Is Aldo Leopold's "~~Biotic Community~~" "Land Community" an Individual?

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1. Introduction

In his 1949 essay "The Land Ethic," Aldo Leopold[1] famously stated:

> "A thing is right when it tends to preserve the integrity, stability, and beauty of the *biotic community*. It is wrong when it tends otherwise" (emphasis added).

Thus, the land ethic made the *biotic community* a locus of direct moral obligation. But what did Leopold mean by "biotic community"? Interestingly, it included abiotic components: "soils, waters, plants, and animals, or collectively: the land." So, "biotic community" is a misleading term; *land community*, another term that Leopold employs in "The Land Ethic," seems more appropriate.

Leopold's biotic/land community is somewhat unusual in another respect:

(i) it emphasizes the *interdependence* among organisms and abiotic components
(ii) it emphasizes *matter and energy flow* through organisms and abiotic components.

Concerning (i): Interdependence (causal relations, causal interactions) among organisms is generally associated with the concept of community and with community ecology.

Concerning (ii): Matter/energy flow through organisms and abiotic components is generally associated with the concept of ecosystem and with ecosystem ecology.

So, Leopold's "land community" combines aspects of the concept of "community" as it is more typically conceived with aspects of the concept of "ecosystem" as it is more typically conceived.

Two questions arise:

1. Is the concept of an integrated community-ecosystem "land community" hopelessly outdated or misguided? Does any contemporary work support such an entity?

2. If the concept of a "land community" can be defended, is it coherent enough to be a locus of direct moral obligation? (Some have argued that it is not). Is it an

[1] Leopold was a 20th century forester, game/wildlife manager, and professor. He has been very influential in environmental ethics and conservation biology.

individual?[2]

My ultimate goal is to see if there is a *defensible* concept of "land community" that is as close to Leopold's own as possible (rather than, say, simply substitute any ecosystem concept and think that we've tested the land ethic). But this is too much to fully achieve today; here, I will mainly just sketch the landscape a bit and offer a tentative suggestion for how to understand "land community" at the end.

2. Early community and ecosystem concepts

First, I offer a (very) potted timeline of central figures in the development of community and ecosystem concepts, with an eye toward a Leopoldean land community:[3]

- **Frederic Clements (1916):** Clements characterized multispecies groupings as *communities*. He is known for thinking of communities as *organisms*, but see Eliot (2011) on this point; he has given us reason to think that Clements' commitments to communities as organisms has been overstated. Regardless, there are traces of thinking of communities as organisms in Leopold (Callicott 1996, 358).

- **Charles Elton (1927):** Leopold derived his concept of community as a close knit group that is interdependent and not a mere assemblage from Elton, not to mention food chains and the land pyramid. The parallels between the two are obvious and striking.

- **Alfred Tansley (1935):** Tansley is generally credited with the *ecosystem concept*; he rejected the community concept altogether. Interesting, it appears that Leopold included abiotic components and energy flow independently of (and perhaps prior to) Tansley (see Appendix A).

- **Raymond Lindeman (1942):** Lindeman was a key developer of the ecosystem concept – but for him, trophic or "energy-availing" relationships occur *within the community.* He thought that discrimination between living organisms and their environment is "arbitrary and unnatural."

- **Eugene Odum (1971):** Like Lindeman, Odum included a community of interacting

[2] See Odenbaugh (2007, 2010) and Eliot (2011, 2013) for discussion of communities and ecosystems as individuals. These accounts leave open the question of whether of whether the two can be combined and whether the combination would be an individual.

[3] There is a marginally less potted timeline in Appendix A.

organisms leading to a flow of energy in his ecosystem concept. Perhaps not by accident; he was influenced by Leopold and cited Leopold explicitly.

So, Odum's and Lindeman's *ecosystem* ideas, by incorporating *community* elements, are actually very much in line with the idea of a Leopoldean land community and could thus potentially be used to flesh out Leopold's concept.

But a lot has changed since 1971, flagged by Donald Worster's (1990) critique of Odum's (and Clements's) notion that nature moves toward order and harmony:

> "Ecology is not the same as it was. A rather drastic change has been going on in this science of late-a radical shifting away from the thinking of Eugene Odum's generation, away from its assumptions of order and predictability, a shifting toward what we might call a new *ecology of chaos*" (Worster 1990).[4]

So, are there *contemporary* candidates for a land community that lack such assumptions while combining community and ecosystem elements?

3. Contemporary community-ecosystem concepts

The short answer is "yes": O'Neill (2001), Post et al. (2007), Chapin et al (2011), Schulze et al. (2005), Hastings and Gross (2012).[5] All of these ecologists combine community and ecosystem elements in describing the entities that they study.

Here are some important and useful insights that can be drawn from these authors.

- The "matter/energy flow"-alone approach creates problems – and so does the "population interaction"-alone approach (O'Neill 2001, Post et al. 2007).
- Sustainability, rather than stability, may be the relevant property (O'Neill 2001).
- What an ecosystem is may be different from its models (Hastings and Gross 2012).
- Some purported boundaries may exclude relevant processes (Schulze et al. 2005).
- Boundaries are set by discontinuities or steep gradients in the flux and flow of

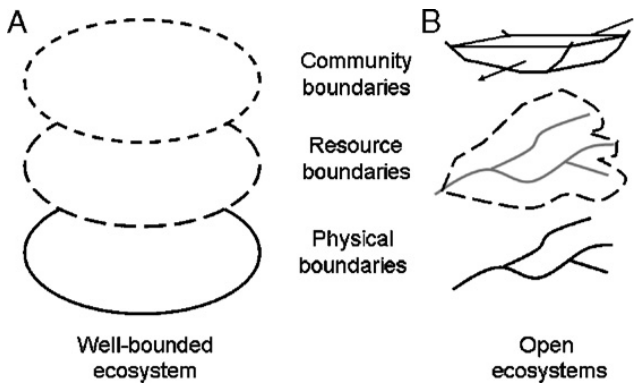
[4] I don't fully accept Worster's characterization of contemporary ecology, but I will grant it for the purposes of this paper.

[5] See Appendix B for a slightly longer answer.

material and energy and/or by discontinuities or steep gradients in interactions between populations of different species (Post et al. 2007).

4. Potential problems with a combined community-ecosystem concept

But there are some potential problems with a combined community-ecosystem approach. Consider that some systems are *well-bounded* while others are *open* (Post et al. 2007).



In well-bounded systems (e.g., lakes, islands) these two approaches coincide – and coincide with physical boundaries as well – making delineating ecosystem boundaries relatively straightforward. In such systems, "...interactions among organisms are typically stronger and cycling of material and energy is typically tighter within than across the physical boundaries of these ecosystems." On the other hand, in open systems (e.g., most terrestrial habitats, estuaries, and streams), the two approaches do not coincide, e.g., if resources come from areas where species are not interacting (e.g., upstream). The problem, then, is how to handle open systems.

Post et al. (2007) describe various scenarios. Suppose, for example, large "inputs" are coming from the "outside" at short temporal scales.[6] Then we should recognize that the system is larger than we had initially thought. Alternatively, suppose (as is common in watersheds and streams) that "internal" cycling of material/energy is stronger than "external" inputs. Then we should consider "internal" cycling to dictate the boundary.

Post et al. conclude: "In open ecosystems where there is little or no congruence among physical and functional boundaries... each different question may dictate very different definitions of ecosystem boundaries." However, I have a bit of trouble seeing how this conclusion follows; I think I may be missing something in their argument.

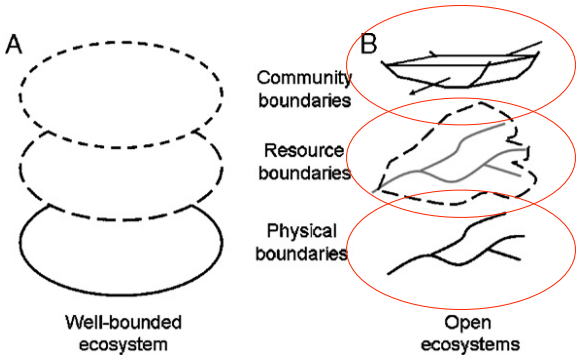
Until I figure that out, here are some questions I see arising in light of Post et al.'s proposals: 1) Have they really made the case for needing *multiple* ways to delineate

[6] O'Neill et al. (1986) imagine a similar situation, but where the community is more extensive than the matter/energy flows.

ecosystem boundaries? Their examples don't seem to support it (as far as I can tell). 2) Are open systems where different questions dictate different ecosystem definitions and different ecosystem boundaries coherent enough to be entities that we owe direct obligations to? That might not be a problem for Post et al., but it could be a problem for a land ethic. 3) Would it even be wise to try to treat purported land communities well while failing to consider some of the population interactions or energy flows relevant to their sustainability? It seems as though one would run into practical problems if one did so. Which leads me to consider the fourth challenge: 4) Are there other ways that boundaries of open systems can be delineated?

There seem to be (at least) three ways of handling open systems, systems where the spatial area of the densely interacting populations is larger than that of the dense matter/energy flow – or vice versa:

1. *The land community exists within the **larger** of the two areas.*
   Possible problem: We lose the concept of the ecosystem as a focal level, going beyond locales that lend themselves to concrete study in the field – perhaps to biomes (Currie 2011).



2. *The land community exists within the **smaller** of the two areas.*
   Possible problem: We might exclude *causally relevant factors* for the future states of populations and abiotic components and thus give a misleading picture that would be subject to error.

3. *The land community includes interactions or matter/energy flows from the larger area if and only if those interactions are stronger or larger than those of the smaller area.*
   Possible problem: None seen at the moment. This is the way that I am leaning.

5. Toward a Leopoldean Land Community Concept

Insights from the ecologists discussed in sections 3 and 4 lead me to a (very tentative) proposal:

A ***Leopoldean land community*** consists of populations of different species interacting with each other and with their abiotic environment, creating interdependencies between

organisms; these *survival-relevant interactions* produce a *flow of energy and materials* between biotic components and between biotic components and abiotic components.

Survival-relevant interactions between the populations include: Competition for scarce resources, predator/prey, parasite/host, pollinator/pollinated, provision of shade or shelter. *Relevant flows of materials and energy include:* primary production (photosynthesis, chemosynthesis), secondary production, evapotranspiration, decomposition, nutrient cycling. *Food webs* are of particular importance to a land community because they can represent species interactions within a community *and* energy flow through those species (Post et al. 2007).

Land community boundaries[7] for *well-bounded systems* are where discontinuities or steep gradients in the flow of material and energy coincide with discontinuities or steep gradients in species interactions. Land community boundaries for *open systems* are at a minimum delineated by the smaller of the two types of discontinuities or steep gradients, including the more extensive interactions or matter/energy flows *if and only if* those interactions or matter/energy flows are stronger or larger than those of the smaller area. This approach has the advantage of including all significant causally relevant factors for the future states of populations and abiotic components (interdependencies). It may mean that there are fewer land communities than one might have thought; however, I am not sure that this is a problem. Ecologists may reasonably choose to study subsets (including particular types of interactions or particular matter or energy flows) of these for various pragmatic reasons, but such choices do not affect the ontology of land communities.

The composition of species in a land community may change over time; it is the same entity if and only if there is continuity of interaction and material/energy flow through time.[8] Thus, land communities may or may not be stable in the sense of "stasis" or "equilibrium." Sustainability (similar to what Leopold meant by stability or land health – see Newton 2006) is a more pertinent trait or feature (O'Neill 2001). For example, Leopold (1943) traced four epochs within Southwestern Wisconsin,[9] but his concern is land health in the face of different practices, not change of species.

A land community so described would be an *individual* in the Ghiselin-Hull sense

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[7] Note that land community boundaries are fuzzy rather than sharp.

[8] See also Odenbaugh (2007) on this point.

[9] Fur trade epoch, 1680-1832; Fire epoch, 1750-1850; Wheat epoch, 1832-1878; Dairy epoch, 1872-(his) present

(see, e.g., Ghiselin 1974, 1997; Hull 1976, 1978, 1980)[10]; it would:

- Be a *particular* thing, not a class; it would be a *spatiotemporally restricted* entity
- Not merely be an assemblage;[11] it would be an *integrated*, cohesive entity because of the *causal interactions* among the parts, giving the parts (to some extent) a shared fate. (This is the most important criterion, in my view)
- Have *beginnings* and *endings* in time.
- Be *continuous* through time, allowing for change over time.

On this view, *individuality comes in degrees*, especially with respect to integration, eliminating the need for a separate term for "wholes" (see Odenbaugh 2007); here I set aside the question of whether the land community is an organism, which brings additional complications.

6. Conclusions

Although there are further issues to be worked out,[12] there is some reason to think that a Leopoldean concept of a land community is consistent with some contemporary ecology. There is also reason to think that were any such entity to exist in the world, it would be an individual. If this is correct, then a Leopoldean land community is at least a candidate for direct moral obligation.

Acknowledgements: Thanks to Christopher Hunter Lean and Alkistis Elliott-Graves for organizing our session, and to Chris Eliot for many helpful conversations about communities and ecosystems.

[10] See also Millstein (2009).

[11] Contra the so-called "Gleasonian" picture.

[12] See Appendix C

Appendix A: Early community and ecosystem concepts[13]

Frederic Clements (1916):

- See Chris Eliot's "The Legend of Order and Chaos."
- **Community** as **organism**?

J. Baird Callicott argues that there are "residual traces of the early twentieth-century Clementsian super-organism paradigm" in Leopold's land ethic (Callicott 1996, 358).

Charles Elton (1927):

- plant and animals are not mere assemblages of species living together, but form closely-knit **communities** comparable to our own (and which include humans).
- Relations between animals are largely food relations, giving rise to food chains, the food-cycle, and the "pyramid of numbers"

Note: Leopold met Elton in 1931 (Meine 2010) and was very influenced by him, not only in terms of Elton's concept of community but also food chains and pyramid of numbers (what Leopold called the "land pyramid").

Alfred Tansley (1935): (generally credited with **ecosystem concept**)

- Plants and animals are too different to be considered part of the same community
- Biomes (sensu Clements), "the whole webs of life adjusted to particular complexes of environmental factors," are real 'wholes,' often highly integrated.
    - But biomes are not organisms.
    - Rather, biomes together with all of the physical factors involved are *systems* (**ecosystems**); this is the more fundamental conception.

According to Betty Craige (2002) and Callicott (2014), Leopold anticipated many of Tansley's ideas of an ecosystem (in essays written in 1933 and 1939 essays, respectively).

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[13] The three appendices represent slides that I prepared for the talk, but had to cut in the interests of time. I kept them at the ready in case they became relevant during the Q and A.

So, Leopold may not be in a Tansleyean tradition, even those there are similarities.

Raymond Lindeman (1942): (a key developer of the **ecosystem concept**)

> "The trophic-dynamic viewpoint emphasizes the relationship of trophic or 'energy-availing' relationships *within the community-unit* to the process of succession.
>
> The discrimination between living organisms as parts of the 'biotic community' and dead organisms and inorganic nutritives as parts of the 'environment' seems arbitrary and unnatural."
>
> (emphasis added)

The point here is that even though Lindeman is seen as a key developer of the ecosystem concept, the community concept is still a core part of that idea.

Eugene Odum (1971):

> "An **ecosystem** is any unit that includes all of the organisms (i.e., the '**community**') in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts) within the system."

- There still seems to be a strong community component to Odum's ecosystem concept.

- Craige sees Odum as having been influenced by Leopold (among others), and Odum cites Leopold explicitly.

The point here is that Odum, perhaps as an intellectual descendant of Leopold, provides a good candidate for a land community concept that incorporates both interdependence between organisms as well as energy flow.

Appendix B: Contemporary community-ecosystem concepts

Robert O'Neill (2001):

- Points out that while **various problems can be solved by viewing an ecosystem purely in terms of functional groups** that recover to the same rate processes, feedbacks, and complex organization (e.g., species moving in and out of an area over time), **such an approach creates its own problems** (e.g., failure to recognize ecotones and also minimizes the role of natural selection).

- Argues that we must **recognize the simple empirical fact that ecosystems are collections of interacting populations**, with component populations shaped by natural selection. Suggests that the resulting biotic potential determines ecosystem dynamics just as much as chemical and physical constraints.

- Maintains that the critical property of an ecosystem is not stability, but rather the ability to change state in response to a continuous spectrum of change and variability (**sustainability**).

Schulze et al. (2011):

- Ecosystems are networks of **interrelations** between organisms and their environment in a defined space.

- The interactions are **"far away" from equilibrium** and there is **no goal** for certain dynamic change.

- The of an ecosystem must, clearly, extend so far that the essential parts of material turnover per ground area (e.g., carbon assimilation, nitrogen mineralisation, formation of ground water, etc.) are taken into account quantitatively.

- For example, a rotting tree trunk is only a partial system within a forest

This suggests that there can be mistaken ways of characterizing the boundaries of an ecosystem. More on that later.

Hastings and Gross (2012):

- **ecosystem -** A system composed of both the organisms (animal, plant, microbe) and the abiotic environment, and all interactions among and between these

components.

- **ecosystem model -** A *model* designed to capture the pools and fluxes of mass (and sometimes energy) in an ecosystem. Ecosystem models use carbon as their basic currency, but most also track the biogeochemical cycles of water and macronutrients

This nicely separates what an ecosystem *is* from the particular aspects of an ecosystem (flow of materials and energy) that an ecologist might study.

Appendix C: Issues to work on

- What makes interactions such as predator/prey interactions population-level rather than organism-level? Does it matter?

- Is there a general way to specify these interactions? "Ecological" or "biotic" seem vague (Eliot criticizes Odenbaugh on this point). Right now I have them characterized as population-level survival interactions. Is that sufficient?

- Have I left open the possibility of land communities at different scales, and if not, is that a problem?

- How to characterize strength of interactions? (see Odenbaugh 2010 for one possibility; Post et al. 2007 also seem to have something in mind).

- How to address Eliot's concern over the "(n + 1)th" problem for interaction accounts? (I'm not convinced it's a problem. Add an interacting population or subtract an interacting population and you still have a community; whether it is a *healthy* community is another story).

- Odenbaugh (2010) suggests that different ecosystem causal relations may specify different ecosystems; similarly, Eliot (2011, 2013) suggests that various interests (e.g., conservation, realism, prediction) determine different relevant causal interactions and pick out different communities. Is this conflating ontology with modeling needs or pragmatic interests? Does "circulates blood" pick out one organism and "circulates oxygen" another?

- How to incorporate evolution into the land community concept?

- Can we go beyond food webs to consider biotic-abiotic "webs"?