhidi (1995) were also utilized.

The *quality of SAIV assignment* depends on the database for the evaluation. For some very rare plants no SAIV have been given (indicated by *?*) or only in *small font* reflecting less reliable SAIV. If a taxon owns no indicator properties because for example the amplitude is too broad, it was classified as indifferent (*x*) with respect to the eco-factor considered.

The *indicator quality* of a SAIV is for the remaining taxa different. The assignment of a SAIV depended on the specific ecological amplitude, its width and peak, and the width of the indicator figure definition. The indicator figure definitions are relatively broad to enable a SAIV designation for many taxa (e.g. R-figures). In many cases the real amplitude of a taxon is much narrower than the definition and clearly within its limit -- thus a (medium) good indicator quality is said to exist. Particularly good or weaker indicator qualities were marked # or ° (the medium indicator quality is left unmarked). Such extensions have not been given in any previous EIV system. However, they provide additional information. In EIV-based investigations they can be useful in species-poor, unsaturated samples by excluding the less reliable EIV and those with weaker indicator quality.

3.1 *Light figures (L)*

The light figures scale is the least altered of all scales as compared with the EEIV system (Table 3). As in the EEIV system it ranges from L1 to L9. Measurements of relative light intensity (at place where a plant was growing compared to in an unshaded neighbouring area) were omitted as they are relative values not universally transferable to the S Aegean. A plant of high mountains growing in full sun receives more light (intensity) than a plant from lower altitudes. Field experience proved sufficient to carry out a relative ordination against a gradient of increasing (absolute) irradiance. The definitions of Ellenberg's light figure scale were thus somewhat changed whereas the values of the shared species could have been transferred unchanged or slightly modified. However, L9 was reserved for full light species of high altitudes above condensation level and those of insolation-rich southern exposed areas near the sea with occasional cloud cover and high reflection. Full light species of the remaining macro habitats were classified L8.

Since the behaviour in young trees, especially seedlings and saplings, differs markedly from that in old trees, L-figure is an expression of the behaviour in young plants. This is formulated, as in EEIV, by the inclusion of brackets around the L-value.

3.2 *Temperature figures (T)*

T-figures were defined by Ellenberg based on the phytogeographical distribution of a species and its occurrence in thermal eco-zones. For the SAIV system (Table 4) Ellenberg's proposal (Ellenberg 1991, 1992) to use mean annual air temperature values for the definition of the T-figures was adopted and further elaborated. By these temperature values (T) nine temperature classes (t) were defined and corresponding T-figures assigned (Fig. 15 in Böhling et al. 2002). Ecological amplitudes of different width (and indicator quality) were considered: an ecological behaviour not ex-

Table 3: SAIV light figures

L	Description	Typical plant (example from IESG)
1	plant in deep shade	not occurring in the S Aegean
2	plant strictly in shade (e.g., in dense *Castanea sativa* woods, dense macchie and at cave entrances)	*Asplenium scolopendrinum* subsp. *antri-jovis*
3	shade plant, but also in more lit places	*Athyrium filix-femina*
4	semi-shade to shade plant, not in full light	*Adiantum capillus-veneris*
5	semi-shade plant, neither in full light nor in deep shade	*Geranium lucidum*
6	semi-shade to semi-light plant, not in deep shade but eventually in full light (e.g., many chasmophytes growing at N-exposition at lower altitudes)	*Carex otrubae, Allium arche-otrichon*
7	semi-light plant, generally in well lit places, but also in moderate shade (e.g., phrygana plants with moderate shade tolerance; plants growing below phrygana shrubs; ruderals in semi-shade of olive groves; many chasmo-phytes growing in S-exposition at lower altitudes	*Aegilops biuncialis* subsp. *biun-cialis, Carum multiflorum*
8	light-demanding plant, in well lit places (e.g., phrygana plants without shade-tolerance; full-light plants of lower altitudes)	*Brassica geniculata (Hirschfeldia incana)*
9	plant in full light, found only in full sun, e.g., in high mountains and insola-tion-rich south exposed areas near sea (reflection of irradiance)	*Acantholimon androsaceum, Zy-gophyllum album*
x	indifferent; plant with an amplitude ranging from full light to shade, or without any centre of occurrence concerning the light factor	*Arisarum vulgare*

ceeding one t-class led to a T-value marked #, an amplitude comprising up to two adjacent t-classes resulted in a T-value without extension, and an amplitude reaching over up to five t-classes was marked by a °. In the case of asymmetric amplitudes the peak of the amplitude was taken for T-value allocation as well as for the other EIV (Fig. 16 in Böhling et al. 2002).

For practical purposes the temperature values were correlated with altitudinal ranges and direction of slope (N-facing, intermediate or S-facing sites) due to the asymmetric island climates. This was achieved by interpretation and interpolation of meteorological data (Fig.15 in Böhling et al. 2002). Additionally, special micro-climatic conditions, e.g., cold air sinks (doline or polje situations), were considered via a rise or reduction (one unit) of the basic T-value.

The T-figures scale comprises 9 classes as in the EEIV system but the definitive content is somewhat different. There was the possibility of connecting and adapting the scales by correlating the mean annual temperature. The S Aegean T-Fig. 1 thus corresponds to a C European T7.

Table 4: SAIV temperature figures

T	Short description (data on vertical distribution given here concern average sites (Fig.15 in Böhling & al. 2002)	Typical plant (example from IESG)
1	plants of cool sites; mean annual temperature < 8,5 °C; centre of occurrence over 1950 m (max. 2456 m) a.s.l.	*Peucedanum alpinum*
2	plants of cool to fairly warm sites; mean annual temperature c. 9,5 °C; centre of occurrence between 1700 and 1950 m a.s.l.	*Astragalus angustifolius* s.str.
3	plants of fairly warm sites; mean annual temperature c. 11 °C; centre of occurrence between 1400 and 1700 m a.s.l.	*Berberis cretica* °
4	plants of fairly warm to warm sites; mean annual temperature c. 12,5 °C; centre of occurrence between 1150 and 1400 m a.s.l.	*Zelkova abelica*
5	plants of warm sites; mean annual temperature c. 14 °C; centre of occurrence between 850 and 1150 m a.s.l.	*Origanum microphyllum*
6	plants of warm to fairly hot sites; mean annual temperature c. 15,5 °C; centre of occurrence between 600 and 850 m a.s.l.; many Mediterranean-sub-Mediterranean species	*Quercus ilex*
7	plants of fairly hot sites; mean annual temperature c. 17 °C; centre of occurrence between 300 and 600 m a.s.l.; many (eu-) Mediterranean and Mediterranean-Atlantic species	*Pistacia terebinthus*
8	plants of fairly hot to hot sites; mean annual temperature c. 18,5 °C; centre of occurrence between 50 and 300 m a.s.l.; many (thermo-) Mediterranean species	*Juniperus phoenicea*
9	plants of hot sites; mean annual temperature c. 20 °C and more; centre of occurrence between 0 and 50 m a.s.l., mainly in southern Crete and the southern offshore islets; many southern Mediterranean and N African species	*Periploca angustifolia*
x	indifferent, with a too broad ecological amplitude and thus having no indicator function; many Eurasian and cosmopolitan species	*Euphorbia acanthothamnos*
#	plants with particularly narrow ecological amplitude comprising only the corresponding t-class	
°	plants with broader ecological amplitude comprising up to five t-classes (such T-values should be interpreted cautiously)	

3.3 *Continentality figure (K)*

The continentality figure K, an abbreviation of the German "Kontinentalität", reflects the width of temperature amplitudes and (climatic) moisture of a site. Continentality is a complex factor. In Europe continentality generally increases with greater distance to the ocean and from west to east. Ellenberg used Jäger's classifications of the plants' occurrence under different continental and oceanic conditions (in Rothmaler et al. 1972). These however, are not available for the S Aegean. The method of deriving the K-values for the SAIV system was to use Jäger's (1968) European and world maps on phytogeographical continentality (oceanity) and to compare these with the total distribution of the taxa to be evaluated. The latter was obtained from literature and herbarium data as well as personal field observations. After defining the K-figures, the range and the centre of specific plant occurrence was detected by comparing the continentality map and species distribution. Again, different indicator qualities were separated: an ecological behaviour complying with the bold lined range (Fig. 17 in Böhling et al. 2002) means a good indicator quality marked by #, the standard lined area means medium indicator properties; including the dashed area results in an extension ° denoting low indicator quality. Some endemics occur under very special local climatic conditions not displayed on large-scale continentality maps. On these small scale levels phenological data, local meteorological data and plant associations were used to adjust the basic classifications. The K-values are the only indicator values in the SAIV system that are plant (taxon) specific and so are generally valid also outside the S Aegean (Table 5).

Table 5: SAIV continentality figures

K	description	typical plant (example from IESG)
1	extreme oceanic: oz1-(2) (extreme Atlantic plants)	*Woodwardia radicans*
2	oceanic: oz1-(3) (Atlantic-subAtlantic plants)	*Anagallis tenella*
3	euryoceanic: oz1-3 (e.g. Atlantic-west Mediterranean plants)	*Aira elegantissima* subsp. *elegantissima*
4	suboceanic: oz1-k(1) (many Mediterranean-W European and S Aegean plants)	*Arbutus unedo*
5	weakly suboceanic – weakly subcontinental: oz(1)-k(1) (most of the omni-Mediterranean and most of the omni-Aegean plants)	*Pistacia lentiscus*
6	subcontinental: oz(1)-k1 (many Mediterranean to weakly Oriental and SE Aegean plants)	*Cupressus sempervirens*
7	eurycontinental: oz2-k1 (many E Mediterranean-Oriental plants)	*Lygeum spartum*
8	continental: oz(2)-k1 (many S Mediterranean to Saharo-Sindian and E Mediterranean-Irano-Turanian plants)	*Zygophyllum album*
9	extreme continental: oz(3)-k1 (Saharo-Sindian and Irano-Turanian plants)	*Suaeda palaestina*
x	indifferent, not classified (following fig. 17 in Böhling & al. 2002)	*Phragmites australis*
#	plants with narrow ecological amplitude covering the core area of the definition only (bold line)	
°	plants with broader ecological amplitude (to dashed line)	

3.4 *Moisture figures (F)*

Water supply is one of the most important ecological factors in Mediterranean-type ecosystems. The delimitation and definition of moisture (German: "Feuchtigkeit") figures was based on a landscape ecological water balance approach considering climatic aridity/humidity and soil water balance (Table 6). The S Aegean F-figures are comparable with the Ellenberg figures as demonstrated by shared taxa. However, because of the higher aridity in some places of the S Aegean a F-figure 0 was included with the 12 F-figures of Ellenberg. So, the SAIV system's F-scale ranges from 0 to 12. If ecological amplitudes comprise more than three and less than six F-Figure core definitions their indicator quality was classified as weak (°).

Table 6: SAIV moisture figures

F	Description	Typical plant (example from IESG)
0	Indicator of extremely dry sites; exclusively on driest (shallow soil with low field capacity) substrates without water inflow at precipitation-lowest, potential evaporation-highest sites in the southern, xero-thermo-Mediterranean zone; many plants with mainly N African or SW Asian distribution; not occurring in C Europe	*Periploca angustifolia*
1	Indicator of very dry sites; especially on dry, thermo-Mediterranean substrates in regions with highest aridity	*Lithodora hispidula*
2	Indicator of very dry to dry sites; widespread on drier (low field capacity and no additional water supply at moderate climatic humidity), thermo-euMediterranean substrates	*Juniperus phoenicea*
3	Indicator of dry sites; on moderately moist, thermo-euMediterranean and drier, montane-oroMediterranean substrates	*Pinus halepensis* subsp. *brutia*
4	Indicator of dry to fresh sites; on more moist, thermo-euMediterranean and moderately moist, montane-oroMediterranean substrates, also on temporarily inundated, thermo-Mediterranean substrates	*Quercus coccifera*
5	fresh-sites indicator; at moderately developed, temporarily wet places, in poorly irrigated land, on more moist, montane-oroMediterranean substrates	*Quercus ilex*
6	Indicator of fresh to damp sites, on moderately moist sites; on moderately wet to fluctuating-wet places, on winter-wet, summer-dry substrates, at early-summer-dry (spring-) rivulets and early-summer-dry springs	*Fraxinus ornus*
7	Dampness indicator, on moist sites; on longer term moist to wet places, on springtime-moist, somewhat summer-dry sites and on springtime-wet, summer-dry sites	*Castanea sativa*
8	Indicator of damp to wet sites, on very moist sites; at springtime-wet, somewhat summer-dry to summer-moist places	*Salix alba*
9	Wet site indicator; on long-term waterlogged substrates without or with poorly developed summer drought	*Hypericum hyrcinum* subsp. *albimontanum*
10	Semi-aquatic plants; plants inundated for a long period from winter to early summer but becoming dry in aerial parts in summer, e.g., Litorelletea-plants	*Alisma lanceolatum*
11	Emerged aquatic plant; plant rooting under water, but at least temporally exposed above the water level (emerging), or plant floating	*Cladium mariscus*
12	Submerged aquatic plant; permanently or almost constantly under water	*Ceratophyllum demersum*
x	Indifferent: plants with a broad moisture amplitude too broad (more than five F-figure core definitions) for assigning F-values	*Pistacia lentiscus*
°	Plants with low indicator quality, but not indifferent: amplitude comprising four to five adjacent F-figure definitions with the peak as its F-figure.	

3.5 *Reaction figures (R)*

Soil reaction can be measured in different ways and the results vary. For the development of the SAIV system it was decided to use the pH ($CaCl_2$) of the uppermost soil layer (at 0.5 to 5 cm depth). More than 11,800 plant data were linked with these pH values. Ellenberg's reaction scale was redefined by using concrete pH ($CaCl_2$) values for the delimitation of each R-figure. This made the evaluations even more comprehensive. The range of the SAIV scale is the same as for C Europe but R-figure 9 was reserved for plants on basic soils only, which is from the ecological point of view very important (Table 7). It should be noted that the upper solum of calcareous substrates may be free of carbonates. Consequently such plants were evaluated with R7 to R5 and not classified as lime indicators (R9). The uppermost soil layer is a stratum, which has to be passed by nearly every plant during its life span.

As siliceous substrates are rather rare in the S Aegean, acid sites and acidity indicators are not represented in the SAIV although they might be growing on such sites in other regions. Detailed descriptions of R-figure 1 to 4 await further studies preferably in other parts of Greece or Turkey.

Table 7: SAIV reaction figures

R	Description	Typical plant (example from IESG)
1	indicator of extreme acidity, never found on weakly acid or basic soils (plants only at pH <6, center at pH 3.0 - 4.9)	no example
2	between 1 and 3	no example
3	acidity indicator, mainly on acid soils, but exceptionally also on nearly neutral soils (plants on soils with pH <7, exceptionally to pH 6.5 - 7.5, center at c. pH 5)	no example
4	between 3 and 5	no example
5	indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils; plants on soils with **pH 5 - 6.5** (in the area: 5.5 - 6.5; Ellenberg (1992: 69): pH 5.0 - 5.9!), rarely also at pH 4 or 8, centre at pH 5,5 - 6,1	*Erica arborea*
6	indicator of weakly acid conditions, plants at **pH 6 - 6.9**, or centre at pH 6.2 - 6.8	*Zelkova abelicea*
7	indicator of weakly acid to weakly basic conditions, never found on very acid soils: plants at **pH 6.5 - 7.5**, rarely down to pH 5, or centre at pH 6.9 -7.1	*Acer semper-virens*
8	indicator of weakly basic conditions, mostly indicating basic soils, centre at pH 7.2 - 7.6 or only on soils with **pH 7.1 - 7.6**	*Vitex agnus-castus*
9	lime indicator, always found on basic soils with **pH > 7.6** (highest pH in the area 8.9)	*Stipa capensis*
x	indifferent: plants with an ecological amplitude too broad to allow assignment of a R-figure; occurring at moderately acid to alkaline conditions without showing any centre	*Genista acantho-clada*
#	good indicator quality: narrow ecological amplitude corresponding to proper-ties highlighted in bold	

3.6 *Nutrient figure (N)*

Ellenberg's N-figure scale was adopted after specifying the N-figure definitions by data of carbon-nitrogen ratio (C/N), carbon-phosphorus ratio (C/P) and total phosphorus content (P_2O_5). The results are shown in Table 8. Ordination along a preliminary nutrient gradient, plant morphological properties, shared species comparisons with EIV systems from other countries (Britain and Hungary) and re-classification after checking correlations with nutrient parameters were used to develop the S Aegean N-figure scale. Soil data exist for c.12,000 plant records. Potassium proved to have no clear correlation with productivity.

Table 8: SAIV nutrient figures

N	Description	Typical plant (example from IESG)
1	indicator of sites extremely poor in nutrients; on soils with very high C/N ratio (17 - >20)	*Arbutus unedo*
2	between 1 and 3	*Calicotome villosa*
3	indicators of sites more or less poor in nutrients; on soils with high C/N (13 - 14) and high C/P (>2)	*Coridothymus capitatus*
4	between 3 and 5	*Sarcopoterium spinosum*
5	indicator of sites with intermediate nutrient supply; centre of occurrence on soils with moderate C/N (10 - 13) and moderate C/P (~1), not found on very nutrient-poor nor very nutrient-rich soils	*Castanea sativa*
6	between 5 and 7	*Ammophila arenaria*
7	indicator of sites more or less rich in nutrient; on soils with narrow C/N (8 - 11) and mostly narrow C/P (<1)	*Oxalis pes-caprae*
8	indicator of sites rich in nutrients; on soils with narrow C/N (8 - 11) and always narrow C/P (<1)	*Malva sylvestris*
9	indicator of extremely rich situations (such as cattle resting places and near polluted rivers); on soils with low C/N, low C/P and higher P content (>6,0 mg P_2O_5/100 g)	*Chenopodium murale*
x	indifferent: plants with broad ecological amplitude concerning nutrient supply	*Pistacia lentiscus*

3.7 *Salt figures (S)*

Salt figures were derived for the S Aegean by detecting the haline (saline) properties of site types (Table 9). This approach using site types and the species' amplitudes and centres over these site types resulted in IESG for further delimitation of S-figures. Chloride contents have been measured in laboratory and served as a basis for preliminary site classification, but for a persistent scaling of S-figures they were insufficient. Salt stress is a function of intensity and duration and varies extremely in space and time.

Ellenberg's S-scale ranging from 0 to 9 was adopted but without accepting the definitions via Cl^- concentrations. After comparison of shared species and plant eco-morphological features the single S-figures were delimitated ecologically on site.

Table 9: SAIV salt figures

S	Description	Typical plant (example from IESG)
0	halophobe (glycophyte); absent from saline sites because not supporting salt, if in coastal situations, only accidental	*Acantholimon androsaceum*
1	slightly halo-tolerant; mostly at sites free from salt, rarely on saline ones (e.g., at moderate salt-spray input)	*Sarcopoterium spinosum*
2	moderately halo-tolerant or oligohaline; found at saline and non-saline sites but saline ones predominant or at sites with low concentration of chloride or with short-term low salt stress	*Imperata cylindrica*
3	very halo-tolerant or slightly mesohaline; mostly at salt-influenced coastal sites but also at non-saline sites, under frequent aero-haline stress during storms (many plants of drifting coastal sand)	*Ammophila arenaria*
4	between 3 and 5 mesohaline; mostly at sites with low to moderate concentrations of chloride, at quite high salt-stress (first plants of brackish waters and others)	*Bolboschoenus maritimus*
5	highly mesohaline; mostly at sites with moderate concentrations of chloride; here obligatory, perennial cliff-halophytes which are not exposed to extreme salt stress; plants of short-term inundated saltmarshes and rocky coasts (during storm); perennials of brackish places inland and others	*Crithmum maritimum*
6	meso- to polyhaline; at sites with moderate to high concentrations of chloride; plants of brackish saltmarshes (influence of tidal inundation), under high (aero-haline) salt stress	*Limonium graecum subsp. graecum*
7	polyhaline; at sites with high concentrations of chloride; plants of lower saltmarshes, under very high (aero-haline) salt stress	*Parapholis incurva*
8	euhaline; at sites with very high concentration of chloride; short-lived (annual) plants of saline waters drying out late, marine plants and others	*Arthrocnemum macrostachyum*
9	eu- to hyperhaline; at sites with extremely high concentration of chloride; halophytes with temporary extremely high concentrations of chloride in their rooting zone (early crystallization of chlorides at soil surface, no sweet groundwater), e.g., plants of salt puddles, plants of small islets under arid climatic conditions	*Mesembryanthemum nodiflorum*
x	indifferent: plants with wide ecological amplitude concerning salinity	*Pistacia lentiscus*

4 CONCLUSIONS

The Southern Aegean indicator value system is the first of its kind for a Mediterranean flora (a separate set however, exists for Naxos, see Böhling 1994, 1995). The SAIV system needs further input, especially to complete the list of indicator values and to check less reliable classifications. Other important eco-factors such as grazing or fire tolerance values (Böhling 1994, 1995) should also be included.

As compared to other indicator value systems the recent methodological improvements result in a more objective system. When transferring Ellenberg's indicator figure scales and/or creating new scales and indicator figure definitions the aim was to produce a more open, "universal" EIV system (not just the EIV itself!) which could be used not only for a particular area but also could be transferred to any European region and other parts of the world.

Indicator values provide essential data on plant species. The ecological behaviour of plants is transformed in an operational form, a coding, which enables quasi-numerical calculations. With the S Aegean system new perspectives in ecological research and environmental monitoring, site classification and evaluation, and sustainable development arise. Applications in agri- and sylviculture, grazing management, tourism planning, and biodiversity protection and nature conservation are all possible.

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