Revista peruana de biología 21(2): 193 - 198 (2014)
doi: http://dx.doi.org/10.15381/rpb.v21i2.9827

ISSN-L 1561-0837
Facultad de Ciencias Biológicas UNMSM

COMENTARIO

On Boundaries

Sobre los límites

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Citación:

Cabrera-Febola W. 2014. On Boundaries. Revista peruana de biología 21(2): 193 - 198 (Octubre 2014). doi: http://dx.doi.org/10.15381/rpb.v21i2.9827

Abstract.

The exchange of information between natural entities is made through boundaries, this begs for a systematic study of them which so far has been lacking. Here, such study is provided, thus it begins by establishing a general conceptualization of boundary, which has been stated in a previous paper by the author, followed by the identification of some kind of boundaries. Thus, interface, limit, border and some of its kinds, and barrier are identified and conceptualized. Then, a partial study of some of the conceptualized boundaries is provided trying to analyze them as much as possible. Finally, a general discussion on the existence and importance of boundaries is given remarking the generality and robustness of the concept of boundary and its different kinds, hence its utility in science and technology is appreciated.

Keywords: Boundary; Natural Structure; Interface; Border; Surface; Barrier; Ecotone.

Resumen

El intercambio de información entre entes naturales se produce a través de los boundaries [límites], este hecho reclama un estudio sistemático de ellos, lo cual hasta el momento no se ha realizado. En el presente trabajo, establecemos el concepto general de boundary, para luego identificar ciertos tipos de boundaries como interface, límite, borde y algunos de sus tipos, y barrera son identificados y conceptualizados. Luego realizamos un estudio parcial de algunos de los boundaries conceptualizados, tratando de analizarlos lo más posible. Finalmente, se da una discusión general sobre la existencia e importancia de los boundaries remarcando la generalidad y robustez del concepto de boundary y sus diferentes tipos, de aquí su utilidad en la ciencia y la tecnología es posible de apreciarse. Por último se comenta sobre su perspectiva en ciencia y tecnología.

Palabras clave: Boundary; límites; estructura natural; interface; borde; superficie; barrera; ecotono.

Introduction.

The sense of boundaries of things in nature is, probably, one of the most easily perceived by human observers, but its study is relatively recent. It has been developed, as it seems, in three areas as the study of physics-chemistry of surfaces, the study of grain boundaries, and the study of ecological boundaries or ecotones. The first is perhaps the oldest established, the second came of age by 1957 (Padmanabhan 1990), and the third has gained acceptance, practically, by 1988 as a result of a meeting held in Paris one year before in spite that Clements described the ecotone in 1905.

One point to be emphasized is that these efforts are disparate lacking a general framework, which may establishes a unified vision of phenomena linked to boundaries.

Presentado: 12/07/2014
Aceptado: 16/08/2014
Publicado online: 07/10/2014

Journal home page: http://revistasinvestigacion.unmsm.edu.pe/index.php/rpb/index

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Here the development of such a general framework is intended, posing as a first step a definition of boundary, then I discriminate the different kinds of boundaries followed by the study of them and concluding with some remarkable points. In this way, the generality of boundaries is systematized and established in the grounds of natural structures, placing the point of departure to new developments on this topic in the search for understanding and explaining nature.

Definition

First of all it is necessary to recall the general definition of boundary (BOU) in Cabrera-Febola (2004). A boundary is everything that delimits an entity, in some way, from the rest. Perhaps it is necessary to clarify that here "from the rest" is referred to all the other entities of the universe.

Kinds of Boundaries

With a general definition of BOU stated it is worth identifying some kind of boundaries. Thus we have:

INTERFACE. Is the zone or place between adjacent entities. As a consequence it is necessary to have at least two entities in order to have an interface. There are three, basic, kinds of interfaces:

- Between Natural Structures (NE)
- Between NEs and any other entities
- Between entities other than NEs

The first will be called frontier or NE-interface, the second will be called NE-entity-interface, and the third will be called entity-entity-interface. It is necessary to clarify that in the definition of interface the word adjacent does not necessarily means touching. It has the sense of meeting, therefore the entities may touch, close approximate or penetrate (mutually or one into the other(s)) and they might go into interaction (which is defined in Cabrera-Febola (2004)).

LIMIT. Is referred to the extent that any entity may have in properties, characteristics or spatial extension. Therefore, there are two basic kinds of limits; one is the limit of properties or characteristics of an entity. The other is the spatial limit.

BORDER. Is the part of an entity that surrounds and contains the rest of it. There are two basic kinds of borders; homogeneous and heterogeneous. Homogeneous when it is composed of the same kind of entities and heterogeneous when it is composed of different kinds of entities. The border is the part that is in direct contact with the exterior which is everything that is not part of the respective entity. It contains the rest of the entity means that all the rest of it do not have direct contact with the exterior, in other words the border is in the spatial limit of the entity.

PSEUDOBORDER. Is something that contains an entity without being a part of it. It could be constituted by elements of he entity or not, although the latter possibility seems to be very difficult to appear in nature.

SURFACE. Is the external face of an entity which is in direct contact with the exterior. In entities with border the surface would be the external face of it.

BARRIER. Since a barrier is anything that shut the passage to other things but it seems that it is not absolute (i.e., there are some things that can cross a determined barrier and others than not), it must be defined from the entities that have to cross it. Therefore, it seems that to any entity there are some other entities which shut its passage, these latter will be called barriers to the first one. It is said "it seems" because we have the neutrino which is able to cross, it seems, anything, therefore, there would not be any barrier to it; but to all the rest of entities it seems that always it will be at least one barrier.

NOTE. The possibility of the existence of other kinds of boundaries out of the ones stated above remains open.

Partial Study of Some Boundaries

INTERFACES. It seems that the meaning of close approximation must be specified. Thus, close approximation would means that two or more entities are at a distance which is equal to an ε that could be as small as possible but never zero and/or as near as possible to the value of the unity of measure of the smaller entity but never equal to it, this unity will be what is usually used to measure the length of this entity from the point or points that is (are) adjacent to the other(s) entity/entities. The precise value of ε would be given by the distance at which the intensity of possible interactions between the adjacent entities is near a maximum. Perhaps it could be represented as an element of an interval like the following: $\varepsilon \in (0, U)$, $0 < \varepsilon < U$; which is an open interval from zero to the respective unity of measure (U).

It seems that the entities are placed in a medium or in a perfect vacuum (which seems to be very difficult to exist in nature). Perhaps it is interesting to point out that interfaces do not have an existence of their own, they are a consequence of adjacent entities. From this, it is clear that if one or both entities go away and/or one or both disappear (i.e., become destroyed) the interface must disappear.

Some other Kind of Interfaces. There could be the zero interface, when the entities in contact are touching, so there is nothing between them. This may be total or partial being the latter when there are some small spaces between the entities. The places of touching not necessarily constitute a bridge or channel. Other kind of interface would be momentary interface when the entities approach and separate only once or when they do this several times, and permanent interface when they remain adjacent until one or all of them disappear (i.e., they never go away from each other). One special case of momentary interface would be the marine shore and perhaps some other similar entities like lacustrine shore. Another kind of interface would be the one formed when one entity embodies another surrounding it completely (e.g., some NE in a medium). Of course the embodiment is not an interface, but the characteristic fact is that the embodied entity relates to an interface that surrounds it completely and it is isolated by the entity that is producing the embodiment. This kind of interface could be called embodiment interface.

The interfaces could be passive and active. Passive when the interface only receives the action of the entities, active when it also acts over the entities. It may be semi passive or semi active when it receives only the action of one of the entities or when it acts only over one of the entities, respectively.

Another kind of interface could be when one an entity is in some way contained in another and the first (the contained) is flowing (i.e., a river, a marine current). A variation of this interface will be when two contained entities are running aside each other, both in the same direction or opposite directions (e.g., two marine currents). This kind of interface could be called flowing interface.

Others could be when the interface something graded and when it is drastically cut from the entities. In the first case the entities may be somewhat mixed or may be intercalating some parts of each other without mixing. Some special case of graded interface will be the marine and lacustrine shores.

Other kind of interfaces would be when the interface is in a greater interaction with one of the adjacent entities and when it is equally interacting with all of the adjacent entities. Also when the interface is more similar to one of the entities or it has the same grade of similarity to all of them, or yet it is totally different to all of them. All this could be graded.

When the adjacency is a close approximation there would be two sub interfaces: one between what is in the zone and each of the entities in close approximation, this will be called second degree interface; and the other between the entities in close approximation, which will be called first degree interface. Additionally, in the interface may appear, develop and exist a NE or any other entity and what has been in the zone would be a part of this entity, this entity will be will be called developed interface; when nothing has appeared or developed in the interface it will be called undeveloped interface. The developed interface probably is formed because of the special conditions that result from the influence of the adjacent entities on the undeveloped interface. The special characteristics could be a result of a greater influence of one of the adjacent entities and these characteristics could be similar to that of this entity; if the influence is equally strong from both entities the similarity could be of the same grade as both entities. The developed interface may also appear when the entities are touching (i.e., zero interface) and when they are penetrating. The second degree interface can be of two types primary and secondary; primary is that between what is in the zone and each entity in close approximation and secondary is between each of these entities and what has developed in the zone. In some cases may not develop anything and remain only undeveloped interfaces.

As it has been clarified above about the word adjacent two or more entities can penetrate and mix. The zone or place between the adjacent entities will be the zone or place of mixing. This might occur between entities that do not have anything to prevent the penetration or simply that are able to permit it. Therefore, the zone of mixing should be the interface. Mix means that the elements of each entity which are in the interaction are surrounded by the elements of the other(s) entitiy (ies). It seems that to become mixed the elements must be disconnected, so they could be connected but they become disconnected in the mixing process, after finished it the elements may remain disconnected or they may become connected again both between the elements of each entity only or between them and between them and the elements of the other entities that are in contact, this could be meaning that a new NE has arisen.

To be a mix it is necessary that the elements are disconnected in the mixing process in spite that they would be connected before and after the mixing process. The mix zone, connected or not, seems to be a kind of developed interface (perhaps a special case of developed interface). When there is an interface that is a mix zone there will be an interface between the mix zone and each entity too.

If two or more entities are totally mixed they do not form an interface, they are, simply, mixed. So, to have an interface it is necessary that part of the entities must not be mixed; in the case that one of the entities is totally mixed while only part of the other is mixed there would be a penetration-mixing but not an interface, between the mixed part and the part of the entity that is not mixed there will be an interface. There could be an entity which is structured like a net and it may be totally surrounded and apparently penetrated by the elements of the other entity(ies) , but in this case there will not be a mixing and the interface would be between the parts (border) of the like net entity in contact with the other(s).

BORDERS. Entities possessing a border may be totally closed when they do not permit anything to go out or in; semi closed when they permit things to go only out or into the entity (when there are two adjacent entities things may go out or into of both or to one go into and to the other go out); open when things going out and into. This may be done continuously (the go of things out and/or into of the entities) or for moments (intermittent). A totally closed border is when nothing can cross it and totally open when everything can cross it. But these cases can be only ideal; the most probably is that they do not exist in nature. Between these two extremes there must be a gradation.

Between adjacent entities there could be the formation of bridges or channels. Also there may be the case of borders which permit the pass of only energy and others that permit the pass of only matter; therefore, the first may be called open to energy and the latter open to matter. The open to matter is closed to energy and the other the inverse. Also there may be semi closed to matter and open or closed to energy and vice versa. Also semi closed for both (matter and energy) in the same or opposite directions. The latter case is the first idea expressed in terms of matter and energy with the specification of the directions.

Zero interface exists in a range from only one point of touching to total touching passing for two, three, etc. , points of touching and to an increase in the length of the space of touching and in the number of such spaces up to a total touching. It seems that the later possibility is only for entities that have border.

The case of mixing saw above may be between entities that have disconnected or partially connected borders, pseudo borders, and also connected borders but with connections of a kind that permit the mixing. The border or pseudo border of any of the two entities will be in its spatial limit when it is included the mixing zone, but without that zone (i.e., the entity as pure) the border or pseudo border will be that aside the mix zone. If the mix zone is a connected entity (i.e., a NE) the only borders will be that of the entities as pure. Of course in any one of the cases above the mix zone has its own border or pseudo border. It seems that borders in general are like barriers of a minimum degree.

Some things that are related to borders are exterior and in-

terior. Everything that is covered or surrounded by the border is in the interior of an entity. Everything that is not covered or surrounded by the border of an entity and is not in the border is in the exterior of the entity. The same must be in reference to pseudo borders when they are formed by elements of the entity in case. In the very improbable case that it is not formed by elements of the entity anything that is not covered or surrounded by the pseudo border is in the exterior of the entity.

It seems that borders "create" discontinuities or disruptions. Also that interfaces do this, this seems to be because the entities that share the interface are reaching their spatial limit at that place, therefore they are interrupted or disrupted. In some cases interfaces can "create," in some sense, a continuity if the entities (they would be sub-entities in this case) that share the interface form part of a major entity, which is a whole and as such it is continuous; therefore, it seems that, in this case, the interface is connecting the adjacent entities. An analogy would be a brick wall, where bricks are joined by cement which is in the space between the bricks. In this way the wall arises as a whole, without the cement there would be "empty" space between the bricks and the wall would not be a wall, it would disappear becoming an aggregate of bricks and no more a whole.

It seems that the earth has a disconnected border which is the atmosphere. It is part of the earth and it is connected to it, but it is a disconnected entity.

It seems that some kind of NEs like couple of mates, animals fighting have a border which is the sum of the individual borders when they are touching each other; this should be in general with NEs of these types. When they are not touching they could be visually connected and the photons must be part of the NE and of the border. In general any particular case of these types of NEs must be analyzed in order to see if they have a border or not. It exists the possibility that some NEs could have disconnected borders like the earth. But it seems that any NE has a border and that only NEs have border.

Other NEs that have borders which are not easy to be perceived would be galaxies, the universe, atoms, the planetary systems, clouds, schools of fishes, and flocks of birds and other similar animal agroupations.

Connection not necessarily means that nothing can pass between the connected entities. But, since two things cannot occupy the same place in space at the same instant, things can move only displacing other things (because it seems that there is not any empty region in the universe), therefore entities very strongly connected would be very difficult of being displaced and borders connected in this way would be barriers of high degree. In consequence, as stated above if things can pass or not connected entities will depend of the kind of connection and how the entities are connected. Some borders may possess spaces which may permit the passing of some things.

LIMITS. It seems that every time that an entity gets its spatial limit an interface appears, because entities are not in a vacuum; in consequence, at the limit of one entity it will be the limit of another one and a zone should be between them.

It seems that in the case of disconnected entities, to pertain to the respective entity an element must be engaged in the same activity than the other elements of that entity and must be covered by the pseudo border or in it; (i.e., all the elements that are engaged in a determined activity and are covered by a pseudo border or in it pertain to a specific entity).

It seems that there should exists a minimum reach of spatial extension in any direction of an entity; under this minimum reach the entity would disappears, also there might be a maximum spatial reach over it the entity would disappears. Therefore, the spatial limit will be called minimum spatial limit and maximum spatial limit respectively. If the minimum and maximum reaches are the same, the entity most probably is limit invariant.

It seems that there is also the durational limit of an entity, which is referred to the span f its existence which would be got without the action of any other entity. This durational limit may be constrained and reduced or, perhaps, enhanced and amplified by the action of other(s) entity(ies). These two possibilities could be denominated fundamental durational limit and realized durational limit.

Remarks and Perspectives

The definition of boundary in this paper encloses the ideas of boundaries given by Salthe, Longman and Jenik, Wiens, and Pinay et al. (1985, 1992, 1992, 1990), and it is in great extent overlapping with the idea posited by Buchler (1990).

Some could doubt if boundaries have any worth? I think that they are very important Allen and Hoekstra (1992), for instance, show us that it is by the surface (a kind of boundary) that the whole communicates to all the rest and is at that boundary "where the dynamic forces dominating the internal functions of an entity reach their functional limits." They, also, add that the skin of animals contain the individual organisms and regulates the passing of pathogens to permit the achieving by the animal of a new infection. Also, they indicate that surfaces filter energy and material. It seems clear that they are calling surface to what has been here identified as border. Hansen et al. (1988) point out that the nature of the boundary between elements of a landscape may strongly influence their mutual interactions. Holland (1988) asserts that ecological boundaries play an important role in the management of natural environments, because they are important for predation and biological control, they are they are zones for many species of cynegetic importance to reproduce and they may have an important role for biodiversity. In consequence, we can see that boundaries play important roles in nature, without boundaries there will not be any individualization of entities everything will be an undivided continuous, and without individualized things there would not be possible the surge of any NE; therefore, the universe including us would not exists. Not only communications but also interactions seem to be produced through boundaries.

Therefore, if boundaries show to be as important as they seem it will be very valuable to study them, and in doing so it could be possible to envisage new important aspects of their role in nature and of nature itself.

One point that is worthy to be mentioned is about the existence of boundaries. It seems that it is clear the finiteness of entities in nature, from this the existence of boundaries arises undoubtly. Margalef (1972) makes this point when he expresses that nature looks discontinuous and that boundaries

seem "real." Also he says "[Either the surface of each organism as, in a different scale, the 'surface' of phytoplankton patches may be conceived as significative frontiers in the ecosystem structure and function (translation by the author)]" (Margalef 1980). Allen and Starr (1982) express that "the cell has a surface that is readily recognizable in human perceptual terms … Since the cell membrane is tangible …" they also say "The prevalence of readily identifiable surfaces in the hierarchies of life (organelles, organs, individuals, population mosaics) is a reflection of the importance of localizing fatalities (by means of surfaces) …" Allen and Hoekstra (1992) indicate that "solid concrete things are surrounded by surfaces. The surface is all that we see of most things because it is the part through which the whole communicates with the rest of the universe. …The integration of the tree produces a tree surface …Processes are held within surfaces …" "the boundary of the organism is usually tangible." "Ron Neilson has data that suggest that the boundaries of entire biomes can be remarkably robust." Bonner (1993) relates how packs of wolves show tangible territorial borders which they patrol. Out of doubt is the tangibility of grain boundaries, being them a field of intense research as is shown by Padmanabhan (1990).

In spite of all this there are some researches who pose some doubts about the existence of boundaries thus Margalef (1975) expresses "Everywhere in nature we can draw arbitrary surfaces and arbitrarily declare them boundaries separating two subsystems … Any ecosystem under study has to be delimited by arbitrary decision …" Allen and Starr (1982) point out "We suggest that it is more profitable to view the discreetness of levels as a product of human perception." Allen and Hoekstra (1992) express "surfaces disconnect the internal functioning of entities from the outside world. The disconnection is significant but not complete. Therefore, the observer has to judge whether or not the disconnection is sufficient to warrant designating a surface. That judgment is what makes all surfaces arbitrary, even natural surfaces that are robust to transformation.", also they pose the difficulties for the spatial tangibility of communities and ecosystems which impose the same problem to their boundaries. In the same vein, Cousins (1990) points out that population, ecosystem, and biotic regions no posses objective spatial boundaries except where a physical discontinuity is provided by topographical, or other aspects of the abiotic environment. He makes note that a problem which is at the heart of ecological science is that of the identification of ecosystem boundaries. But what is clear that all of these authors are doing is transferring the difficulties that exist in recognizing some ecological entities to the existence or not of boundaries in nature which from the above previous paragraphs are clear to exist. In addition, one more time the subjective way of looking to nature is at work. Thus the problem is if we can recognize some unities like ecosystems and by doing it if we are able to find their boundaries. What it seems must be done is an effort to elucidate if researchers wish, simply, to create units to develop their work artificially for practical goals or to clarify what really are the entities in nature in order to explain and know it.

One point which is interesting to be mentioned is about the existence of the boundary of the universe which is put in doubt for some researchers. What can be say is that since the universe is a NE it must have a boundary which would also be expanding with the expansion of the whole universe.

It seems that some entities might have multiple boundaries, in the sense that they are inner parts or elements of another entity which has its boundary, therefore these would have at least its own boundary and the boundary of the whole that contains them. The boundaries of this multiple boundary may be from two to n.

Allen and Starr (1982) pose the possibility of antisurfaces (it seems that they are referring to antiboundaries and antiborders). They express that homogeneity is a feature of antisurface (in their parlance), but the fact that the world is populated by a diversity of entities which in addition are finite does not mean that heterogeneity is a feature of surfaces (I understand boundaries), because the homogeneity of something say pure water is not due to the lack of discrete units (molecules, atoms, etc.) therefore it is not the lack of borders (and boundaries in general) but this not eliminate the homogeneity of the entity. Another point is that it seems that they are proposing that structural surfaces (borders?) are dependent of steep gradients which is not so, it is possible that in general this may occur at borders and other boundaries, but it not necessarily mean that a boundary depends of any gradient this only might be a consequence of certain boundaries. What must be pointed out is that if there is something like antiboundaries it must be something that not delimits, in any way, an entity from the rest; therefore, what this imply is not homogeneity but strictly continuity. Perhaps, in some sense, an antiboundary and in the specific antiborder would be communication channels which Allen and Starr come across.

The definition of ecotone based on operational concerns presented by Holland (1988) represents the application of the definition of interface to ecology with some complementarities that are in some extent unnecessary as part of the definition, because it is logical that the ecotone must have some specific characteristics which might be put in a complementary paragraph. It seems that ecologists also use the idea of border as ecotone. But, it must be taken in consideration that they are two different kinds of boundaries.

To come to an end it is worth to say that the generality of the concept of boundary and its different kinds is unquestionable, they may be applied to any entity like ecological boundaries or ecotones and some related boundaries like the transition zones between populations with different genetic structure to durational discontinuities, to surfaces and interfaces of materials, to the biggest and the smallest entities in nature. From these diverse entities the central and unified concept of boundary and its traits can be enhanced and viceversa.

Acknowledgements.

The author would like to thank T. F. H. Allen for a review of the first part of the article, and to C. Marcelo-Serván, R. J. Naiman, and D. Pacheco for a general review of the whole article. They should not however be blamed for any remaining shortcoming.

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