Modelling Ecology from Logic

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Abstract

The thesis of this essay is that logically valid formulations guarantee correct and coherent summaries of scientific data. Several studies are presented that can be shown to be inadequate or simply wrong by logical procedures. But large and small aspects of nature are described and then summarized correctly by logically valid formulations.

Logical Formulations

The intent of the following enterprise is to present several logical formulations and how they can be applied to scientific data. The reason for presenting these formulations is that the discursive presentations of data are often inadequate or simply wrong. First, the logical formulations will be given as a series of instructions. Second, several studies will be given, their inadequacies pointed out, and their data reset in a correct logical format. Third, some features of nature, both large and small, will be presented and then summarized by the logical formulations.

The instructions for logical procedure come under three headings: contraposition, equivalence, and constructive dilemma.

Contraposition comes in two forms:

a) If this then that – equivalent to: if not that then not this.

b) That if this – equivalent to: not that only if not this.

An example of a) is: if a vertebrate is functional year-round (a squirrel), then it is adapted to year-round temperature – equivalent to: if a vertebrate is not adapted to year-round temperature, then it is not functional year-round (a toad). An example of b) is: a vertebrate is adapted to year-round temperature, if it is functional year-round (one squirrel) – equivalent to: a vertebrate is not adapted to year-round temperature, only if it is not functional year-round (one toad). Instead of two animals there can be one *x* so that we have: *x* in a squirrel is adapted ….; *x* in a toad is not adapted…… One *x* in two animals is like one coin with two sides, one head of Janus with a face looking back and a face looking forward.

Equivalence is this:

> If this then that, and if that then this – equivalent to: this equivalent to that.

An example is this: if plant species *a* is adapted to habitat *b,* then habitat *b* is adapted to species *a*, and if habitat *b* is adapted to species *a*, then species *a* is adapted to habitat *b* – equivalent to: species *a* is adapted to habitat *b* if and only if habitat *b* is adapted to species *a.* Wherever we have *equivalent to* we can have instead *if and only if.*

Constructive dilemma is this:

> First or third; if first then second, and if third then fourth; therefore, second or fourth.

An example is this: there is leaflessness or there is leafiness; if there is leaflessness, then there is winter adaptedness, and if there is leafiness, then there is summer adaptedness; therefore, there is winter adaptedness or summer adaptedness.

This is the first part – a bare presentation of logical structures. The presentation is in terms of two entities, two concrete particular land vertebrates in temperate regions in contraposition. This structure can be generalized to cover all temperate land vertebrates. Likewise equivalence can be generalized for various pairs. Constructive dilemma has four entities here; each entity is a single abstract entity as indicated by the suffix *ness*. Of course constructive dilemma could be carried out using concrete entities and generalizations applied to these.

Contraposition and constructive dilemma are involved with temporal change where the entities can be linked by a single *x*. Equivalence describes steady state.

Confused Thinking

Five cases of confused thinking are presented next.

Let us consider the account of Kricher and Morrison (1989, pp. 141-143). They say that in the eastern woodchuck of the U.S.A., “the ability to hibernate……is an adaptation”. The gray squirrel is pointed out because it lacks this adaptation. They want us to believe, *without a shred of evidence,* that “In the past, probably millions of years ago, woodchuck ancestors possessing the ability….to sleep deeply for at least part of the winter, were the ones that survived best….and left most offspring in the overall woodchuck population.” They are concerned with the origin of adaptation. They say “an adaptation in one species is never guaranteed to evolve in all species, even though it would be advantageous.” They are referring to the woodchuck. But here the ecological issue is this. Is the woodchuck adapted because it hibernates and is the squirrel *not* adapted because it does *not* hibernate? It is baffling that such an obvious ecological contrast is not made. This ecological issue can be expressed in the first form of contraposition as follows:

> If a woodchuck hibernates, then it has an adaptation to winter – equivalent to: if a squirrel does not have this adaptation, then it does not hibernate.

The ecological issue can be expressed also by the second form of contraposition:

> A woodchuck has an adaptation to winter if it hibernates – equivalent to: a squirrel does not have this adaptation only if it does not hibernate.

In the first form, a), there is denial and reversal of the structural parts. In the second form, b), there is denial but no reversal.

A similar line of confused thinking is from Seger and Stubblefield (1996, pp.99-102). A frequency distribution of clutch sizes for nearly 4500 clutches is given for great tits (*Parsus major)* in Wytham Wood near Oxford (England). A tit produces 1 egg per day to give its clutch size; clutch sizes over 11 eggs per clutch rarely occurred, and the average clutch size was 8 or 9. Newly hatched birds were often added to other clutches and all young were ringed and captured a year later (Boyce and Perrins, 1987; Perrins, 1965). The clutches that produced the greatest number at the end of one year was 12. Though this large number of successfully bred and surviving birds was partially artificial, Seger and Stubblefield say "The most productive clutch is 12, but the commonest clutches are 8 or 9. Parents therefore appear to lay smaller clutches, on average, than those that would maximize their fitness." If "maximize their fitness" is interpreted to mean "best adapted", then it would seem that the commonest clutches are *not* best adapted. Their thinking is confused and wrong. What is correct is made available by the formulations of contraposition:

> If a tit produces 12 offspring per clutch, then it maximizes its fitness (is best adapted) - equivalent to: if a tit does not maximize its fitness (is not best adapted), then it does not produce a clutch of 12 offspring (produces 8 or 9 instead).

And the second form of contraposition could be marshaled to show the wrongness of the authors' approach.

Lewontin (1978) is confused as he presents a large scale view of adaptation. He says "the wholesale reconstruction of a reptile to make a bird is considered a process of major adaptation by which birds solved the problem of flight." This wholesale reconstruction of a reptile includes the four traits or properties common to all birds: hollow lightweight bone, increased size of sternum, change in integument to feathers for flight and insulation, and increased forelimb. With these properties a vertebrate is adapted to flight. What is not mentioned is that without these properties a vertebrate is *not* adapted to flight. This is what "process of major adaptation" is: from *not* adapted to adapted. If *x* in a reptile is *not* adapted to flight, then *x* does *not* have the four traits – equivalent to: if *x* in a bird does have the four traits, then *x* is adapted to flight. Same *x*. Two animals. This is a correct description because it achieves continuity of process in the logically valid structure of contraposition.

A further case of confused thinking is provided by Gould and Vrba's (1982) treatment of adaptation and exaptation: adaptations fit the organism to the environment and originate through natural selection, whereas exaptations fit the organism to the environment, but do not originate through natural selection. One case of theirs is the black heron of Africa, which stands on the bottom and stretches its wings out and shades the water so that small fish can be seen and caught, a process called mantling. They say the following: "We see, in this scenario, a sequential set of adaptations, each converted to an exaptation of different effect that sets the basis for a subsequent adaptation. By this interplay, a major evolutionary transformation occurs that probably could not have arisen by purely increasing adaptation. Thus, the basic design of feathers is an adaptation for thermoregulation and, later, an exaptation for catching insects. The development of large contour feathers and their arrangement on the arm arise as adaptations for insect catching and become exaptations for flight. Mantling behavior uses wings that arose as an adaptation for flight. The neuromotor modifications governing mantling behavior, and therefore the mantling posture, are adaptations for fishing. The wing per se is an exaptation in its current effect of shading, just as feathers covering it also arose in different adaptive contexts….". This array of imaginings, presented in a deceiving factual way, is totally inexcusable in itself. But the array further conceals the plain truth that it is a matter of fact that the wing is adapted, is fitted, is suited for flying and also for mantling. Both examples of being adapted are simply factual matters. The adaptedness of the wing is exemplified in two concrete activities, flying or mantling. What is a correct statement of actual facts is this:

> There is flying or there is mantling. If there is flying, then the adaptedness of the wing is exemplified in flying; and if there is mantling, then the adaptedness of the wing is exemplified in mantling. Therefore, adaptedness of the wing is exemplified in flying or mantling.

Here a single abstract property, the wing's adaptedness, is distinguished from the concrete physical activities of flying or mantling, which are embodiments, examples, of this adaptedness. The structure presented is constructive dilemma.

And the next issue is an inadequate theoretical presentation. Brandon (1990, p.11) says "If *a* is better adapted than *b* in environment *E*, then (probably) *a* will have greater reproductive success than *b* in *E*." This is incomplete. Brandon should have said also, "if *a* does not have greater reproductive success than *b* in *E*, then *a* is not better adapted than *b* in environment *E*." These two sentences are a complete description. The two sentences together are a case of contraposition that we have been considering. The mistake is to consider only the affirmative half of contraposition and in so doing only consider unreasoningly the better adapted, omitting the worse adapted. Brandon goes on and says (p.15), "*a* is better adapted than *b* in *E* iff [if and only if] *a* is better able to survive and reproduce in *E* than *b*." But this is only part of the logical formulation of equivalence, which is (omitting the irrelevant phrase 'to survive'): if *a* is better adapted than *b* in *E*, then *a* is better able to reproduce in *E* than *b*; and if *a* is better able to reproduce in *E* than *b,* then *a* is better adapted than *b* in *E* – equivalent to: *a* is better adapted than *b* in *E* if and only if *a* is better able to reproduce in *E* than *b*. This is correct. In order to be correct the whole formulation must be written out in complete detail.

Some Features of Nature: Contraposition

Adaptedness and non-adaptedness occur in temperate land vertebrates and higher plants.

Let us consider the property of being year-round functional (functionality) in the sense that the organism is metabolically and behaviorally active year-round. This single property would be in a non-hibernating mammal, would be exemplified by each such animal. Additionally, this property would dictate having the property of year-round adaptedness in each non-hibernating mammal. Then let us consider the property of not being year-round functional (non-functionality) – getting through the winter in a moribund or inert state and only coming to life, so to speak, with the return of spring and summer. Cold-blooded vertebrates become active and gymnosperm plants grow only with the return of spring and summer. So these organisms are examples, exemplifications of the single property of being year-round non-functional. Additionally, this property dictates the property of not being year-round adapted, of having the property of year-round non-adaptedness in each cold-blooded vertebrate and each gymnosperm plant. But though considerable integration of the biological situations is achieved by seeing the structure of nature via properties and their exemplifications, the portrayal is still basically inadequate and disconnected without being reset in a logical framework. And so summarizing we get:

> Year-round adaptedness is exemplified by non-hibernating mammals if it is dictated by the year-round functionality[1] of these mammals – if and only if year-round non-adaptedness is exemplified by cold-blooded animals and gymnosperms only if this property is dictated by the year-round non-functionality of these animals and plants.

The *if and only* if version of *equivalent to* in the b) part of contraposition connects the two aspects of nature in a detailed way. In a simpler way we could have;

> There is year-round adaptedness if there is year-round functionality – equivalent to: there isn't year-round adaptedness only if there isn't year-round functionality.

The connectedness of the two aspects of nature is achieved here, too, and this feature is simply a requirement for coherent science.

A specific case very much like the preceding situation will now be given. The common mud snail *Nassarius obsoletus* hibernates in effect in winter, whereas the worm *Capitella capitata* does not. *Nassarius* grows rapidly near Woods Hole (northeastern United States) during summer months, any population showing at least three size classes of animals from this year, last year, and the year before. During late

[1] functionality = the property of being functional

autumn, winter, and early spring there is essentially no growth. This is related to the cessation of feeding, followed by a migration into deeper water, and a subsequent period of quiescence (Scheltema, 1964, p. 164). But *Capitella*, when the environment is disturbed, may then become overwhelmingly abundant. A period of such abundance extended from October 1969 to September 1970, subsequent to an oil spill near Woods Hole (Grassle and Grassle, 1974). *Capitella* has a short life span, taking 30-40 days to mature, so that a number of generations would be expected to maintain the year-long abundance. In support of this were observations of settlement of larvae in winter and summer, though with the greatest settlement from May to October.

> This description can be brought together in this way. If *Capitella* in effect does not hibernate, then it has a number of generations of growth through out the year – equivalent to: if *Nassarius* does not grow throughout the year, then it does in effect hibernate.

The *a)* form of contraposition organizes the desultory empirical details, transforming crude science into coherent science.

Further Features of Nature: Equivalence

Each flowered plant and spot that bears it go forth hand in hand, for each is adapted to the other. Similarly, each of the 900 species of North American birds is attuned, is adapted to its area of occurrence as its area of occurrence is attuned, is adapted to it (National Geographic Society, 1999). Then further, the species of bird that stays in the north throughout the year, is adapted when breading to its area, which is adapted to it, and when not breeding has the same reciprocal adaptation. And further still, the species of bird that flies south for the winter has its non-breeding area and reciprocal adaptation there and then when it flies north for spring and summer has its breeding area and reciprocal adaptation there.

And so when species is adapted to its area and its area is adapted to it, we can tighten this linkage by: *if* species is adapted to area, *then* area is adapted to species. But why should the asymmetry go from species to area; so let's have the asymmetry go the other way: *if* its area is adapted to species, *then* species is adapted to its area. Let's just settle for both, and cap the sequence in the following way for all North American bird species:

> If species *x* is adapted to area *y*, then area *y* is adapted to species *x*; and if area *y* is adapted to species *x*, then species *x* is adapted to area *y* – equivalent to: species *x* is adapted to area *y* if and only if area *y* is adapted to species *x*

This is a complete distributional summarization of the birds of North America. Any other summarization would be incomplete and wrong, in the sense that any other summarization would lack the coherence of this logically valid one.

A different and more detailed case of equivalence is the gastropod larvae of the Atlantic and Pacific oceans. Veliger gastropod (snail) larvae are tiny snail-like forms (Sheltemea, 1971; Sheltema and Williams, 1983). They are planktonic, existing for as long as 55-320 days in a form capable of settlement and metamorphosis if contact with land happens (Sheltema, 1971). They occur over large areas of the Atlantic Ocean or Pacific Ocean. They are carried passively by equatorial westward currents; there are north equatorial and south equatorial currents and a minor eastward countercurrent between them in both the Atlantic and Pacific Oceans. The larvae are produced of course by parent sub littoral snales on the shores of the Atlantic continents and on Pacific islands. The tiny larvae (1 mm. or less) occur as a number of species in about a dozen families. A number have been studies in detail; 15 are described in detail in the two studies just mentioned. But many more are present in the samples that span the equatorial oceans. Though they are produced along the shore, they are supported by the single equatorial environment of the Atlantic and by the single equatorial environment of the Pacific (Sheltema, 1995; Sheltema et al, 1996). Additionally, the environment of the Atlantic is suited to all larval species which are suited to the environment. Likewise for the Pacific environment. The larval species seem to be indiscriminately scattered across the Atlantic and across the Pacific, too. All this is summarized in the next paragraph.

> If the tropical ocean is suited (adapted) to many gastropod larval species, then these larval species are suited (adapted) to it; and if the larval gastropod species are suited (adapted) to the tropical ocean, then the tropical ocean is suited (adapted) to them –equivalent to: the tropical ocean is suited (adapted) to the gastropod larval species if and only if they are suited (adapted) to it.

Thus at length there is a correct description of this oceanic situation, wherein there is a one-many-one sequence of ocean to species to ocean. Looking back to the birds of North America, there is the same sequence in that the whole continent is adapted to all the species scattered across it which are adapted to it, a one-many-one sequence. Additionally, there is a one-many-many sequence, wherein the continent is adapted to the many species and each species is adapted to its own unique area. One sequence in the ocean, two sequences on land – this is the mark of the ordered pair, wherein a single sequence constitutes a single–membered set which *precedes* a double sequence which constitutes a double-membered set which looks like this:

{single sequence a}, {double sequence a,b}

This is a central feature of set theory, and its application in the natural world is extraordinary.

Some Major Features of Nature; Constructive Dilemma

The case of the non-hibernating mammal, which is active year-round and so adapted to year-round temperatures, and the case of the cold blooded vertebrate and the gymnosperm plant (pine or spruce) which are not active or functional year-round and so are not adapted to year-round temperature are cases of large features of nature that involve contraposition. The next cases are large feature too, but they will involve constructive dilemma.

1.	Leafless limbs	Leafy limbs
2.	Seeds of annuals	Plant forms of annuals
3.	Underground parts of perennials	Above ground parts of perennials
4.	Hibernating individuals of hibernation type mammals	Non-hibernating individuals of hibernation type mammals
5.	Diapause insects	Non-diapause insects

The pairs of the five cases are concrete physical objects, unlike the example in the beginning of this essay where the first pair is two abstract entities. The plural form refers to all entities. In order from the top we have: all limbs are leafless or leafy, all annuals are seeds or plants, all perennials have underground or above-ground parts, all hibernation type mammals are hibernating or not hibernating. The last pair can be put into constructive dilemma form as follows:

> All insects are in diapause or non-diapause condition. All insects, if in diapause condition, are winter adapted; and all insects, if in non-diapause (winged) condition, are summer adapted.
>
> Therefore, all insects are winter adapted or summer adapted.

All pairs can be gotten into this structure, delineating a large portion of nature explicitly and coherently.

A more specific case of constructive dilemma is the following.

Steele and Koprowski (2001, pp. 66-69) describe the red or pine squirrel (*Tamiasciurus hudsonicus)* and the Douglas squirrel (*T. douglasii)* as perfect examples of larder-hoarders. The pine squirrel in particular has the physical traits of being smaller than other squirrels, of being reddish. It has the behavioral trait of being aggressive in defending its middens of spruce and pine cones that it collects for future eating. It has the trait of making collections of cones that will last at least a year. These collections are close to where it lives. In addition to all these traits, these properties, it has the property of being distributed across northern U.S.A. and southern Canada, and thus we can see its larder-hoarding is carried out where cones are easily gotten. And thus the pine squirrel has the property of being adapted to the environment that has the property of supporting it. And additionally, the pine squirrel has the property of being adapted to an environment having the property of being adapted to it.

Steele and Koprowski (2001, pp. 68-82, 143-147) describe the eastern grey squirrel (*Sciurus carolinensis)* and the fox squirrel (*Sciurus niger)* as good examples of scatter-hoarders. Both have the property of being larger than the pine squirrel and Douglas squirrel, of being grey, of being non-aggressive and having widespread small caches of various foods, quite often acorns. The two species overlap each other in their distributions, though the fox squirrel may occupy a more open, more upland habitat than the grey squirrel. The two species are distributed throughout the eastern U.S.A. So they are adapted to this deciduous environment that supports and is adapted to them.

Let us pause and reflect for a moment. When we look about, we are predominantly surrounded by friendly people. Do we wish to think of them as bearers of friendliness? Yes or no, there are three steps in the following sequence: 1) a friendly person, 2) a person is friendly, 3) a person has the property of friendliness. The austere nominalist, who doesn't believe in properties, chooses 1) and maintains that 2) reduces to 1) because 2) is only a linguistic formula (Loux, 2003, pp. 60-83). The metaphysical realist, on the other hand, believes in properties and endorses 3) and says that 2) is just an ill-formed version of 3) (Loux, 2003, pp. 20-35). 3) is vastly superior, in the opinion of the author. Properties are in the members of the group, in each friendly person. But the group groups its members by taking and marshalling their property. There can be a set or group of friendly people only when the group has the property of friendliness to group them by. There can be a set or group of larder-hoarding squirrels only when the group has the property of larder-hoarding to group them by; this is A_1. There can be a set or group of scatter-hoarders only when the group has the property of scatter-hoarding to group them by; this is set A_2. We can have thence further sets and their properties:

1. A_1 has the property of larder hoarding or A_2 has the property of scatter-hoarding.
2. If A_2 has the first property then A_1 has the property of being adapted to the northern spruce forest, and if A_2 has the second property then A_2 has the property of being adapted to the eastern deciduous forest.
3. Therefore, A_1 has the property of northern spruce adaptedness or A_2 has the property of eastern deciduous adaptedness.

Symbolization

The foregoing presentation has been carried out without benefit of logical symbolization. A simplicity of procedure was the reward of this method of presentation. Yet the éclat and definitiveness of symbols improves discursive presentation. So next some symbolization will be offered to bolster the preceding development.

For contraposition, *if this then that* can be *if* P *then* Q, which can be $P \supset Q$. *Equivalent to* is $\equiv$. *If not that then not this* can be *if not* Q *then not* P, which is $\sim Q \supset \sim P$. We have:

$$(P \supset Q) \equiv (\sim Q \supset \sim P). \qquad 1)$$

Only the a) form of contraposition is available.

For equivalence, *if this then that* is $P \supset Q$, *if that then this* is $Q \supset P$. And is represented by $\cdot$. We have:

$$[(P \supset Q) \cdot (Q \supset P)] \equiv (P \equiv Q) \qquad 2)$$

For constructive dilemma, where *or* is represented by *v* and *therefore* is represented by $\therefore$, we have:

$$(P \vee R) \qquad\qquad 3)$$
$$[(P \supset Q) \cdot (R \supset S)]$$
$$\therefore (Q \vee S)$$

Once this notation is available, 1), 2), and 3) can be proved by an axiomatic method in 112 steps (Hulburt, 2002). Once a proof is achieved a different approach to reality is to be entertained. Just as numbers, sets of numbers, infinities, etc., can be part of reality – just as abstract properties are real in the view of the metaphysical realist – so proofs might be construed as part of reality, too.

Conclusion

Contraposition, equivalence and constructive dilemma range over a considerable variety of cases. It is clear that the content of these cases is haphazard and indeterminant at the empirical level. Any attempt to generalize these cases will automatically be wrong unless the generalization is logically valid. There are of course other logically valid formulations. But the three employed here are important, as indicated by their extensive use and elaboration in previous studies by the author (Hulburt 1992, 1996, 1998, 2001, 2002, 2004).

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