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A Biosemiotic Perspective of the Resource Criterion: Toward a General Theory of Resources

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Abstract Describing resources and their relationships with organisms seems to be a useful approach to a 'unified ecology', contributing to fill the gap between natural and human oriented processes, and opening new perspectives in dealing with biological complexity. This Resource Criterion defines the main properties of resources, describes the mechanisms that link them to individual species, and gives a particular emphasis to the biosemiotic approach that allows resources to be identified inside a heterogeneous ecological medium adopting the eco-field model. In particular, this Criterion allows to couple matter, structured energy and information composing the ecological systems to the biosemiotic and cognitive mechanisms adopted by individual species to track resources, transforming neutral surroundings into meaningful species-specific *Umwelten*. The expansion of the human semiotic niche that is a relevant evolutionary process of the present time, assigns the role of powerful and efficient agency to the Resources Criterion to evaluate the effect of human intrusion into the natural systems with habits of key stone species, under the challenge of a growing use of alloctonous, immaterial and symbolic resources of the actual globalized societal models. The Resource Criterion interprets the ecological dynamics contributing to complete the epistemology of the ecology, to open a bridge toward economy and other societal sciences, and to contribute to formulate a General Theory of Resources.

Keywords Resources · Ecological complexity · Biosemiotics · Eco-field · Semiotic niche · General Theory of Resources

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Introduction: Ecology a Science in the Middle of the Ford

Ecology, a science which is devoted to the study of the relationships between living beings and their environment, is an important tool between the environmental sciences in the fields of both research and education (Lubchenco et al. 1991). However, it currently appears to be in difficulty when it comes to producing robust, key references with which to guarantee the sustainable development of human societies (but see Carpenter and Folke 2006; Rockström et al. 2009). This is largely due to the fact that ecology has assumed a distinction between human and natural processes that generates a continuous disaffection of man towards natural entities as reported by Vining et al. (2008). Indeed, it is sometimes regarded as being useless or harmful, and is only temporarily connected to humans by weak paradigmatic bridges—the ecosystem service paradigm is a recent example (Gomez-Baggethun et al. 2010)—while frequently being badly copied or inadequately replaced by technological (artificial) or potentially harmful solutions.

In Western culture, in particular, nature is perceived as an element that is distant from human dominion (but see, Ingold 2000; Williams 2007). Nature is often perceived by people (mass media) as hostile, and as an enemy to be defeated, especially when events like volcanic eruptions, earthquakes, tsunamis, hurricanes and floods pose a risk to populations and are a source of damage to the entire anthropocene (sensu Crutzen 2002; Anonymous 2003; Zalasiewicz et al. 2008). Moreover a cultural attitude drives the perception of human ecology (Eisler et al. 2003).

With the recent increase in knowledge and the refinement of many ecological concepts, nature has come to be considered both as an indispensable and continuous distributor of ecosystem services, as well as an entity which can be tamed in terms of most of its structural and functional components (Bekoff 2003; MEA 2005a, b; Mooney et al. 2009). This taming of nature has not only involved plants and animals, but has also been extended to entire regions of the planet. For instance, urban sprawl has imposed technological solutions to environmental constraints, producing albedo, impervious surfaces, artificial night lighting (Rich and Longcore 2006), and an unexpected economic impact (Burchell et al. 2005).

These days, a philosophical and epistemological foundation with which to face the complexity of the natural world seems to be an approach that scientists cannot renounce (Eder and Rembold 1992; Scheiner et al. 1993; Cadenasso et al. 2006; Sodhi and Ehrlich 2010). Chaos, information and entropy are some of the concepts that ecologists have not only adapted from mathematical and physical theories, but have also gone on to consider strategically in order to better understand the flux of energy, matter, information and meaning across ecosystems (Kauffman 1993; Levin 1999; Baranger 2001; Ulanowicz 2009).

The field of ecology has also been subjected to the influence of both the tumultuous development of technology and political dynamics, suffering a sub-disciplinary fragmentation as a consequence. This has resulted in a weakening of its philosophical and epistemological bases, leading to a failure to support and guide human dynamics.

Economic processes are currently the most important drivers of the environment, the worldwide dominance of economic philosophies means that ecological theories have to compete to emerge, even though ecological thought represents an important bulwark with which to defend the fragile position of humanity and its associated biodiversity (Farina et al. 2003).

Towards a Unifying Ecology and Biosemiotics

Ecological thought requires a cultural scenario within which to form principles, paradigms, and general laws that are modulated on the flux of energy, matter, information and meaning existing in organisms and their aggregations.

For this reason, it is also necessary to take an integrated approach (f.i. Harte 2004; Scheiner and Willig 2005, 2007), and to enunciate a general framework within which to identify the principles that are useful when it comes to interpreting some of the phenomena that attain ecological complexity (Levin 1999) and guide us in how human societies should be sustained (Lubchenco 1998; Barrett et al. 2009).

Individual-based ecology, that considers the relationship between every organism and the environment, has been often chosen as the basis for the empirical verification of the functioning of such agencies. This is the case of the Metabolic Theory of Ecology (Brown et al. 2004) that has empirically described the presence of a few of the physiological constraints which both regulate the dimension, activity and dynamics of all organisms, and fix the relationships between these and the available resources. This theory "opens [up] a grand vista on ecology", as argued by Cottinghamm and Zens (2004).

The functional approach in ecology is a well known way of facing ecological complexity (e.g., Allen and Hoekstra 1992), but it has never been suitably formalized as argued by these two authors.

The aim of this contribution is to present a new vision of the ecological complexity when resources are used as a criterion to describe and interpret such complexity and the relationships between organisms and their ecological context. We also discuss the strict relationship between ecology and biosemiotics, so important that we believe that a specific field of investigation could exist (e.g., Kull 2010).

Dealing with resources means to find a common element to the eight levels of organization described by Allen & Hoekstra (Cell, Organisms, Population, Community, Ecosystem, Landscape, Biome, Biosphere).

Resources are active common subjects for every one of the eight levels, but it is the scale at which resources are incorporated into each level that makes the difference. In a cell, for example, resources pass through the cellular membrane by active selection. The input of resources like nutrients into an ecosystem occurs by non intentional mechanisms. For this reason, the elaboration of a conceptualisation, which focuses on the functional aspects of biological complexity and illustrates the relationship between organisms and resources, seems to be a necessary and useful step if we are to move some of the ecological paradigms from an empirical basis of observation and description to a more speculative domain as recommended by Allen and Hoekstra (1992) at the end of their book "Toward a unified ecology".

The recent field of biosemiotics seems a good candidate to integrate the ecological paradigms and produce a new era of epistemological and empirical exploration of ecological complexity (Favareau 2007; Barbieri 2008). In fact, biosemiotics enters in action immediately after ecology has delineated the relationships between different agencies (individual species, population, communities, ecosystems) integrating matter and energy dynamics with information, communication and meaning. In a recent paper, Harris-Jones (2009) has argued that the collapse of ecosystems is due primarily to a collapse in its communicative order rather than to changed physical states that could appear with slower biophysical effects “when for instance a global warming become apparent”. Working for general rules on resource definition, properties and dynamics, a biosemiotic approach seems to be the best way to investigate the interactions between organisms their aggregation and resources.

Fundamentals and some Definitions of a Resource Criterion

The term ‘resource’ is used in both ecology and economics, and literally it means to “re-surgere”, from the Latin “spring (surgere) again (re)”. The Oxford English dictionary defines resources as: “a stock or supply of materials or assets that can be drawn on in order to function effectively”.

We have adopted and apply the term to every natural element (abiotic and biotic) as well as to any man-made element, material or immaterial, which, after having been used/consumed, regenerates itself by way of its internal, independent mechanisms. Considering the high spectrum of resources it is possible to classify them into different categories:

According to consistency, in Material, Immaterial
According to origin, in Abiotic and Biotic (Biotic resources may be further distinguished into alive or no more alive)
According to their abundance, in limited (such as food) and unlimited (such as light)
According to the semiotic mechanisms utilized to track them, in indexical, iconical and symbolic.
According to the level of complexity, in simple (like water) or complex (like cultural identity or biodiversity).

The resource may be represented by matter (e.g. proteins), energy (e.g. warmth, light, potential energy), information (e.g. choices, discrimination, convention, rules, psychological and behavioural conditions), meaning (sign processes), and culture (established knowledge).

Material resources, like water, food and shelter, are popular subjects in ecology, while immaterial assets, such as safety, sociality or organized aggregation, identity, and sense of place, are the preferred subjects of the behavioural, psychological and societal sciences, as well as being part also of the overall ecological framework (Naveh 2000).

Some resources, like light or oxygen, are provided in quasi unlimited amounts and it appears difficult to connect them with an organismic feedback. For instance, sunlight is provided in such a large amount that we cannot state that plants ‘consume’ light by reducing the brightness of the sky, but effects like albedo are still a signal that some interactions occur. In the same way, the oxygen necessary to organisms is provided in so large amount that feedback arises only when the context is oxygen-limited like in a lake after an algal bloom.

Maintaining an organism alive is not a single event, but a regular, repetitive and continuous process in time and space, which also requires a constant supply of matter, energy, information and meaning (see the definition of life by Barbieri in "The organic codes" (2003)). For this reason, every organism must have access to a self-renewable system of refuelling, which must be available again sometime after its initial use.

When searching for an entity that is common to all living beings, the resource criterion seem to be the best candidate to link different processes across temporal and spatial scales. Resource pulsing not only affects individuals, but also determines the dynamics of populations and communities (Scheiner et al. 1993; Schwinning and Sala 2004; Holt 2008; Yang et al. 2008).

Describing resources, their relationships with organisms, and their aggregation (population, community, ecosystem, landscape and biome) seems to be a powerful approach to a "unified ecology". An emphasis on resources means that there needs to be a reconsideration of the habitat concept in ecology. It also requires more thought to be given to the role of the subjective status of each individual organism in relation to an external world that is different according to internal perception and elaborative status, as recently highlighted by McIntyre and Wiens (1999) (see also Boyce and McDonal (1999)).

Every living organism uses autopoietic mechanisms (*sensu* Maturana and Varela 1980), which are associated with a teleonomic project, to ensure the omeostatic maintenance of its interior system. Moreover, in combination with other perceptive and cognitive mechanisms, an organism also enters into a relationship with its external subjective context, the Umwelt (von Uexküll 1982).

Both the maintenance of the autopoiesis and the contemporary sensorial exploration of the surrounding context require 'fuel'. This is represented by matter, energy, information integrated by processes of meaning and culture to which we assign the generic term of 'resources'.

We refer to 'culture' as an agent not restricted to human context but extended to every organism that has accumulated some experience by the mechanisms of trials and errors. For instance, 'conceptual' resources like biodiversity are definitively difficult to evaluate and require specific cultural tools to assess them. At the same time, we are aware of the risk of a definitive deterioration caused by the expansion of infrastructure, urbanization and rural intensification, to which we have had no opportunity to assign a real value (Pearce and Moran 1994).

The generic term, *biodiversity*, refers to a collection of organisms and related processes to which we assign a value. These then become a resource with an additional or eventual function of being a Culturally Defined Key Stone Species (sensu Cristancho and Vining 2004). The value of biodiversity is not easy to quantify, as has been recently argued (Edwards and Abivardi 1998). For instance, the Mediterranean basin, although long subjected to human exploitation, retains a high biodiversity and is a major hot spot (sensu Myers et al. 2000).

Biodiversity thus becomes an "undetermined" resource. It is popular to claim that several tropical species, which have yet to be discovered and classified, could hold the key to special substances which may be of value to all mankind. However, we can only present a hypothesis that is based on a probabilistic model. In other words, without a sophisticated cultural model, such potential resources cannot be considered and evaluated.

Some Emergent Properties of Resources

This incomplete narrative is a first attempt to describe the basic properties of resources, their behaviour and their biosemiotic connections with organisms. We have encountered some difficulties in our search of the most general characters of resources and of their universal behaviour. Some entities, like sunlight, for example, act like resources when present in limited amounts, whereas in other cases they become the physical context in which organisms are embedded. The same is true for water, a medium for fishes and a true resource for terrestrial plants.

The more sophisticate relationships between organisms and resources occur when the resource is represented by other living organisms. In this case, the semiosis between the two entities is fully expressed by a reciprocal communication flow.

The resource 'springs up again' after its utilization. This property is particularly relevant because it states a strategic condition for the existence of life. This is that the energy necessary to complete the autopoietic cycles is available *continuously*. Limited resources become available at a certain period of time after their previous depletion. We say that resources have 'invented' rhythms.

Resources have the capacity to become available again sometime after their initial depletion. For instance, water in a pond in a desert will again be present after the aquifer has been recharged. The rhythm of 'refuelling' a resource becomes a continuous relationship with organisms thereby producing 'living rhythms' (daily, monthly, early, etc.). The birth of these rhythms is the birth of regularities, as well as of the spatial and temporal intervals necessary to enable resources to be regenerated; in other words, to rise again.

Thanks to meristematic cells, grasses recover the parts browsed by herbivores in just a few days, nevertheless obliging these animals to move around searching for other available resources. Similarly, soil that is farmed recovers its fertility after sabbatical intervals imposed by farmers, resulting in a shifting mosaic of cultivated and abandoned fields. In this way, the relationship between organisms and resources becomes intense in terms of information with a substantial reciprocal influence.

The appearance of regular characters makes finding them easier. Resources are characterized by regular features (chemical, morphological, behavioural) in order to facilitate their reconnaissance by the utilizers which adopt genetic or cultural mechanisms to track them down. Such regularities express information at the highest level (von Barwise and Seligman 1997), and every organism acts definitively in a 'regular' perceived world, while noise and disorder reduce the identification of resources and bring about environmental uncertainty.

According to their level of importance, resources are distinct in terms of being: necessary, optional and unnecessary. Necessary resources are those without which organisms can neither stay alive nor complete their life-cycle (e.g. oxygen, water, food, safety). Resources which are optional, like food diversity, degree of freedom, etc., determine the ill-being status of the individual when they are absent or only available in insufficient quantities. Finally, the resources which do not have an impact on the likelihood of individual survivorship, but access to them nevertheless expands the semeiotic niche (Hoffmayer 2008) (e.g. for humans, cultural resources like tribal performances, parties and ceremonies) are considered to be unnecessary.

Exploring the Biosemiotic Mechanisms Applied to the Resource Criterion

When resources are heterogeneously distributed in time and/or in space, accurate mechanisms of interception are requested in order to reduce the energetic cost necessary for their localization.

The 'central place foraging theory' (Stephens and Krebs 1986) demonstrates the adaptability of organisms when it comes to coping with the distribution of resources and to organizing themselves accordingly. Moreover, resource pulses produce an immediate concentration of organisms which are attracted by a local and unexpected abundance (Holt 2008). For example, in order to increase the availability of materials and cultural resources (see e.g. Turner et al. 2003), and thus improve local knowledge, aborigine people around the world have the ability both to look for resources at the edges, and to transform homogeneous areas into heterogeneous spaces.

The relationship between organisms and living resources is a kind of semethic interaction. This is when regularity is produced by a relationship of knowledge between two entities: the first of which assumes the role of resource for the second (e.g. prey/predator, flower/impollinator). This relationship represents a semethic (from *semion* (sign) + *ethos* (habit)) interaction: a 'personal' reciprocal knowledge (Hoffmayer 2008).

Living resources often adopt cryptic strategies to escape the 'predators/consumers' condition. There is an impressive amount of literature on this subject. Mimetism and cripticity seem to be the two main strategies adopted by some resources (animal and vegetal prey) to escape predation/consumption (e.g. Ractliffe and Nydam 2008).

The sequence <Need – Function – Semiotic interface – Resource> describes the hierarchical mechanisms necessary to track resources. The epistemological framework of this criterion foresees a specific physiological need as an indicator of the level of scarcity of a resource inside an organism's body. Every need activates a related function, and this has the role of finding the resource in the surroundings *via* the use of semiotic mechanisms. A resource is intercepted by a function using a semiotic interface which, in most cases, has a spatial structure.

Functions can be imagined as strings of instructions which activate the semiotic mechanisms that are capable of tracking a resource from its surroundings. When they are localized, resources are collected by using specific organs in the case of a material resource, or by cognitive processes for immaterial assets. In the particular case of animals (man included), each need activates at least one function which, in turn, produces cognitive templates (e.g., Real 1993) used to localize spatial configurations that are carriers of meaning (eco-fields) (Farina and Belgrano 2004, 2006; Farina et al. 2005). Such a semiotic process can be effectively described by formally adopting the triadic mechanisms of the Peirce semiological model (Farina 2008).

Different spatial configuration carriers of meaning (eco-fields) can exist in the same location and at the same time, producing different processes of meaning. The eco-field is function-specific for every resource, and can be found in association with others in the same location. For instance, the spatial arrangement of trees which creates a roosting site for some species of birds, can be perceived differently by squirrels, which use this spatial aggregation as a corridor through which they can move from one foraging site to another.

The collection of all of the species-specific eco-fields becomes the landscape, or Umwelt (sensu von Uexküll 1982), of an individual species (Farina and Belgrano 2004, 2006).

Taking into consideration the distinct nature of each individual, it is clear that there are subjective surroundings to the same extent that there are individuals. The surroundings are also distinct for both the different (social) aggregations (e.g. group, flock, pack) and the species. In this way, the complexity of an environmental context is the product of the different perceptual and cognitive interactions of each individual species.

The recognition of a spatial configuration carrier of meaning (eco-field) does not guarantee the presence of a resource, but does indicate the context in which a specific resource can be found. The eco-fields are indispensable when it comes to tracing resources while, relatively, saving energy. However, the existence of an eco-field does not guarantee the presence of the associated resource or does not predict their abundance. If a resource is not present, this is a failure of the process of obtaining this asset; we are in the presence of an ecological trap (sensu Dwernychuk and Boag 1972). When an organism enters into an ecological trap, it is unable to access that specific resource. This condition produces as a consequence a state of ill-being in the organism which will either become extinct or see its life expectancy dramatically reduced. This phenomenon has been described by Pulliam (1988, 1996) in terms of population source-sink dynamics. According to this last model, a source condition means that the necessary and optional resources have been located, whereas a sink status indicates the scarcity of one or more resource, with the consequence that an individual remaining in a specific location will not achieve the expected state of well-being.

When a (limited) resource is neglected and can no longer be identified, both it and its semiotic interface are lost. In large mammals like the wild boar when a resource like bulbs is neglected, for instance because sweet chest nut fruits are seasonally available, the disturbed patches regularly visited during bulb research are abandoned and the specific plant community based on regular disturbance regime (ploughing) is temporarily lost.

From a human perspective, in particular, the disruption of the use of a resource often causes its physical or cultural disappearance followed by the loss of the semiotic interface that is necessary for its identification. In this way, resources like fruit or varieties of seed lead to the disappearance of a specific eco-field if they are neglected. For instance, the abandonment of cereal production on mountain ranges will later result in the disappearance of the terraces that are man-made eco-fields and have lasted for centuries. The abandonment of silkworm rearing in Europe has likewise led to the loss of mulberry plantations, a very popular landscape configuration. Also immaterial resources when neglected produce the loss of their semiotic interfaces. This is the example of rural chapels that are fallen in ruin after the religious oblivion.

A Competition Perspective

The availability of contemporary resources is not a sufficient condition to guarantee the individual well-being, but the interferences between the proxies instead determine the final result. A condition of uncertainty can arise when the attainment of a resource reduces or eliminates the likelihood of realizing another. For instance, the foraging eco-field can come into conflict with the safety eco-field when the need for food creates a high risk of predation, meaning that this safety eco-field is lost.

A trade-off must be put in place if different needs are to be satisfied. In such a case, the single eco-field determines a selective process which can ultimately lead to the birth of new characters in the population or sub-population. In order to have access to resources, organisms often actually build the necessary spatial configurations. In the human case, agriculture is the process by which resources are provided. Other assets, like recreation and amenities, which are specific eco-fields, are achieved by planning and design (Farina et al. 2007). Likewise, several wild and domestic animals modify their foraging sites to facilitate the spotting of resources. In ecology this process is called 'niche construction' (Odling-Smee et al. 2003), and in humans and higher animals, the semiotic niche is of particular interest in this constructive process.

Competition between two species can arise when they have a resource in common which is located by using the same process of meaning generation. The ecological competition for assets such as territory, reproductive sites, and food is regarded as a competition for resources when these are specifically located by using the same mechanisms of meaning.

Moreover, two species are in competition when they share a resource that is considered to be 'important' for both of them. For instance, a mouse is prey for the fox (*Vulpes vulpes*) and the stone marten (*Martes foina*) as well (e.g., Padiala et al. 2002). This form of competition is, however, diminished when the same resource is considered 'necessary' for one species and 'optional' for the other, as reported by Patalano and Lovari (1993) between wolf (*Canis lupus*) and fox.

When resources have a common origin, their contemporary use creates indirect competition. Many resources have a common original agency which is considered to be the entity from which they are produced. For instance, the shade of a tree during the hottest part of the day is a resource for animals living in tropical savannahs, while the same tree is also a source of fruit for the same species. Similarly, a tree can produce food for local people as well as wood for the fire that is used to cook meals.

This phenomenon produces complex processes of indirect interaction between organisms. Such processes are particularly important for human societies in which social categories act as specific species. Soil is a common agency for foodstuffs (produced by farming), but also an agency for housing resources (urbanization). The same soil cannot, however, contemporarily provide the two resource in the same location.

The expansion of the semiotic niche favours the discovery of new resources, but this process requires novel and increasing investment in matter, energy and information. The niche construction hypothesis (Odling-Smee et al. 2003), by which every organism modifies its surroundings to improve its living space, is particularly useful when it comes to describing human expansion across the Earth. Agriculture is the best example of human niche construction, and has increased the number, variety and quantity of resources. But unlike other species, humans are also able to expand the semiotic niche in order to intercept new resources, thus buffering adaptive lag through cultural niche construction, as suggested by Laland and Brown (2006).

Habitats and Resources: A New Perspective

The habitat is defined by traditional ecology as both the place in which species (viruses, bacteria, animals or plants) usually live, and the physical place which is characterized by a specific geo-morphology, vegetation cover and peculiar climate (Clements & Shelford 1939). When a species prefers a specific habitat, it is considered to be a habitat specialist. But when a species can survive in a wide range of environmental conditions it is regarded as a generalist. For this reason the habitat concept requires more precision in a general accepted definition.

According to the resource criterion, the habitat can be defined as a place in which the resources that are necessary to maintain a species in a state of well-being are available. In this way, the habitat of the wood lark (*Lullula arborea*), which is based on morphology and vegetation, is represented by dry grass clearings in warm-climate woodlands. In contrast, the firecrest (*Regulus regulus*) is associated with conifers, wherever they are. This small bird has a clear preference for conifer woodland and gardens which range from sea level to the tree-line on mountains, and for it, the conifer plants are the habitat.

Yet the blackbird (*Turdus merula*) can be found in a wide variety of conditions, where shrubs and woodland cover is present irrespective of plant varieties and climate. We suspect that this species is able to extract resources in a variety of circumstances. In this example, the habitat definition is not enough rigorous. For instance, what if the woodlark's habitat is simply based on vegetation morphology-plus-microclima, while that of the blackbird is based on vegetation only? In these cases, by using the traditional habitat definition, it would be difficult to identify the proxies that distinguish the two species. In such a situation the concept of habitat could not be utilized, since it would be considered satisfactory only for some species and not for others. But if a specific habitat does seem to exist for some species, then the question arises: what would be the environmental variables to consider? It thus seems clear that the traditional definition of habitat is unsatisfactory, and creates difficulties in its description and interpretation.

Alternatively, if we adopt the Resource Criterion and define the habitat as the total space inside which a species' most important resources are available, it could have a more general definition which could be applied to all (see also, Magnuson et al. 1979). In this way, if the semiotic niche is larger, a species would be more environmentally informed and able to discover and use new resources. In the habitat conceptualization a species with a broad habitat is considered 'tolerant' or with an ecological valency. Having different strategies with which to trace the same resource seems to be the appropriate way to reconsider the habitat concept. With this approach, the hypothesis discussed here assumes that a species has a different capacity to find the same resource by using the semiotic interface (eco-fields) present in many areas that are distinctive because of their geographical and/or ecological conditions. This hypothesis is based on the notion that adaptations to different conditions are only possible after a broadening of the semiotic niche. In conclusion, these are the sign processes which enable access to different resources.

A species with a reduced semiotic capacity is always obliged to be on the look-out for the resources that can be found by using a limited sign process. In doing this, it transforms itself into a specialist. In this way, the firecrest (*Regulus regulus*), which practically lives on conifers, is unable to find resources elsewhere. This is not caused simply by a physical constraint, but by its incapacity to recognize other eco-fields outside the context of the conifers.

The semiotic niche and the ecological niche (*sensu* Hutchinson 1957) seems the two faces of the same coin. But while the ecological niche is defined as “an n-dimensional hypervolume, where the dimensions are environmental conditions that define the range in which a species can persist”, the semiotic niche is defined by Hoffmayer (2008) “the totality of signs or cues in the surroundings of an organism—signs that it must be able to meaningfully interpret to ensure its survival and welfare”.

Relationships Between the Resource Criterion and Human Societies

The access to resources is the obligatory status for every living entity. When all the necessary resources are intercepted, the organism enters into a state of well-being. But the limitation or lack of a satisfactory interaction with resources contributes to a state of ill-being. In particular, when applied to a multitude of people, well-being and ill-being can measure the health of human societies in relation to the efficacy of local, national, and international governance.

The more resources a society is able to locate, and the more efficient the mechanisms involved are, the greater its well-being, as recently argued by Dietz et al. (2009). The poverty of a society is determined by how possible it is to recognize (culturally) resources and/or to create the conditions in which they can be traced. In fact, ‘objects’ become resources only after semethic identification.

The access to resources must also be verified in terms of conflict in the contemporary use of two or more of them (tourism-agriculture, protected areas, logged areas, urban sprawl-agriculture). The economic evaluation of resources is not always easy (Boyd and Banzhaf 2007), especially when they are of a spiritual or a symbolic type, or when new fields of investigation, like conservation psychology, are introduced, as recently discussed by Saunders (2003). To assess these resources means evaluating the cost to society of healing the consequences of the lack of these assets in terms of ethics; creating rules which affect individual behaviour that can be criticized in a modern and open society.

Individual (personal) ethics and resources appear to be a relevant point for discussion. Personal ethics delimit the action of the individual without reducing or damaging the other components of a society. Ethics assume a relative character springing up from adaptive habits and rules. Every ethical habit reflects the use of resources. In this way, when we are dealing with the ethical use of resources, we should not jeopardize their access and their utilization by other individuals. This principle can be extended from individuals to societies.

In a human society, the access to resources is the first priority in everyday behaviour. A constitution lists the common assets that are guaranteed to every individual and community. The availability of a resource is considered to be a right. In this way, the right to freedom of expression, the right to have a job, the right to choose a parliamentary representative etc., are expressions of resources which shall 'not be renounced'. The right *per se* is the conventional context in which to guarantee access to resources. The complexity of human habits obliges societies to provide themselves with oral and written rules which describe the appropriate behaviour to be used so as to not interfere with access to the different resources available.

In natural systems, organisms have access to resources which are found within the vital (home) range (animal migration seems more an exception than a rule), but the use of assets that are located far away is strongly limited by the significant energetic cost expended in acquiring them. Often, in human systems, resources are also sought in distant locations. Such assets, called alloctones, create competition and conflict between individuals and societies. In such a system, the presence of available energy enables the use of alloctonic resources, which may be economically advantageous. This is possible because the cost of purchasing resources is not connected to their intrinsic value, but is the result of agreements or economic alliances between different countries. Indeed, several resources are available thanks to the political, financial and economic weaknesses of the offering nations.

The frequent use of alloctonic resources produces an imbalance in the areas from which an asset originates. In exceptional cases the resource is sold at the 'right price', but the equity of the commercial transaction and its ethics remain out of control. Equality in the democratic system interested in the transaction is a necessary criterion.

Globalization creates problems due to the geographical displacement of resources and to the unequal confrontation between trading and political systems (e.g. Andersson and Lindroth 2001). The existence of several political systems which are far from being democratic can lead to asymmetric exchanges which, ultimately, produce financial and economic distortions. Guaranteeing the use and availability of resources is a priority for every government, because this leads to the well-being of individuals and societies.

In non-human species, the location of resources is connected to specific Umwelten (sensu von Uexküll 1909), and individual habits in a species are fairly homogeneous. In humans, the Umwelten are differentiated at the level of each individual. In human species, the semiotic niche of each individual produces major differences in habits. This results in a continuous overlap and competition for resources in a society, making it necessary to come up with rules that are able to drive the resource use process. The rules then become laws, which represent the backbone of social dynamics.

Discussion and Conclusions

The Resource Criterion (RC) herein illustrated is the premise for a General Theory of Resources that could be able to link together conceptual and phenomenological domains which, until now, have been regarded by the ecological, economic and anthropological sciences as distinctive (Müller 1997).

The RC represents the necessary premise for a better understanding of the increasingly popular concept of ecosystem services, which is a field of research of exponential interest, as reported by Fisher et al. (2009). It is also a promising tool with which to apply and expand upon the economic theory of value (Straton 2005).

This criterion enables us to create a powerful epistemological context, analyzes in detail the mechanisms that connect all living beings to the physical and biological framework, and describes the ways in which species have semethic contact with their surroundings.

This approach connects the physical, informative, energetic and meaning components of the eco-systemic approach to both the semiotic processes of meaning, which were recently described by Nielsen (2007) as ecosystem semiotics, and the cognitive mechanisms for more evolved species. Moreover, resource criterion also considers the spatial attributes of ecological dynamics, adopting the eco-field hypothesis (Farina and Belgrano 2004, 2006).

Capturing resources becomes the goal of every vital project, and the mechanisms utilized are part of the complexity that surrounds every organism. The perceptive subjectivity of every biological species (plants included (Witzany 2007)) concurs with the complexity and vagueness of the ecological systems, although the physical constraints continue to be first order drivers.

According to this criterion, every species has at its disposal a limited range of sign processes (as expressions of evolutionary and adaptive mechanisms) which enable it to have access to corresponding resources. This permits many species to share the same physical, energetic and informative spaces with other species and organisms, thus reducing the risk to enter into direct competition with them.

We have to imagine that a forest has different meanings and functions for a fox, an owl, a little girl and a forester, as described so well by von Uexküll (von Uexküll 1982). Each species perceives a species-specific environment, and in agreement with the niche theory, this should reduces the direct competition between species that share the same location.

If morphological adaptation has represented the peculiar aspect of Darwinism, the mechanisms of meaning are considered by the Resource Criterion to be fundamental proxies in the evolution of species. If the processes of meaning could not be regarded as a priority in the tropical environments in which most of the resources are super-abundant throughout the year, in an environment in which resources are scarce, like in the cold regions around the world, the meaning capacity is the difference between dominant and subordinate species of a community. It is clear that if humans are now the key species in the totality of existing ecosystems, this has not been due to physical performance, but to the broader semiotic niche that enables people to have access to a growing number of material and immaterial resources. The problem with this semiotic adaptation is man's growing competition with many other species, arising from the fact that most of the new resources used by humanity have a common agency with the assets utilized by all other species.

The Resource Criterion is not the solution to the problems created by the semiotic expansion of humanity (see e.g., Rockström et al. 2009), but it is nevertheless an important tool with which to justify and address the new proactive behaviour that man ought to adopt in an attempt to reduce the growing risk of an irreversible deterioration in the entire Earth system.

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