

Introduction to the Population and Community Ontology (PCO)

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<div> <div>RELATION TO TIME</div> <div>GRANULARITY</div> </div>	CONTINUANT			OCCURRENT
	INDEPENDENT		DEPENDENT	
COMPLEX OF ORGANISMS	Family, Community, Deme, Population			Population Phenotype
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)	
MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)		Molecular Function (GO)	Molecular Process (GO)

<http://obofoundry.org>

The PCO:

- is rooted in the Basic Formal Ontology.
- covers material entities, qualities, and processes that pertain to collections of organisms.
- imports terms from or exports terms to other OBO library ontologies, such as CARO, PATO, GO, OBI.

Domain of the PCO:

- collections of organisms (populations, communities, family groups)
- qualities of collections of organisms (with PATO)
- processes that have collections of organisms as participants (with GO)
- roles for organisms within a collection of organisms (e.g., parent, sibling, predator, herbivore)

Why study collections of organisms?

- Ecology and Evolution:
 - intra- and interspecific interactions, interactions with environment
 - population as the unit of evolution
- Medicine:
 - collections of humans, pathogens, vectors
 - epidemiology, disease transmission, sociology
- Agriculture:
 - crop breeding, plant pathology, animal diseases, weeds

Examples of collections of organisms:

- A unicellular colony
- A microorganism infection (the bacteria in a bacteremia, the viruses in a viremia)
- A herd (bunch of big animals living in close proximity)
- The sum of the infectious agents in a herd's infection (all potentially eradicated with the same antibiotic)
- The occupants of a biological niche (most susceptible to a pan-species toxin)
- My microbiome
- Ashkenazi jews (some common genetic elements due to being a herd at some earlier part of history)
- People with malaria
- People immune to HIV

(Thanks to Alan Ruttenberg)

Diverse definitions of population on BioPortal:

- SNOMED: A social condition (no text definition)
- MESH: The total number of individuals inhabiting a particular region or area.
- OBI: a population is a collection of individuals from the same taxonomic class living, counted or sampled at a particular site or in a particular area
- Experimental Factor Ontology: A population is a group of material entities consisting of individuals which share a particular characteristic such as inhabiting a particular region or area or ability to interbreed.
- NIFSTID: A collection of independent organismal entities engaged in some form of spatio-temporal interaction or aggregate behavior
- Malaria Ontology: An aggregate of organisms.
- NCI Thesaurus (population group): A group of individuals united by a common factor (e.g., geographic location, ethnicity, disease, age, gender)
- ICF: Groups of people living in a given environment who share the same pattern of environmental adaptation.

Definitions of **population** from some evolutionary biologists:

- Gotelli's **A Primer of Ecology**: A group of individuals, **all of the same species**, that **live in the same place**. Although it is sometimes difficult to define the physical boundaries of a population, the individuals within a population have the **potential to reproduce with one another** during the course of their lifetimes.
- Futuyma's **Evolution**: A group of **conspecific organisms** that **occupy a more or less well defined geographic region** and **exhibit reproductive continuity** from generation to generation; **ecological and reproductive interactions are more frequent among these individuals than with members of other populations of the same species**.

Essential elements of the definition of a population:

- More than one organism (or virus or viroid)
- All members of the same species
- Geographical proximity – potential for reproductive or other ecological interactions
- Maximal?
 - a random sub-sample of a population is not a population in the biological sense (but is in statistical sense)
 - sub-populations and meta-populations are populations

Examples of (possible) populations:

- A herd of cattle
- The sunfish living in Roth Pond
- The lady slipper orchids living in Kettle Hole County Park
- The pigeons in Central Park
- The people of Buffalo

Collections of organisms of a single species that are **not** populations:

- People with malaria
- People immune to HIV
- Every oak tree in Pennsylvania
- Five sunfish chosen randomly from Roth Pond
- My family

Definitions of **ecological community** from some ecologists:

- From Morin's **Community Ecology** (paraphrased): A collection of organisms of at least two different species, living in a particular area.
- From Begon et al.'s **Ecology**: The species that occur together in space and time.

Essential elements of the definition of an ecological community:

- More than one organism
- Members of at least two species
- Geographical proximity – living in the same area

Definitions disagree on whether or not:

- the organisms must interact with each other (but generally some interaction is assumed)
- a community must include all organisms present at a location

The borders of an ecological community may be defined by:

- discrete physical or habitat boundaries
 - the biota of a pond, a decaying carcass, your gut
- the presences of a dominant species
 - beech forest community
 - tall grass prairie community
- statistically similar species composition in multidimensional space
- significant interactions among members

Some important subsets (sub-classes) of ecological community

- **guild:** A collection organisms of different species that use resources in a similar way.
 - Often used in the sense of a trophic guild or trophic level (herbivores, detritivores, primary producers, etc.)
- **taxonomically-defined community:** A set of taxonomically related species within a community (plant community, insect community, bird community, etc.)

Communities, ecosystems, and biomes

- An **ecosystem** is an **ecological community** plus the abiotic (physical) environmental features (soil, air, water, sunlight, slope).
- Many ecologists consider a **biome** to be a type of large-scale **ecological community**.
- Need to collaborate with ENVO on these terms.

Biome and its subclasses are covered by the Environment Ontology (EnvO)

biome (EnvO:00000428)

def.: A major class of ecologically similar communities of plants, animals, and other organisms. Biomes are defined based on factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and other factors like climate...

(<http://www.environmentontology.org>)

examples include: tundra biome, Mediterranean forest biome, small river biome, estuarine biome

Qualities of collections of organisms

- Population quality: A quality that inheres in a population.
 - carry capacity
 - population birth rate, death rate, growth rate, etc.
 - sex ratio
 - Are these BFO:qualities?
- Ecological community quality: A quality that inheres in a community
 - diversity
 - species richness
 - stability, resilience
 - community structure
 - number of trophic levels

Possible changes for PATO

- **population quality** (PATO:0002003) =def. A quality that inheres in an entire population or part of a population.
 - The phrase “part of a population” is problematic – includes qualities that inhere in organisms or their parts.
 - Has two subclasses: mixed sex (PATO:0001338) and morbidity (PATO:0001415).
- **organismal quality** (PATO:0001995) =def. A quality that inheres in an entire organism or part of an organism.
- *Suggest that PATO redefine organismal quality as a quality that inheres in an entire CARO:organism or a PCO:collection of organisms, or possibly get rid of these terms.*
 - *Should PATO have categories of qualities that are defined only by the entity in which they inhere?*
 - *Don't all qualities in PATO inhere in an organism?*

Processes that have collections of organisms as participants

- Population process
- Community process
- Other inter-organism processes
- sub-classes of BFO: process
 - may move to GO: biological process

PCO: population process

- def.: A process that has as primary participant a population.
 - Population processes may depend on the processes of individual organisms {e.g., population growth reflects the cumulative multicellular organism reproduction (GO:0032504) and death (GO:0016265) of all individuals in a population} but cannot be described for an individual organism.
 - Some processes (e.g., evolution, extinction) can occur at both the species and the population level, so PCO distinguishes between, for example, population extinction and species extinction.

PCO: population process

- Examples:
 - population growth
 - exponential population growth
 - logistic population growth
 - population extinction
 - evolution
 - selection
 - immigration, emigration

Population and community processes in the context of the GO

- **biological process (GO:0008150):** Any process specifically pertinent to the functioning of integrated living units: cells, tissues, organs, and organisms. A process is a collection of molecular events with a defined beginning and end.
- **multi-organism process (GO:0051704):** Any process in which an organism has an effect on another organism of the same or different species.

Community processes in the context of the GO

sub-classes of multi-organism process:

- **interspecies interaction between organisms (GO: 0044419)**: Any process in which an organism has an effect on an organism of a different species.
- **intraspecies interaction between organisms (GO: 0051703)**: Any process in which an organism has an effect on an organism of the same species.
- **behavioral interaction between organisms (GO: 0051705)**: Any process in which an organism has a behavioral effect on another organism of the same or different species.

PCO: community process

- examples:
 - competition
 - predation
 - facilitation
 - mutualism
 - parasitism
 - pollination
- Some of these terms are already in the GO. PCO will work with GO to define new terms, then import them into PCO as needed.

Applications: Other ontologies that need terms from the PCO

- Ontology for Biomedical Investigations (OBI)
- Any ontology that studies interactions among people or other organisms (social ontology)
 - populations, family groups
- Infectious Disease Ontology (IDO)
 - Any biomedical ontology that describes groups of pathogens, hosts, or vectors
- NCBO-BioPortal lists results for 45 ontologies for “population” and 21 for “community”, with variable definitions. Terminology should be unified across ontologies.

Application of the PCO: ecological modeling

- $\xrightarrow{+}$ has positive effect
- $\xrightarrow{-}$ has negative effect
- $\xrightarrow{\text{grey}}$ has stage
- $\xrightarrow{\text{purple}}$ has quality
- $\xrightarrow{\text{red}}$ unknown effect

