Challenges of Taxonomy & Systematics

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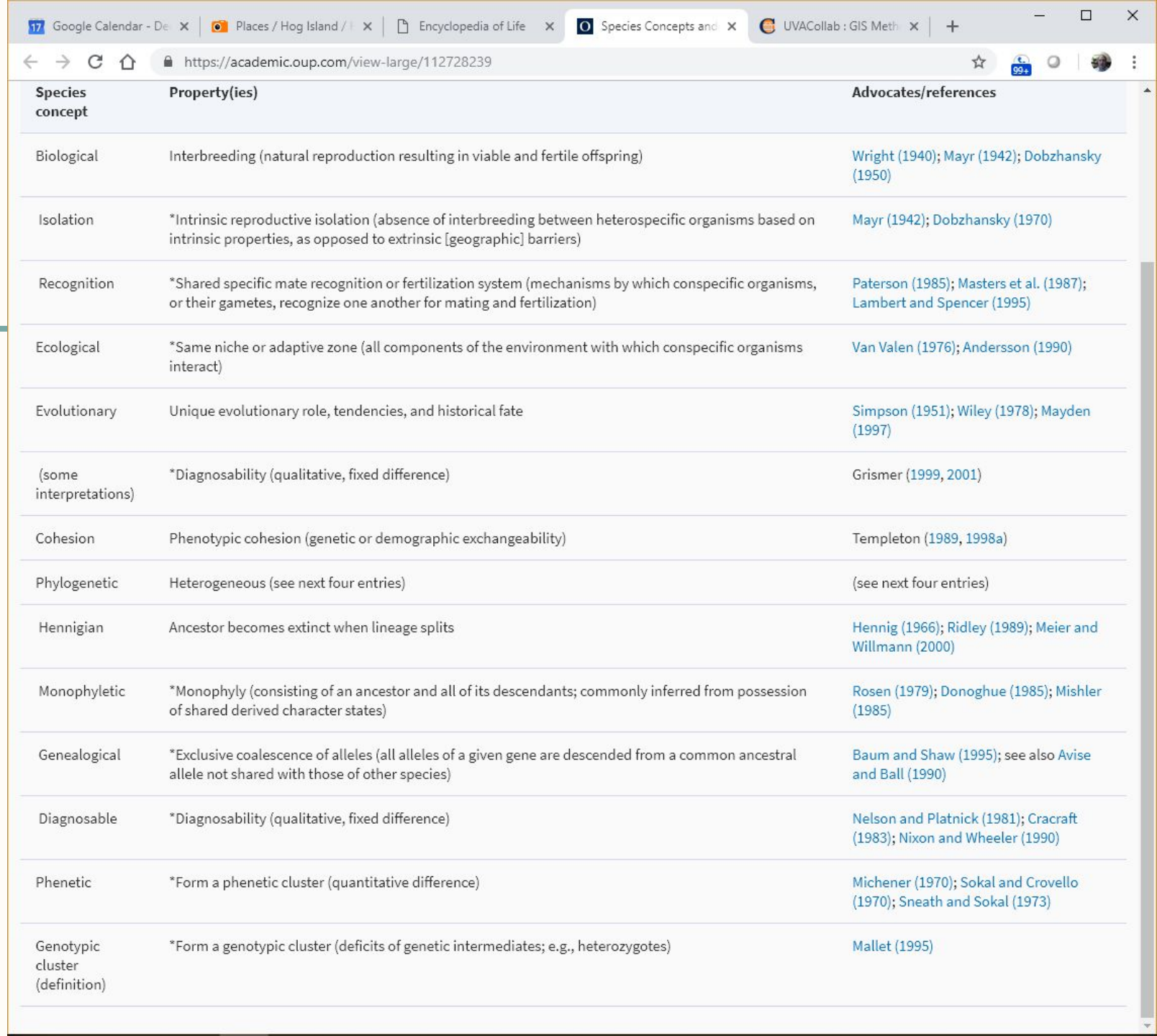
What is a species?

- Lots of different ideas about how species should be defined, much less delineated
- Different definitions may work better for different taxa (mammals vs insects vs plants vs microbes)

Kevin De Queiroz; Species Concepts and Species Delimitation, *Systematic Biology*, Volume 56, Issue 6, 1 December 2007, Pages 879-886, https://doi.org/10.1080/10635150701701083



Google Calendar - De | Places / Hog Island / | Encyclopedia of Life | Species Concepts and | UVACollab : GIS Meth

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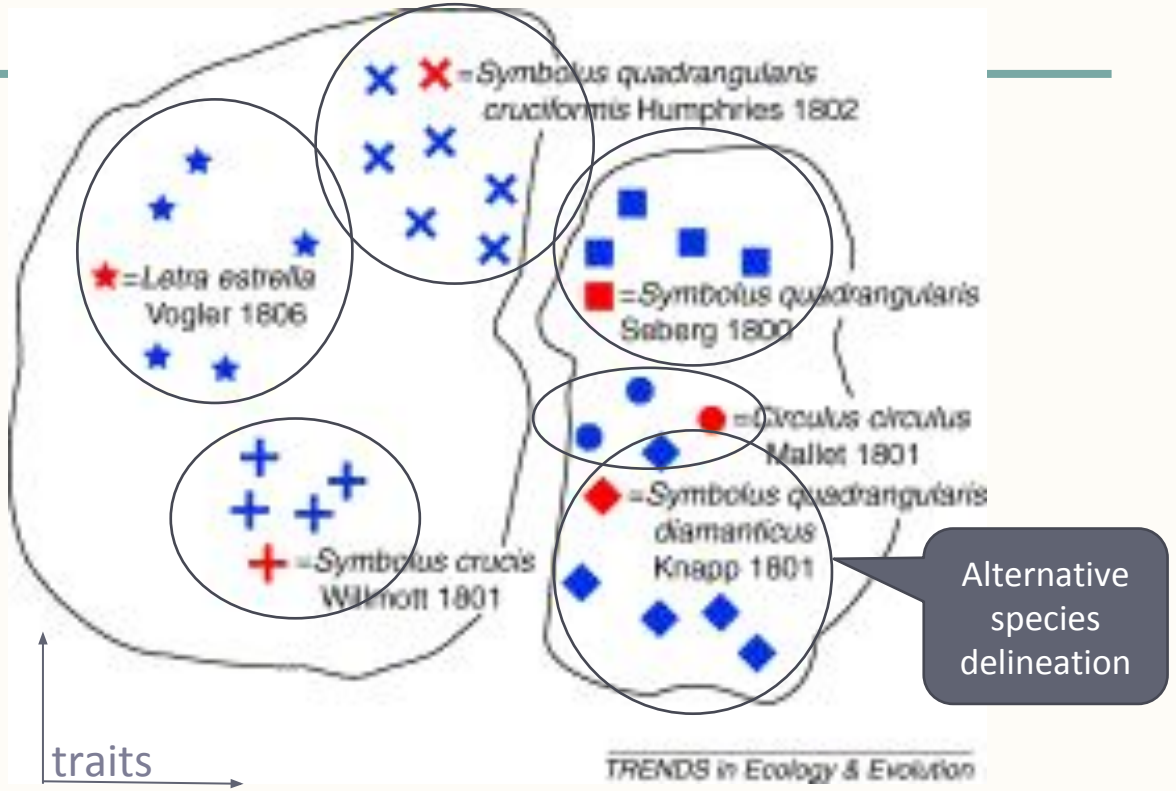
Species concept	Property(ies)	Advocates/references
Biological	Interbreeding (natural reproduction resulting in viable and fertile offspring)	Wright (1940); Mayr (1942); Dobzhansky (1950)
Isolation	*Intrinsic reproductive isolation (absence of interbreeding between heterospecific organisms based on intrinsic properties, as opposed to extrinsic [geographic] barriers)	Mayr (1942); Dobzhansky (1970)
Recognition	*Shared specific mate recognition or fertilization system (mechanisms by which conspecific organisms, or their gametes, recognize one another for mating and fertilization)	Paterson (1985); Masters et al. (1987); Lambert and Spencer (1995)
Ecological	*Same niche or adaptive zone (all components of the environment with which conspecific organisms interact)	Van Valen (1976); Andersson (1990)
Evolutionary	Unique evolutionary role, tendencies, and historical fate	Simpson (1951); Wiley (1978); Mayden (1997)
(some interpretations)	*Diagnosability (qualitative, fixed difference)	Grismer (1999, 2001)
Cohesion	Phenotypic cohesion (genetic or demographic exchangeability)	Templeton (1989, 1998a)
Phylogenetic	Heterogeneous (see next four entries)	(see next four entries)
Hennigian	Ancestor becomes extinct when lineage splits	Hennig (1966); Ridley (1989); Meier and Willmann (2000)
Monophyletic	*Monophyly (consisting of an ancestor and all of its descendants; commonly inferred from possession of shared derived character states)	Rosen (1979); Donoghue (1985); Mishler (1985)
Genealogical	*Exclusive coalescence of alleles (all alleles of a given gene are descended from a common ancestral allele not shared with those of other species)	Baum and Shaw (1995); see also Avise and Ball (1990)
Diagnosable	*Diagnosability (qualitative, fixed difference)	Nelson and Platnick (1981); Cracraft (1983); Nixon and Wheeler (1990)
Phenetic	*Form a phenetic cluster (quantitative difference)	Michener (1970); Sokal and Crovello (1970); Sneath and Sokal (1973)
Genotypic cluster (definition)	*Form a genotypic cluster (deficits of genetic intermediates; e.g., heterozygotes)	Mallet (1995)

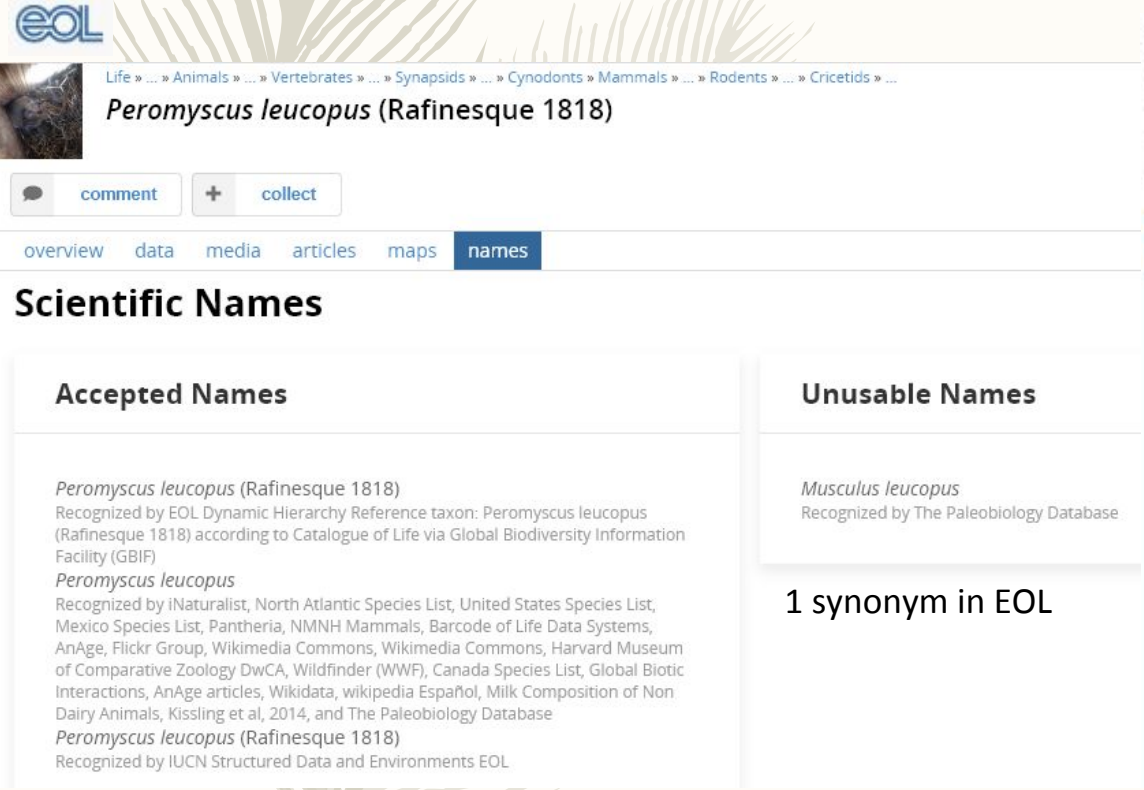
Delineating Species Is Subjective

- Different authorities recognize different groups of characteristics as species
- A species designation consists of
  - Genus
  - Species
  - Authority (name and year)
- DNA “barcoding”?
  - A developing technology



A fictitious example from Mallet & Willmott, 2003

Implications: Synonyms & Subsets



1 synonym in EOL

ITIS

Peromyscus leucopus (Rafinesque, 1818)

Taxonomic Serial No.: 180278

Download data (Download Help) ***Peromyscus leucopus*** TSN 180278

Taxonomy and Nomenclature

Kingdom:	Animalia
Taxonomic Rank:	Species
Synonym(s):	Hesperomys affinis J. A. Allen, 1891 Peromyscus arboreus Gloger, 1841 Hesperomys campestris Le Conte, 1853 Peromyscus canus Mearns, 1896 Peromyscus cozulmelae Merriam, 1901 Arvicola emmonsi DeKay, 1840 Vesperimus mearnsii J. A. Allen, 1891 Mus michiganensis Audubon and Bachman, 1842 Peromyscus musculoides Merriam, 1898 Cricetus myoides Gapper, 1830 Hesperomys texana Woodhouse, 1853 Peromyscus tornillo Mearns, 1896

12 names associated with “Peromyscus leucopus” in ITIS (subspecies excluded)

Systematics

ITIS

Taxonomic Hierarchy

Kingdom	Animalia – Animal, animaux, animals
Subkingdom	Bilateria
Infrakingdom	Deuterostomia
Phylum	Chordata – cordés, cordado, chordates
Subphylum	Vertebrata – vertebrado, vertébrés, vertebrates
Infraphylum	Gnathostomata
Superclass	Tetrapoda
Class	Mammalia Linnaeus, 1758 – mammifères, mamífero, mammals
Subclass	Theria Parker and Haswell, 1897
Infraclass	Eutheria Gill, 1872
Order	Rodentia Bowdich, 1821 – esquilo, preá, rato, roedor, rongeurs, rodents
Suborder	Myomorpha Brandt, 1855 – Rats, souris, Mice, Rats, Voles, Gerbils, Hamsters, Lemmings
Superfamily	Muroidea Illiger, 1811
Family	Cricetidae Fischer, 1817
Subfamily	Neotominae Merriam, 1894
Genus	Peromyscus Gloger, 1841 – Deer Mice, White-footed Mice
Species	Peromyscus leucopus (Rafinesque, 1818) – souris à pattes blanches, White-footed Deermouse, White-footed Mouse

EOL Dynamic Hierarchy

Life
Cellular Organisms
Eukaryota
Opisthokonta
Metazoa
Bilateria
Deuterostomia
Chordata
Vertebrata
Gnathostomata
Osteichthyes
Sarcopterygii
Tetrapoda
Reptiliomorpha
Amniota
Synapsida
Therapsida
Cynodontia
Mammalia
Theria
Eutheria
Placentalia
Boreoeutheria
Euarchontoglires
Glires
Rodentia
Mouse relatives
Myomorpha
Muroidea
Eumuroidea
Cricetidae
Neotominae
Reithrodontomyini
Peromyscus
***Peromyscus leucopus* (Rafinesque 1818)**

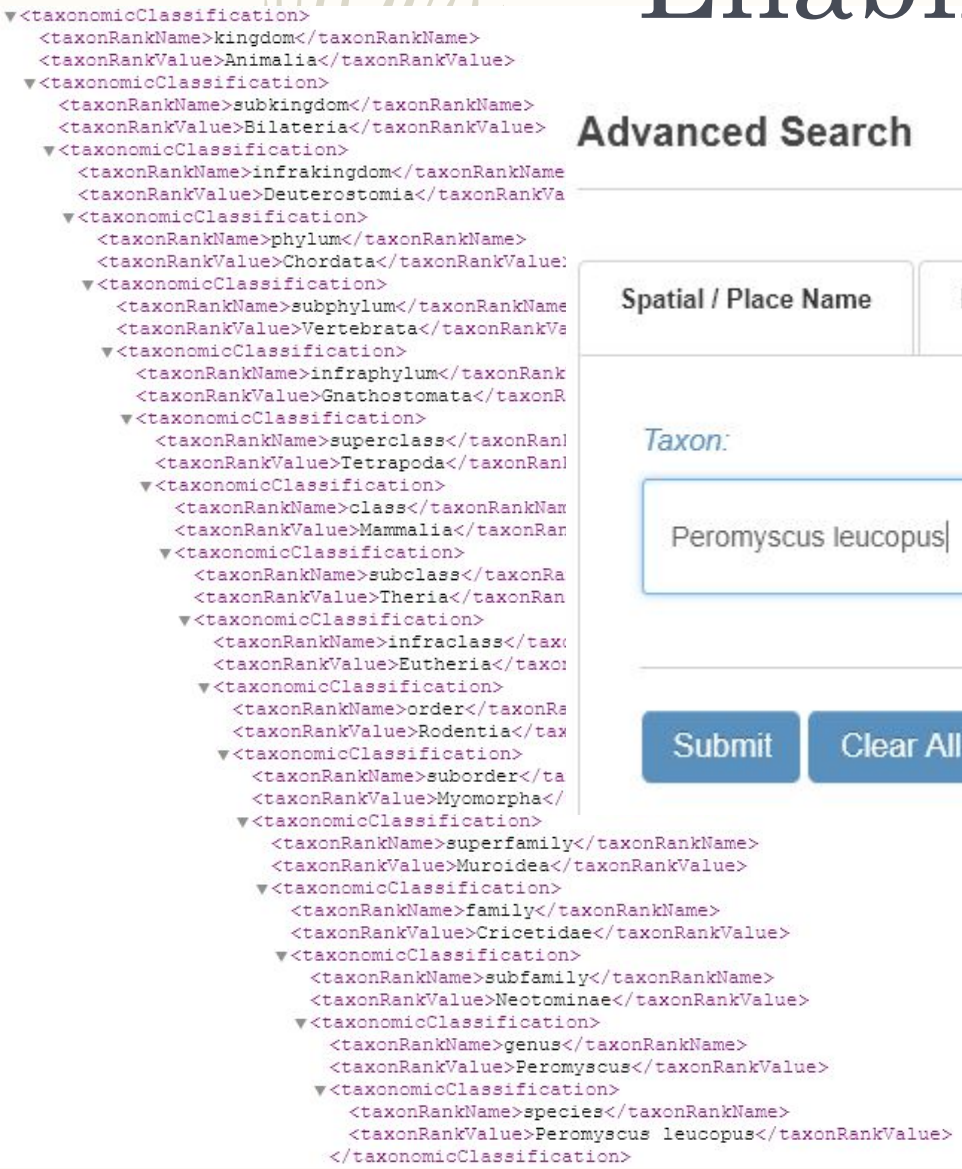
- The systems used to describe relationships among taxa also vary by authority (but often overlap)

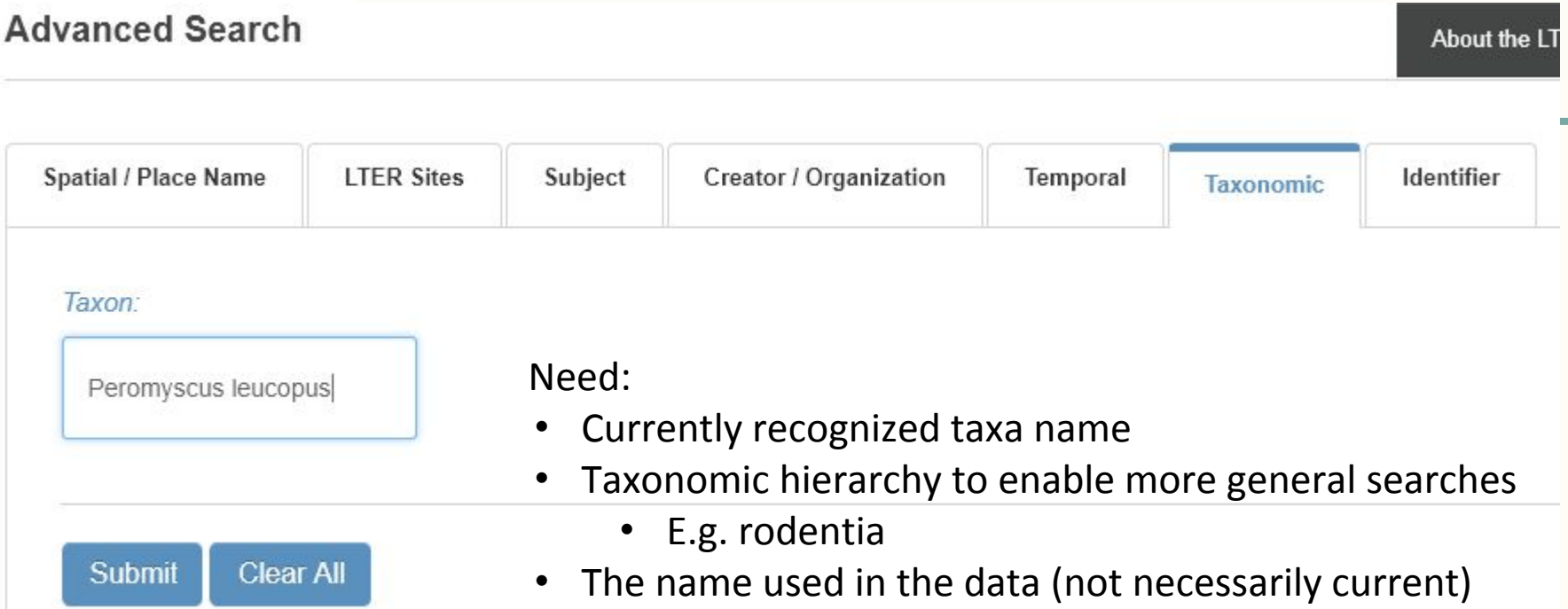
Good News

- A number of organizations have API's that allow searching for names
  - But they won't necessarily agree or have the same taxa
- Each LTER site probably has one, or a few, best sources that can be used as authorities for that site's data

API	prefix	SOAP?
Encyclopedia of Life (EOL)	eol	FALSE
Taxonomic Name Resolution Service	tnrs	FALSE
Integrated Taxonomic Information Service (ITIS)	itis	FALSE
Global Names Resolver (from EOL/GBIF)	gnr	FALSE
Global Names Index (from EOL/GBIF)	gni	FALSE
IUCN Red List	iucn	FALSE
Tropicos (from Missouri Botanical Garden)	tp	FALSE
Theplantlist.org	tpl	FALSE
Catalogue of Life	col	FALSE
National Center for Biotechnology Information	ncbi	FALSE
CANADENSYS Vascan name search API	vascan	FALSE
International Plant Names Index (IPNI)	ipni	FALSE
World Register of Marine Species (WoRMS)	worms	TRUE
Barcode of Life Data Systems (BOLD)	bold	FALSE
Pan-European Species directories Infrastructure (PESI)	pesi	TRUE
Mycobank	myco	TRUE
National Biodiversity Network (UK)	nbn	FALSE
Index Fungorum	fg	FALSE
EU BON	eubon	FALSE
Index of Names (ION)	ion	FALSE
Open Tree of Life (TOL)	tol	FALSE
World Register of Marine Species (WoRMS)	worms	FALSE
NatureServe	natserv	FALSE

Enabling Data Searches





Need:

- Currently recognized taxa name
- Taxonomic hierarchy to enable more general searches
  - E.g. rodentia
- The name used in the data (not necessarily current)

Today

- Taxonomy in Ecological Metadata Language Metadata, EcoCommDP and Darwin Core – Margaret O'Brien
- Cleaning Taxonomic Data – Colin Smith
- R tools for generating taxonomic coverages – Colin Smith

Helpful Literature

- BENOÎT DAYRAT; Towards integrative taxonomy, *Biological Journal of the Linnean Society*, Volume 85, Issue 3, 1 July 2005, Pages 407–417, https://doi.org/10.1111/j.1095-8312.2005.00503.x
- Mallet, J. and Willmott, K., 2003. Taxonomy: renaissance or Tower of Babel?. *Trends in Ecology & Evolution*, *18*(2), pp.57-59.
- Isaac, N.J., Mallet, J. and Mace, G.M., 2004. Taxonomic inflation: its influence on macroecology and conservation. *Trends in Ecology & Evolution*, *19*(9), pp.464-469.