Taxonomic Concept Alignment in TaxonWorks

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Version 1.3

Names vs. Taxonomic concepts

- Perennial issue in biology

- A **name** is a *point* in variation space, tied to a single type specimen

- The **taxonomic concept** in the mind of a human is a *region* in variation space, circumscribed by descriptions or specimen lists

- Problem: over time a name may remain the same, but the concepts that use it may vary greatly

- To refer to a specific concept we must specify a usage: {**Name 'sec.'** (or 'sensu') **Publication**}
  E.g., *Ephedra torreyana* Watson **sec.** Wendt 1993

Taxonomic concept alignment

- Because they are regions/clouds/sets, taxonomic concepts can be aligned, or 'mapped' using five simple set relationships: **congruent with**, **includes**, **is included in**, **partially overlaps**, **disjunct with** (RCC-5)

(from Franz et al., 2008)
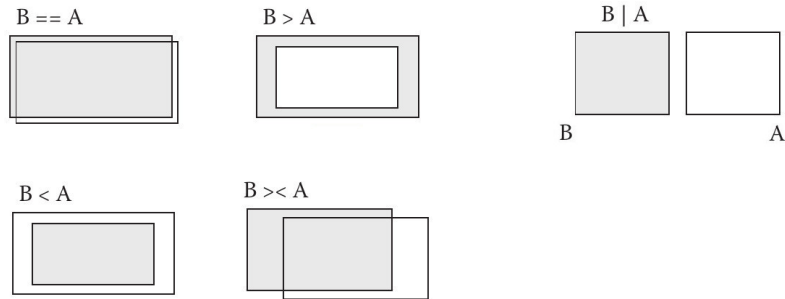
Example: Alan Weakley's Flora of the Southeast

Name and concept **sec. Weakley (2015)**

Andropogon virginicus Linnaeus *var. virginicus,* Old-field Broomstraw, Broomsedge, "Sedge Grass", "Sage Grass". Old fields, roadbanks, disturbed sites. Sep-Oct. MA west to MI and e. KA, south to FL and e. TX, and in the Caribbean and Central America. Campbell (1983) recognized 3 "variants" within *A. virginicus* var. *virginicus*; the "deceptive variant" he later (1986) described formally as var. *decipiens* (see above). The "old-field variant" is the common "variant" in our area, occurring abundantly throughout the state. It has green stem internodes and the leaves usually pubescent, at least on the margins near the collar. The "smooth variant" is known only from the Coastal Plain and is apparently rare in our area. [< A. virginicus var. virginicus – FNA, K, WH3, Va, Z; < *A. virginicus* – Pa, RAB, S, W; < *A. virginicus* var. *virginicus* – C, WV; < *A. virginicus* var. *virginicus* – G, HC; >< *A. virginicus* var. *virginicus* – F; > *A. virginicus* var. *tetrastachyus* (Elliott) Hackel – F]

https://fsus.ncbg.unc.edu/; see this taxon

Synonymy and T.C. alignments

- The relationship between concepts is often implicitly inferred from traditional, *nomenclatural* **synonymy**:
  - "A is a (homotypic/heterotypic) **synonym** of B" *suggests* either $A == B$ or $A < B$ (where A means the taxonomic concept of name A by author of A)
  - "A is a **pro parte synonym** of B" *suggests* $A > B$ (see Turland et al., 2018, 52.2.Ex.5)

- **But** such inferences may be incorrect. Making *explicit set* statements about taxonomic concepts is far more informative.

# T.C. alignment for the Alaska flora

- Example: the *Papaver* (poppy) graph among related uses of each name in 5 publications (thanks to Kimberly Cook)
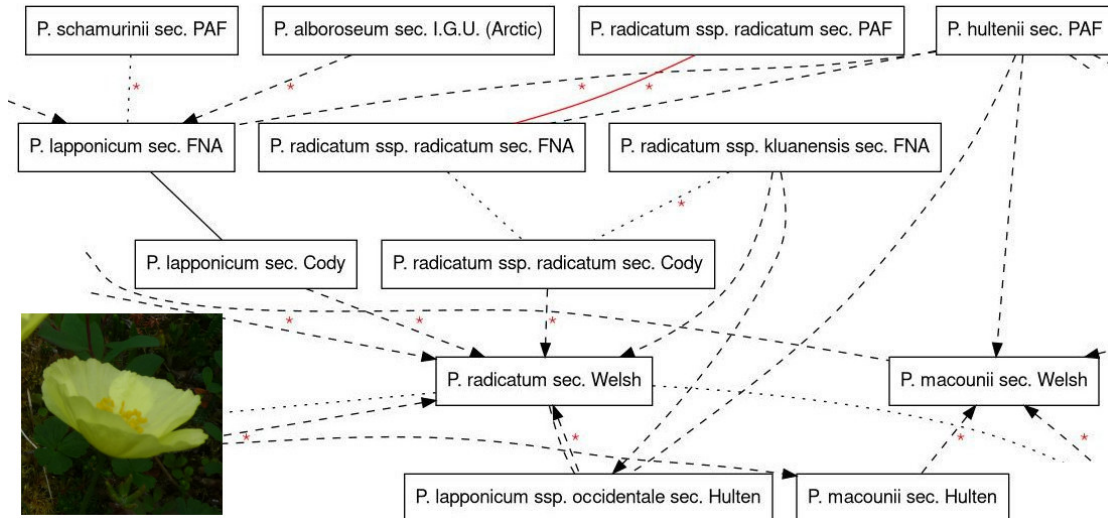
Managing T.C. alignment data

- `TaxLink` (Gradstein et al., 2001) (MS windows) based on the Berlin Model (Berendsohn and al., 2003)

- `ConceptMapper` (Liu et al., 2007) (Java) from NCEAS

- Since 2020, `Arctos` (Thanks Dusty!)

- **TCM**: web app for publications, names, concepts, and relationships (Webb et al., 2021)

- **TaxonWorks**: only system with comprehensive taxonomy model
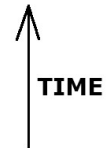
Steffi's work on Ephedra
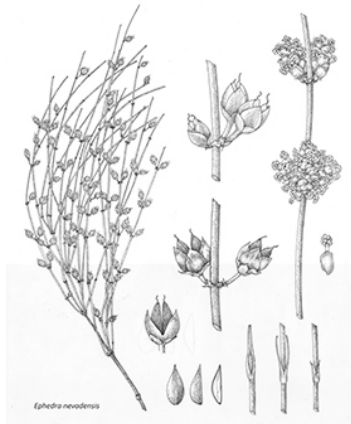
Gymnosperm shrubs, c. 60 species, worldwide, desert regions.
Testing TaxonWorks as platform for a monograph

An Ephedra T.C. example

Ephedra americana sec. Hunziker 1949

Ephedra breana sec. Hunziker 1949

TIME

Ephedra americana var. humboldtii sec. Stapf 1889

Two cases of a *partially overlapping* relationship

TCM app: names and concepts

Name

Code	Genus	Species	Rank	Infrasp	Author	Orig. Publ.				
Ephedra americana Humb. & Bonpl. ex Willdenow	Ephedra	americana			Humb. & Bonpl. ex Wi...	Willdenow 1805	V	E	D	[tc]
Ephedra americana var. humboldtii Stapf	Ephedra	americana	var.	humboldtii	Stapf	Stapf 1889	V	E	D	[tc]
Ephedra breana Philippi	Ephedra	breana			Philippi	Philippi 1895b	V	E	D	[tc]

Add | [Search] (Searches on primary sort field; use '%' as wildcard)

Taxon Concept

Code	Name	Publication	BHL pg1 ID						
Ephedra americana se...	Ephedra americana Humb. & Bonpl. ex Willdenow	Hunziker 1949		V	E	D	[tcm]	[tcm]	☐
Ephedra americana va...	Ephedra americana var. humboldtii Stapf	Stapf 1889		V	E	D	[tcm]	[tcm]	☐
Ephedra breana sec. ...	Ephedra breana Philippi	Hunziker 1949		V	E	D	[tcm]	[tcm]	☐

[Make congruent TCMs for checked TCs]

Add | [Search] (Searches on primary sort field; use '%' as wildcard)

TCM app: TC relationships

TC Relationships

TC1 newer	Relation	Synonymy	TC2 older	Publication	Graph	
Ephedra americana sec. Hunziker 1949	overlaps		Ephedra americana var. humboldtii sec. Stapf 1889	inferred by Ickert-Bond 2023	1	V E D
Ephedra breana sec. Hunziker 1949	overlaps		Ephedra americana var. humboldtii sec. Stapf 1889	inferred by Ickert-Bond 2023	1	V E D

Add | [_____] Search (Searches on primary sort field; use '%' as wildcard)

TCM graph

| Ephedra americana sec. Hunziker 1949 | | Ephedra breana sec. Hunziker 1949 |

| Ephedra americana var. humboldtii sec. Stapf 1889 |
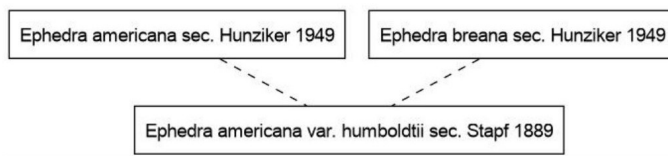
Nodes and edges are clickable. Hover over edges that are marked with * to see notes.
Edge style key:

Solid black: *congruent with* (=)
Dashed black: *overlaps* (><)
Dotted black: *intersects* (∩)
Dashed black with arrow: <arrow from> *is included in* <arrow to> (<)
Solid red: *is disjunct from* (|)

TaxonWorks

📖	Sources	⭐
✏️	Taxon names	⭐
▦	Otus	⭐
B	Otu relationships	⭐

TaxonWorks OTUs

- TaxonWorks is *preadapted* for handling taxonomic concepts and taxonomic concept relationships because of the foundational use of Operational Taxonomic Units (OTUs): "regions, not points"

- What we mean by an OTU is almost exactly the same as what we mean by a Taxonomic Concept

- In TaxonWorks, one name may have many OTUs

Sources → Names → OTUs

We name the OTUs: **Name sec. Publication**

TW: taxon concept alignments

B   Otu relationships   ⭐
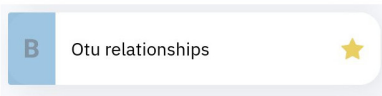
| TaxonWorks v0.35.1 Issues | | | Project   Account   Sign out   Campbell Webb |

Ephedra Monograph   **Otu relationships**   Otus

Displaying all 5 otu relationships   Display   ↻ Reset

‹ Back   Next ›   *Download not yet available.*   👁 housekeeping

Subject OTU	Type	Object OTU	Updated by	Last updated
Ephedra americana sec. Hunziker 1949 *Ephedra americana* Humb. & Bonpl. ex Willdenow ✓	overlaps	Ephedra americana var. humboldtii sec. Stapf 1889 *Ephedra americana* var. *humboldtii* Stapf ✓	Campbell Webb	about 2 hours
Ephedra breana sec. Hunziker 1949 *Ephedra breana* Philippi ✓	overlaps	Ephedra americana var. humboldtii sec. Stapf 1889 *Ephedra americana* var. *humboldtii* Stapf ✓	Campbell Webb	about 2 hours

Annotations can be added to the OTU relationships
for the "according to"

TW: taxon concept alignments

- Possible relationships (RCC5) in TaxonWorks:

  A *is disjoint with* B (|)

  `OtuRelationship::Disjoint`

  A *congruent with* B (==)

  `OtuRelationship::Equal`

  A *includes* B (>)

  `OtuRelationship::ProperPartInverse`

  A *is included in* B (<)

  `OtuRelationship::ProperPart`

  A *overlaps with* B (><)

  `OtuRelationship::PartiallyOverlapping`

  (A *intersects with* B

  `OtuRelationship::Intersecting`)

$\rightarrow$ Taxonomic concept alignment is easy to implement in TaxonWorks. Yay! Thanks

Wishlist:

- Taxonomic concept alignment visualization within TaxonWorks (*hinted at by Matt on Tuesday!*)
- Taxonomic concept panels, with alignment visualization, in TaxonPages
- Export concepts and alignments using TCS2 (an emerging TDWG standard)

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- **FOSS**: Linux, Apache, MySQL/MariaDB, Gawk, Graphviz, LaTeX, Arctos, TaxonWorks...

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