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An index of naturalness

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Summary

The concept of naturalness both as a conservation value and as a descriptor of state is discussed. Previously used indexes or criteria for expressing naturalness are summarised, pointing out particular conservation activity fields where a structured index ought to be useful. Strongly focused on its practical application, a qualitative index for expressing naturalness of a given system is developed. The index ranks from a maximum of [10] to a minimum of [0] (artificial systems). Its ecological foundation (system analysis), diagnostic criteria and application procedures (mapping included) are explained. Finally, a set of three examples taken from different working scales is presented: an archipelago (Galapagos), an island (El Hierro) and a map sheet at scale 1:25 000. The latter examples originated in the Canary Islands. The index has been tested on oceanic islands, but it can be applied to any environment.
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Introduction

In the context of conservation biology, the term natural is used to define anything that has not been made or influenced by humans, particularly by technology (Hunter, 1996; Angermeier, 2000). In many situations, the human footprint may be difficult to recognise; thus, some authors tune the concept, accepting as natural a situation that is not measurably influenced by humans (Freedman, 1989). If we accept "natural" as being the antonym of "artificial", the "naturalness" or the quality of being natural would express the level at which something occurs without artificial influence, a gradient ranking from the extreme of absolutely natural to the opposite, absolutely artificial.

This conceptual approach is not free from debate, affecting both the role of humans in the ecosystem, as well as the time span of its influence (see Anderson, 1991). For the Australian Administration (Mackey, Lesslie, Lindenmayer, Nix, & Incoll, 1998), for instance, the irruption of technology in modern human society is the starting point of artificiality, the influence of aborigines in the ecosystems being accepted as natural. Demangeot (1989) places artificial influence at the start of agriculture (since ca. 8000 years). Some authors (i.e. Comer, 1997) consider humans as a part of

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nature; therefore all their activities should be taken as natural. Conversely, other authors see humans as a mix of biology and culture, and one should evaluate the condition of naturalness or artificialness according to which of each component is leading the activity. Angermeier (2000) is correct in noting that a human birth without technological assistance is a natural birth.

Without fully escaping this mostly philosophical and semantic debate, conservation has used the concept of "naturalness" in two different but related fronts: (1) as a conservation value, and (2) as a parameter or state descriptor of ecosystems. The same term is used in both cases, thus generating some confusion (Grumbine, 1994).

Naturalness as a conservation value

Conservation biology is a discipline which, being an applied science and oriented by a mission, has to do with values (Barry & Oelschlaeger, 1996; Meffe & Carroll, 1994). Society gives value to ecosystems for various reasons, such as the material good they harbour, the ecological services they provide or merely for their beauty. The value—utilitarian or intrinsic—is clearly defined: natural systems and biological diversity are good and should be conserved (Soulé, 1986). However, the extent to which these ecosystems need to be more or less natural to permit the subsistence of our species (or others), because of moral reasons (religion included) or only as an aesthetic option, is a question that probably cannot be resolved objectively; despite the extensive discussions over the last decades, the issue remains an ethical one that is open to various interpretations. (Spellerberg, 1981; Goldsmith, 1983; Grumbine, 1994; Callicot, 1994; Haila & Levins, 1997; Noss, 1996; Freyfogle & Newton, 2002).

It is not necessary here to replay previous debates, but it is worth introducing some other similar "values" that are commonly employed as conservation goals. The "environmental health"—or the health of an ecosystem (Costanza, Norton, & Haskell, 1992; Knight, 1996; Callicott, 1999)—is a metaphoric application of economic or public health to a given territory, and transmits an implicit idea of vigorous functioning and maintenance of, or a development towards, a desired direction (Freyfogle & Newton, 2002). As a conservation aim it is as legitimate as naturalness, but Hunter (2000) critiques the clementsian[1] bias underpinning the concept, which suggests that there is only authentic health when the successional phase of climax is achieved. I for one would consider a forest that is recovering from a hurricane to be healthy, and I consider such a disturbance being an entirely natural phenomenon, following the work of Holling (1973).

The concepts of ecological integrity (Woodley, Francis, & Kay, 1993; Pimentel, Westra, & Noss, 2000), biological integrity (Karr, 1990) or biotic integrity (Hunter, 2000) are also gaining attention as ultimate goals in conservation. The latter two do not consider non-biotic elements of the ecosystem as a handicap when compared with naturalness. Regarding ecological integrity, if we accept the definition of the Parks Canada Panel on Ecological Integrity (November, 1998)—an ecosystem achieves integrity when it has all its native components (plants, animals and other organisms) and processes (i.e. growth, reproduction) intact—the concept can resemble that of naturalness as it is implied that all components and processes are natural (native and intact). However, the wording of the concept reflects a somewhat biased use of the term ecology, a science that studies both natural and non-natural components of ecosystems.

Other guiding values being used in conservation are beauty, complexity and productivity. These are factors that can be manipulated or enhanced by humans, without implying that by doing so ecological sustainability will increase, as called for by the conservation approach (see Callicott & Mumford, 1997).

In conclusion, the concept of naturalness as a conservation value has clear advantages over the others commented. Authors like Angermeier (2000) give preference to it and even consider naturalness as an imperative in conservation. Of course, the management context has much to say. We understand that natural protected areas like reserves, parks and monuments—categories I, II and III, according to IUCN 1994—should be managed towards naturalness; while other areas where humans are present and living, should be managed towards sustainability.

Naturalness as a state descriptor

If one accepts naturalness as an obligatory value in conservation, either top priority or not, the next and complementary step is to see how one can recognise it along the continuum or gradient that moves from a maximum natural to a maximum artificial situation.

[1] Clements (1916) originally defined ecological succession as a linear and deterministic phenomenon.

Naturalness, together with diversity, rareness and area, is one of the four commonly used factors that, according to Margules and Usher (1981) have a scientific basis. Using this approach it has been applied to different things (i.e. populations, habitats, territories) and even processes (i.e. fires, erosion, climate). However, there are very few authors who explicitly define the criteria they use to evaluate naturalness—or conversely, anthropization. In fact, there is a dispersion of approaches that have not yet been revised. This situation clashes with the existing ample debate about naturalness as a conservation value.

Anderson (1991) developed some conceptual remarks from the Yellowstone National Park case. He proposed three criteria to evaluate naturalness: (1) degree of expected change if humans were removed, (2) the amount of cultural energy required to sustain the system in its current state, and (3) the proportion of native species that still remain present. Angermeier (2000), even more briefly, suggested four similar criteria, including the time factor: (1) degree of change, (2) degree of sustained control, (3) spatial extent of change, and (4) abruptness of change. Both authors discuss their criteria without offering an operational way to apply them.

The next section contains a brief summary of some different approaches—indexes or other formulas (i.e. semantic scales)—that aim to reflect the grade of naturalness of a given system or subsystem. Several authors simply use a scale of less to more natural, ranking from 1 to 3, or 0 to 10, without giving further details. Others develop more complex formulas, usually qualitative descriptions related to a specific theme (i.e. landscape, forestry). Apparently there is no general diagnostic method, and that is the reason for the present work.

A qualitative index of naturalness is then presented, based on systemic thinking and conceived and designed to be applied in practical work. Temporal processes have been excluded, thus using naturalness as a state descriptor of spatial systems, without including tendencies in one or the other direction, as if one would talk about the temperature of the body. This restriction is needed in order to simplify the diagnostic procedure. Finally, some examples of the use of the proposed index at different working scales are presented. All examples referred to come from island environments because of their ecological peculiarities (see Moore, 1983; Carlquist, 1974; Gorman, 1991) deserve major attention in some aspects (i.e. impacts of invasive species). Nonetheless and despite the fact that it has been tested only on islands, the index should work equally well in any other environment: continental, oceanic, etc.

Diagnosis of naturalness

Ranking ecosystems by their naturalness may be imperfect but need not be arbitrary (Angermeier, 2000). A diagnosis is to sample and analyse data to evaluate problems of various kinds (diseases, mechanical failures, etc.). In this case, the "problem" is the anthropization of the system, and from its inverse reading, we will deduce the grade of naturalness that is still present. Therefore, it may be not very appropriate to speak of diagnosis of the naturalness, but this semantic licence is rather convenient as it gives a clear idea that the process is underpinned by an analysis of information, despite how varied and uneven it may be. Thus, one should evaluate exclusively the results of the analysis undertaken, and the evaluation criteria applied must be the same throughout all units considered. In other words, one has to develop an equivalent diagnostic.

Some methods and classifications in use

Most of the cases found in the specialised literature refer to classifications of human intervention (artificiality, ruderality, etc.), which could give a sense of naturalness in its reverse reading; and fewer are directly based on naturalness, usually showing a minor development of the categorisation method. This consists normally in the enunciation of one or several, more or less precise criteria, which must be fulfilled by each category. Quantitative methods are scarce and specifically adapted to individual cases.

In land use and development planning it is common to bring vegetation into play as a synthesis-indicator of many environmental circumstances (Ellenberg, 1979), and several authors treat naturalness as one more descriptor of vegetation (Blume & Sukopp, 1976). Another much larger group of authors refers to the naturalness/artificialness of the landscape either only in its perceptual aspect or as a more general system. That is the case of the so-called landscape ecologists (Forman & Godron, 1986) or geographers of some landscape-oriented schools (see Bolós, 1992). Finally, a few authors share a more holistic and ecological approach or use indexes with a quantitative base, as is requested by Margules and Usher (1981). Because of their interest, some of these cases are presented here.

In evaluating naturalness of vegetation, Grant (1995) first considers if there has been a change in relation to the past, and secondly, he tries to infer to what extent such change is due to humans. He proposes a simple classification with four categories:

- *Natural environments*: not disturbed by humans or their animals.
- *Subnatural environments*: some changes, but the structure of vegetation is basically the same (a forest remains as a forest).
- *Seminatural environments*: the basic vegetation has been altered but without intentional change in the composition of species, which is spontaneous (i.e. overgrazed areas, *maquis*).
- *Cultural environments*: artificial systems such as cultivated land; the vegetation has been deliberately determined by humans, with loss of the previous habitat.

Edarra (1997) proposes to estimate the naturalness of plant communities from 0 to 10, according to the grade of anthropic influence. Value 0 corresponds to areas intensively urbanised, fully occupied by buildings, roads, etc, almost without plants; and 10 is the value for mature forests that are not exploited, vegetation on rocks, cracks and gravel beds, peat land, marsh lands, coastal salt marshes, non-intervened dunes, etc. But he gives no further criteria to separate the intermediate categories.

In assessing the relative importance of vegetation units for conservation, some phytosociologists, mainly European, use naturalness among other criteria. However, the phytosociological approach may introduce some conceptual errors. According to Loidi (1994), "naturalness can be widely expressed in terms of distance from the climax or potential natural vegetation; the highest naturalness would correspond to potential natural vegetation in an undisturbed situation". Its zero to ten-pointed scale developed for the Iberian Peninsula ends, for instance, with mature non-exploited forests. However, naturalness cannot be teleologically linked to a climax situation because natural disturbances may revert ecosystems to more juvenile or intermediate stages, which are as natural as the mature ones.

The concept of hemeroby—from the Greek *hemeros*, cultivated, tamed, refined—was originally developed from earlier more informal concepts by Jalas (1955) to measure disturbance and unnaturalness of vegetation. From a four-point scale based largely on the degree of disturbance to the soil, it has been extended to five (Kim, Zerbe, & Kowarik, 2002), seven (Steinhardt, Herzog, Lausch, Müller, & Lehmann, 1999) or to ten-point scale (Hill, Roy, & Thompson, 2002). This sort of "reverse" index of naturalness is used mainly to categorise plant species and plant communities, but has also been applied to places in Central Europe or Asia (Grabherr, Koch, Kirchmeir, & Reiter, 1995; Kim et al., 2002). Kovarik (1999) defines hemeroby as "the sum of the effects of past and present human activities on the current site conditions or vegetation which prevent the development to a final state" and Sukopp, Hejnỳ, and Kovarik (1990) claim hemeroby to be "an integrative measure for the impact of all human interventions on ecosystems". Most plants in the flora of Berlin, for instance, have a hemeroby value assigned (Kovarich in Lindacher, 1995), but such values, for instance, do not apply well to Britain (see Hill et al., 2002). The concept is still being reformed and needs further tuning. At present it shows a heavy flora-bias, a terrestrial approach and, following Steinhardt et al. (1999), a terrible terminology: ahemerobe (natural), oligohemerobe (close to natural), mesohemerobe (semi-natural), beta-euhemerobe (relatively far from natural), alfa-euhemerobe (far from natural), polyhemerobe (strange to natural) and metahemerobe (artificial).

In their classic work "*Landscape Ecology*", Forman and Godron (1986) recognise that the combined effect of methods and tools used by humans give rise to a gradient of landscape modifications, which extend from a natural landscape without significant human impact, towards a urban landscape. They establish five categories that are more or less self-explaining: natural landscape, managed landscape, cultivated landscape, suburban landscape and urban landscape. Conversely, other landscape ecologists present rather meticulous descriptive categories, which are extremely prolix (i.e. Èliáš, 1982).

Bovet and Ribas (1992) develop a landscape classification according to the dominance of structural elements (abiotic, biotic and anthropic) using symbols (square, circle and triangle, which are combined graphically, one within the other, following their order of dominance or, eventually, inexistence. Fifteen combinations are possible. They start by selecting the working scale and delimiting the landscape area under study. Thereafter, they define the group of dominant elements (visual) and, finally, they consider the present functioning of the landscape. A classification scheme of the landscape dynamics in relation to the input of energy (natural or anthropic) helps to predict in which direction the landscape would evolve. The term naturalness is not used explicitly; however, these authors provide a general classification that covers—in a particular way (visual dominancy)—the full natural-anthropic gradient.

For the Australians, the concept of wilderness implies remoteness, naturalness and size. In their *National Wilderness Inventory Handbook* (Lesslie & Maslen, 1995), naturalness is evaluated as an indicator of wilderness by considering the degree to which the landscape or natural environments are respectively free from the presence of permanent structures (apparent naturalness) or biophysical perturbations (biophysical naturalness) associated with modern technological society. Apparent naturalness is graded as high, medium and low, obviously within a narrow margin of prominent naturalness. Discriminating criteria are, for example, the presence of medium or high-grade access routes with cleared land boundaries instead of tracks for 4-wheel vehicles or minor intrusive infrastructures. For diagnosing biophysical naturalness some basic impacts are considered: ranching [cattle raising], forest exploitations and, eventually, the presence of exotic species, but only if precise information is available. The gradient ranks from 1 (low) to 5 (high) and two sets of criteria are given: one for arid environments combined with a complicated method for evaluating water availability, and another for non-arid environments. Finally, everything is normalised on base 5. This is one of the most elaborated methods with proven utility, although perhaps a bit specific for the Australian situation.

A good example of a quantified index is that elaborated by the Autonomous University of Baja California (Ferman-Almada, 2001) for a project aiming to assess the quality of the coastal zone of San Quintin, Baja California, Mexico, in order to support tourism. Environmental quality is defined as a direct function of the grade of naturalness. The latter is evaluated using "pressure-state-response" indicators (see OECD, 1998) such as kilometres of road or houses per unit area (pressure), cover of climax vegetation (state) or surface of protected areas (response). Each indicator is normalised to common scaling from 0 to 100, then weighted and finally incorporated with an integrated index of naturalness.

Milanova, Arshinova, and Kotchurov (1992) apply absolute and relative coefficients of anthropic stress to assess the agrarian landscape of the Moscow Region. These are very complex coefficients involving parameters like erosion, density of rural population or the number of cattle or tractors per hectare. Its inverse reading gives a certain idea of the variation of naturalness within the narrow margin offered by agrarian landscapes, for which they were designed.

Within the framework of an environmental diagnostic study of the Galapagos, Machado, Blangy, and Mota (1994) introduce an index from 1 to 10 to synthetically reflect how natural a system is—islands in this case—or, to the contrary, how altered it may be. This index, based on a systemic analysis (elements and relations), is the one more elaborated (adjusted, generalisation of criteria, terminology, etc.) presented here.

Fields of application

As previously discussed in the introduction, naturalness is useful or even necessary as an evaluation criterion in several fields of conservation and land use planning. Therefore, a scaled index of naturalness as proposed here should be a powerful tool assisting in the following aspects (the list is not comprehensive):

Land description

- Visualising the state of conservation and giving a general idea of human intervention (see Jacobi & Scott, 1985).

Environmental impact studies

- Evaluation alternatives and the impact of fragmentation (see Canter, 1997).

Land use and natural resource planning

- Assessing the interest of conservation of particular subsystems, i.e. vegetation (see Loidi, 1994; Edarra, 1997; Meaza & Cardiñanos, 2000).
- Elaborating suitability matrixes (see Gómez Orea, 2002).
- Assessing leisure options (Raunikar & Buongiorno, 2001; Fischer, Ferman-Almada, Garcia, Gastelum, & Galindo Bect, 2000).
- Establishing conservation priorities (Margules & Usher, 1981).

Protected areas

- Selecting areas and networks of areas (Ratcliffe, 1977; Pressey, Humphries, Margules, Vane-Wright, & Williams, 1993; Margules, Cresswell, & Nicholls, 1994).
- Designing limits and zoning (Theberge, 1989; Machado, Redondo, & Carralero, 2004).

Wildlife management

- Guiding translocations, introductions or re-introductions of living organisms (IUCN, 1987).

- Assessing habitats for species recovery (Jacobi & Scott, 1985).

Ecological restoration

- Prioritising initiatives (Anderson, 1991).
- Defining baseline states and restoration objectives (see Jackson, 1992; Jordan, Gilpin, & Aber, 1987; Cairns, 1988).

The index of naturalness

As for any model, the merit of an index is not measured by the fidelity with which it represents reality, but rather with regard to its explanatory or interpretative capacity (Gómez Orea, 2002) and its operational functionality [usefulness]: it helps to answer important questions. Despite the reluctance of some theoreticians of conservation biology, in the practice of conservation management there is a growing demand of assessment methods that are "rapid" (i.e. Olivier & Beattie, 1994). What is the usefulness of an index, however well conceived it may be—if its data requirements are not attainable within a reasonable time and with reasonable effort? Full confidence and guarantees must accommodate some levels of imprecision and vagueness—but not arbitrarily—in order to cope with time and financial restrictions. Economics, for instance, normally works in this sphere of approximations.

With a clear practical orientation, an index is proposed that ranks from [10] to [0] to cover the full gradient of a maximum to a minimum of naturalness. Some of its characteristics are:

- The scale used is qualitative and of nominal type; that is why the numbers are placed in brackets to avoid any confusion with a cardinal scale. However, as the numbers represent a hierarchical gradient with relative and proportional stretches, the scale can be interpreted as a scale of order in evaluation activities and its ranks can be used directly as values (0–10) without any transformation.
- Each grade ...[7], [6], [5]... describes a state of naturalness, and intermediate states can be expressed by using decimals, i.e. [8.4].
- The grades of naturalness are expressed by [numbers]. The use of descriptive names (i.e. rural, urban, etc.) is a free choice of the user in accordance to the semantic particularities of each culture.
- Although most applications of such an index may relate to territorial systems, the "diagnosis" or grade assignation is based on systemic analysis and therefore the units studied can be ecosystems at any spatial scale, from a pool to the whole planet.
- The level of information required to gain reasonable insight of the system and have a useful diagnosis is not excessive. Such information is normally available in most cases of environmental or land use planning projects.
- The index is really operational and gains precision when used in the same context and by the same team.
- The decreasing gradient of naturalness from [10] to [0]—with its equator natural/cultural at [5]—as well as the graded colours (blue > green > yellow > red) proposed for cartography, is expressive and intuitive even for the general public. The same applies for the naturalness profile explained later.

Ecological foundation

A system is defined by its limits, its elements and the relations among these and with the exterior; it has a structure and behaviour. The same applies to an ecosystem, and the naturalness index is based on a simple principle: ecosystems are artificially altered basically by three often interrelated causes: the incorporation of new elements (i.e. exotic species, pollutants, artefacts); the relocation or loss of its own elements; and the change in fluxes and dynamics due normally to the input of additional energy. The resulting states of such alterations can be represented conceptually in a scheme of three orthogonal axes, two related to elements and the third to the input of energy of anthropic origin (see Fig. 1).

The state of maximum naturalness [10] is achieved when 100% of the elements are natural and all present, and anthropic energy input is zero. When anthropic energy is maximal and 100% of the elements are of anthropic origin, naturalness will be minimal [0]. The gradient is thus established along the line which runs diagonally from [10] to [0] and which is not necessarily straight.

A system analysis approach forces us to set limits or boundaries for the study unit in order to be able to recognise inputs or outputs in the (eco)system. Occasionally a greater scale outcome may require that several smaller adjoining units be integrated in a bigger one. In such cases, the new global boundaries will be used to discriminate what is internal and what is external to the new

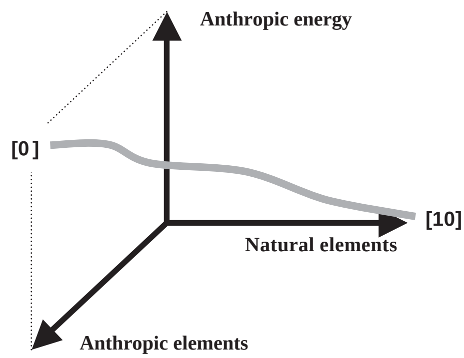

Figure 1. Principal factors affecting the naturalness of a system.

aggregated system. For instance, an animal or plant—whether native or exotic—introduced by man into the defined boundaries will count as anthropic
and subtract naturalness from that unit. Both the constitution of the element and the cause of its presence are deciding factors in questions of naturalness.

The criteria selected to diagnose the state of naturalness are not mutually exclusive, and they are based on:

- *The elements*, paying attention to the cause of their presence/absence and dominance. Biotic elements can be natural (native species) or anthropogenic (exotic species). Artificial elements include recognisable objects and artefacts as well as manufactured chemical pollutants. Natural or manipulated disposition of the elements in the environment, and whether they are or are not self-supported and need anthropic assistance are also considered.
- *Addition of energy and matter* to the system by humans (usually from the outside). The cultural physical work directly done by humans is considered an anthropifying factor.
- *Physical alteration* of the geomorphology or of the disposition of physical elements in the environment; i.e. excavations, stonewalls, terraces, etc. (see Bell, McCoy, & Mushinsky, 1994).
- *Extraction of elements* from the system, either biotic (game, fish, crops) or abiotic (minerals, earth, water); that is to say non-natural exports.
- *Fragmentation* of the *continuum naturalis* by infrastructures (see Noss & Csuti, 1994).
- *Dynamics*. Natural environments turn cultural when the dynamic of the system begins to be dependent or governed by the activity of humans or their inputs of energy (category [5] and below). The flow-circuit of water deserves special attention, particularly to which extent it has been altered or is controlled by humans.

Time may become a relevant factor in the proposed state-descriptor model. Thus, the term "virgin" is used in category [10] in the sense given by the Spanish Royal Academy's Dictionary: "it is said about what has no artificiality in its formation". A secondary forest that develops freely without human interference, will end as a natural system, despite it may have been felled in a more or less remote past. It is a different question that it is not anymore pure, intact, virginal (in the sense of untouched) or pristine.

If humans are present, they cannot and should not be abstracted from the ecosystem. There may be a problem in interpreting whether human presence is natural or not (see Hunter, 1996). In the case of oceanic islands, the situation is simpler, as they have all been colonised by using technology (navigation). Human presence is therefore not natural. In continental territories doubts may easily rise, but it may help to judge human activities, separating those cases where our species impacts basically as one more collecting and predatory mammal (very few remain), from those cases where technology is applied with sensitive impact on the environment, starting with agriculture.

The scaling of naturalness

The scale of naturalness (Table 1) is read top-down and each grade is defined by a set of descriptive conditions. Some of these conditions are possibilities, not obligatory, while others are implicit as they were defined in previous grades. To help with the analysis in a more disaggregate and comparative manner, an auxiliary table is provided (Appendix A). Its use will be explained in the next section.

A range of graded colours is proposed for cartographic use: a cold set from greenish blue [10] to pale green [6] for the natural systems, and a warm set from yellow [5] to dark red [1], for the cultural systems. Grade [0] is rarely to be found in territorial units; thus a grey colour is assigned to it.

The working method

The proposed index does not consider solitude, beauty and other intangible values of nature that are not strictly linked to ecology. All diagnostic criteria are based on aspects of the ecosystem that can be measured. Another question is whether such a measurement may become costly or tedious.

Table 1. Naturalness categories

[10]	Natural virgin system; only natural elements and processes. Possible anecdotal presence of negligible or hardly noticeable anthropic elements, or totally insignicant physical-chemical pollution coming from exterior anthropic sources
[9]	Natural system; presence of few exotic biological elements (no qualitative effects); minimal articial infrastructure, temporary or removable. Physical-chemical pollution absent or of no signicance
[8]	Sub-natural system; possible extended presence of wild exotic species, but not dominant (low impact); articial elements located, not extensive. Occasional pollution processed by the system (does not go beyond resilience). Possible minor extraction of renewing resources. Fragmentation irrelevant. Natural dynamic little altered
[7]	Quasi-natural system; extensive anthropic activities of low physical impact; facilities if present, dispersed, not connected; wild exotic species well established but not dominant; natural structures modied but not distorted (re-location of physical or biotic elements). Moderate extractions, if present. Little alteration of water dynamics
[6]	Semi-natural system; anthropic infrastructure scarce or concentrated; possible dominance of wild exotic species; native elements considerably reduced. Occasional addition of energy and/or extraction of renewable resources or of non-relevant materials. General dynamic still controlled by natural processes. It may include abandoned cultural systems undergoing natural recovery
[5]	Cultural self-maintained system; processes conditioned by extensive activities of man; biological production not too forced. Native species altered, occasionally managed. Little or no presence of constructions or artefacts. Little or no management of water cycle (passive)
[4]	Cultural assisted system; important infrastructures and/or conditioning of the physical environment; forced biological production; moderate addition of matter (usually with pollution associated). Natural elements intermixed, in patches or corridors. Active management of water
[3]	Highly intervened system: still areas with biological production (natural/cultivated/breeding) mixed (mosaic) with buildings and infrastructures. Natural biodiversity severely reduced; its elements rather isolated (intense fragmentation). Water dynamic manipulated. Geomorphology usually altered; soils eventually removed
[2]	Semi-transformed system; biological production not dominant, disarticulated. Predominance of constructed elements. Occasional moderate vertical development of facilities. Intensive input of energy and matter (food, water) from the outside. Intensive control of water
[1]	Transformed system; anthropic processes governing; clear dominance of articial elements; frequent intensive vertical development; vestiges of natural elements; those exotic confined, decorative or not visible. Full dependence of external inputs of matter and energy. Absolute control of waters
[0]	Articial system; high closure; without self-maintained macroscopic life; microscopic life absent or in containers

Those who work in management know that factors like time and economic resources are usually determinants when choosing a methodology to assist in the decision-making process. There is a sort of tension axis with rigour at one extreme, action at the other, and the unpleasant necessity to find a compromise at some intermediate point. An excessive search for rigour from the scientific side normally implies an inadmissible delay in decision taking; but a hasty decision of the manager with little scientific support increases the risk of failure at levels equally unacceptable. Consequently, it is not surprising that the so-called quick-methods[2] are emerging more and more. Despite their supposed weakness, such methods are giving important services to conservation (Peroni & Abrahamson, 1985; Olivier & Beattie, 1994; Günster, 1995; Rijsoort, 2000).

The present method can be applied with reasonable quickness if some basic information is available (i.e. cartography, aerial photography, vegetation map), which is normally the case in land use planning events. As more information becomes available, the diagnosis can become more

[2]Conservation International started a *Rapid Assessment Program* in 1990. The *RAPS* are being published in the *RAP Bulletin of Biological Assessment,* Washington DC.

accurate. A fixed working process is not advisable, as each author should accommodate to the circumstances and apply the index in the most practical and efficient way. However, some general suggestions can be useful.

Working scale
The working scale is changeable and usually determined by the planning context in which the naturalness index is to be used (see examples in the last section). Larger scales (>1:50 000) are normally obtained by the integration of units resulting from a more detailed analysis (i.e. 1:25 000).

Analysis of data
All useful information compiled should be transferred to a cartographic base (transparencies or GIS). It is practical to work on a topographic base-map reflecting the major watersheds (bold lines) and, eventually, the secondary ones, because basins are functional units, at least regarding water dynamics. Aerial photography (1:18 000–1:25 000) is probably the best ally for land interpretation and almost an indispensable tool to work with large territories (Myers & Shelton, 1990; Davis, 1994). Equally useful are maps of land use activities, infrastructure, cultivation, vegetation, cattle range or any other which reflects human influence on the territory. Maps of environmental units[3] are very helpful, if available.

Field inspection
It is highly advisable to check the territory in order to contrast the impressions derived from the analysis of available compiled data and, particularly, when needed to solve doubts or discriminate among close situations. Moreover, some aspects, like the presence/dominance of exotic species, are not normally registered in land or urban-planning processes. A quick field check helps to adjust the diagnosis without excessive time costs. Obviously, the progressive experience and intuition that is gained with practice will revert positively in the agility of the method.

The diagnosis
Scale has a fundamental role in ecology and conservation (Noss, 1992). The diagnostic units will be defined in accordance with the working scale. The way in which the grades of naturalness have been defined allows for zooming in or out during the analysis and to integrate smaller units into larger ones. At the beginning, there is a tendency to separate units based on vegetation or other outstanding physiognomic characteristics, but one soon realises that there is no problem in melting together a forest with open grassland if both show the same grade of naturalness. It is very practical to start by gauging the extent of naturalness by first delimiting a unit with the maximum naturalness present, and then another with the minimal. By doing so, the spectrum of possibilities will be reduced in many cases. Thereafter, one locates a unit with an intermediate value, which will help also as a reference. This facilitates the comparison and assessments of further units in a continuously adjusting feedback process. At this point, it is very useful to use decimal index values in order to reflect appreciated differences. One should decide if decimals are to be kept or rounded off to unitary values at the end of the diagnosis.

Table 2. Naturalness index of the Galapagos

Name	Surface (km^2)	Index
Isabela	4588	[7]
Santa Cruz	986	[7]
Fernandina	642	[9.5]
Santiago	585	[8.5]
Cristóbal	558	[7]
Floreana	173	[7.5]
Marchena	130	[9.5]
Española	60	[9.5]
Pinta	60	[9]
Baltra	27	[7]
Santa Fé	24	[10]
Pinzón	18	[9.5]
Genovesa	14	[10]
Rábida	4.9	[9.5]
Seymour	1.9	[9]
Wolf	1.3	[9]
Tortuga	1.2	[10]
Bartolomé	1.2	[10]
Darwin	1.1	[10]
Daphne Mayor	0.32	[10]
Plaza Sur	0.13	[9.5]

The auxiliary diagnostic table
To assist in the diagnosis process an auxiliary table (Appendix A) is provided. The diagnostic criteria are disaggregated into columns by category and each diagnostic unit to be individually evaluated by

[3]Cendrero (1975) defines an environmental unit as a portion of territory established in relation to its soil constituency, subsoil, active processes, biological communities and anthropic alterations to which it has been submitted.

sequentially marking the appropriate boxes (if information is available). Finally, one can visualise the overall trend of the bar built by all the boxes and read the grade of naturalness that fits better.

Graphic presentation

The diagnostic units will be delimited by polygonal frames, ideally filled with the correspondent colour of the index, and/or with its value noted in the interior. If it is required by the study, the successional tendency of each diagnostic unit can also be expressed—if known!—by a symbol attached to the index or placed within the polygon:

=	Stationary or withheld
~	Unstable, fluctuating
↓	Regressive (loss of biodiversity and nutrients, decrease of biomass)
↑	Progressive (increasing diversity of native species and biomass)
?	Unknown

The work team

There is enough knowledge about the impact of man on nature and about the behaviour of ecosystems under stress—either natural or anthropic (see Rapport, Regier, & Hutchinson, 1985; Freedman, 1989; Grant, 1995)—so as to expect that a professionally trained ecologist with some

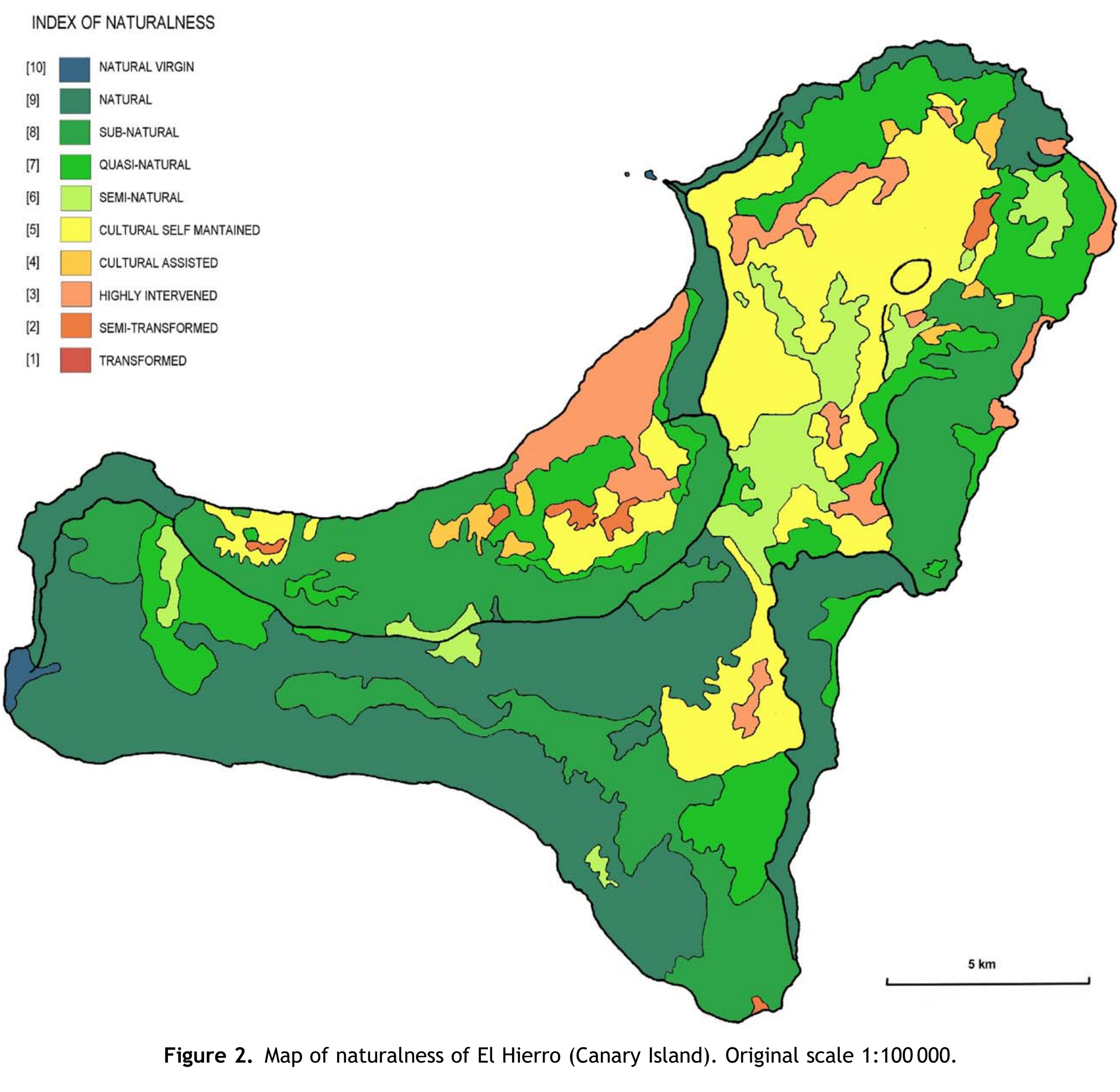

Figure 2. Map of naturalness of El Hierro (Canary Island). Original scale 1:100 000.

experience knows where to look for the human footprints in a given case. Nonetheless, the work team should optimally be formed at least by two or three members (i.e., ecologist, geographer, biologist). They all should understand that the ecological perspective—processes, not just structures—is essential for a good diagnosis. Moreover, having various members on a team allows for repetitive evaluation of a given unit to upgrade or downgrade the index (including decimals) until it becomes congruent with the others. If discrepancy still persists, a numerous team provides opportunities to introduce agreement techniques such as the Delphi method (Adler & Ziglio, 1996). What is obligatory in any case, is that the individual team members are not changed during a given project. Obviously, absolute objectivity regarding naturalness is not affordable with quick methodology such as the one here proposed, but the relativity of index values assigned by the same team offer sufficient operational usefulness.

Naturalness profiles

Once the map of naturalness for a specific territory is finished, a naturalness profile can be built by using a horizontal bar chart divided in proportional sectors according to the percentage of each naturalness category in the whole territory. It is drawn from the left [10] to the right [1] and filled with the corresponding colours (i.e. Fig. 4). Such profiles are very expressive, ideal for comparison between equivalent territories and easy to elaborate with GIS techniques.

Some test-examples

In the naturalness evaluation of the archipelago of Galapagos entire islands were used as integrated diagnostic units, independent of their size (Machado et al., 1994). The diagnosis was based mainly on the study of the major ecological negative impacts

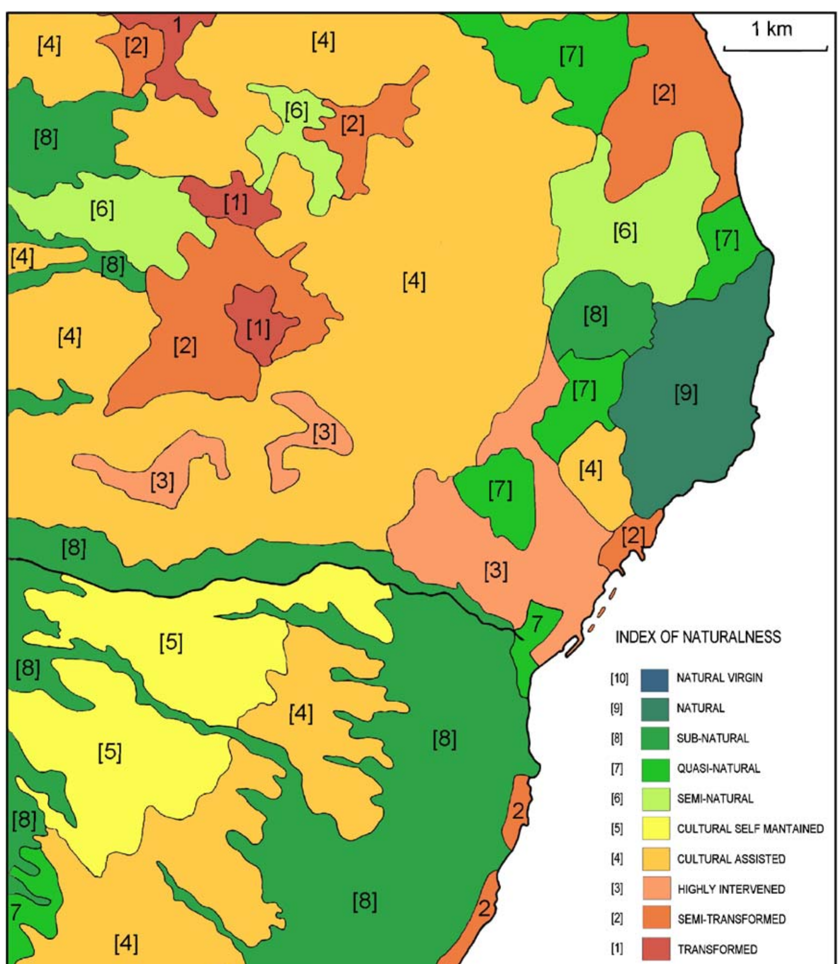

Figure 3. Map of naturalness of page 1092-V (Güímar), Tenerife (Canary Islands). Original scale 1:25:000.

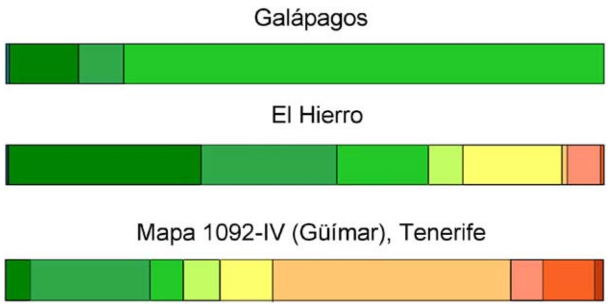

Figure 4. Examples of naturalness profiles.

(analysed by activities and recipients) with special emphasis on the presence and spread of exotic invasive species, tourist pressure, and agriculture and livestock activities. The team used indexes with decimals because the range of variation was very narrow after integration was accomplished (Table 2).

The results of the evaluation of the island of El Hierro (269 km^2) in the Canaries, Spain, were finally integrated in a single map at scale 1:100 000, whereas the base working scale was 1:50 000 (Fig. 2). Despite the abundant information available, the aerial photography at 1:10 000 was decisive in accelerating this project (Machado, Redondo, & Carralero, 2004).

A third example (Fig. 3) from the same source is provided by a test realised on the territory represented by map 1092-V (Güímar, Tenerife) of the National Topographic Map of Spain, at scale 1:25 000 (sea was excluded). Only partial vegetation maps were available, but again aerial photos and orthophotography (scale 1:18 000) rendered a splendid service. The more anthropised an area is, the more useful aerial photos become. Field inspection was necessary, but the overall exercise for 52 km^2 (sea excluded) took only a few days (Fig. 3).

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Appendix A. Auxiliary table for the diagnosis of naturalness

Index	Biotic elements		Artificial elements		Inputs of energy and/or matter	Physical alterations	Extraction of elements	Level of fragmentation	Dynamics		
	Native	Exotic	Artefacts	Pollutants					Water	General	
[10]	Exclusively/ almost excl.	None or insignificant	None or insignificant	None or insignificant	None, only natural	None	Only natural vectors	None or insignificant	Free running, natural	Natural	
[9]	Dominant	Some, irrelevant effect	Punctual, irrelevant	Possible, irrelevant	None, only natural	None or irrelevant	None or irrelevant	None or insignificant	Free running, natural	Natural	
[8]	Dominant, but altered	Concentrated, or extended, low impact	Occasional, some roads	Occasional, biodegradable	None, only natural	None or irrelevant	None or some renewing resources	None or irrelevant	Free, natural, irrelevant use	Natural, irrelevant alteration	NATURAL
[7]	Diminished, but dominant	Settled, not dominating, widespread	Scarce, (i.e. roads and /or buildings)	Occasional/ regular biodegradable	Irrelevant	None or scarce	Moderate renewing resources	None or low, no qualitative effects	Minor alterations	Natural, little alteration	
[6]	Reduced, possible minority	Wild, occas. dominant, widespread	Scarce or aggregated	Low impact, biodegradable	Occasional, not dominant	None or minor (i.e. roads)	Renewing resources, limited matter	None or moderate	Deviation, no significant management	Natural, eventually accelerated	
[5]	Managed, much altered	Cultivated/ ranged but not forced	Conspicuous, but not dominant	Water and soil slight	Low, regular, occasional or periodic	Moderate (i.e. stone-walls)	Sustainable, possible matter (low)	None or relevant (patchwork)	None or little management, passive	Oriented, but self-sustained	
[4]	Intermixed, patchy or in corridors	Dominant, usually forced	Important presence	Water and soil moderate	Moderate, determining factor	Important (i.e. channels terraces)	Regular, more intense (i.e. export)	Moderate, with or without corridors	Important management, event. inputs	Forced by man	
[3]	Notable loss	Abundant or not, patchwork	Abundance	Water and soil intense, air moderate	Intensive, determining factor	±Extended, excavations included	Moderate to very intense (i.e. mining)	Intense, very extended	Soft or hard management, extra inputs	Very forced; unconnected, dependent	CULTURAL
[2]	Scarce	Abundant or not,	The majority	Water and air permanent	Intensive, important dependence	Extended, excavations included	Variable (i.e. waste)	Very intense, no corridors	Intensive management extra inputs	Dependence from external inputs high	
[1]	Vestiges or absent	widespread In gardens, confined	Clear dominance	Water and air severe	Very intensive, absolute dependence	Almost full modification (little soil)	Variable (i.e. waste)	Maximal	Full control, extra inputs	Full external dependence	
[0]	Absent/ irrelevant	Absent/ irrelevant	Almost/all	Variable	Total dependence	Variable	Variable	Not applicable	Variable or closed	Artificial, conducted	

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