**Rypel et al. 2019, *Fisheries*.**

* Flexible classification of WI lakes for fisheries conservation/mgmt.
* Temperature and water clarity (+ hydrology) drive fisheries / fish community structure. So, as habitat / environmental conditions change, the fish community and fishery can shift, and so can lake classifications as they are based on environmental conditions in lakes.
* classified ~6,000 lakes into 15 lake ‘flexible’ classes
  + >8 hectares
* 2-part approach
  + cluster intro simple (<3 sportfish) vs complex (>4 sportfish) fish communities
    - 9 ‘groups’ (14 species excluding trout)
  + clustered into final classes using temperature and water clarity (Secchi depth)
    - k-means cluster for assignment, LDA for predictions
* Then, summarized fishery metrics within each class
  + relative abundance (CPE), size structure, growth (all metrics varied among classes)
  + used mean + IQR for ‘standards’ among classes

Diagram

Description automatically generated

**Mitro et al. 2019, *Hydrobiologia*.**

* Projected shifts in trout distribution from CC
* Used FishVis to predict current and project future BKT / BNT distributions
* Current suitable = 34k km for BKT and 20k km for BNT
* BKT to lose 68%, BNT to lose 32%

**Stewart et al. 2016**

* USGS Report. FishVis
* Predicted fish species occurrence under current and future climate conditions (RFs)
  + 5,627 sites; 432 in WI; 48 environmental variables
  + 13 species (cold-warm water representatives) across US Great Lakes
  + 369,214 km of stream across regions
* Projected fish occurrence under future climate conditions using downscaled GCMs

Map

Description automatically generated

**Diebel et al. 2015, WDNR Report**

* ELOHA in WI streams
* Developed hi-res 24k hydrography and assembled database of stream/watershed attributes
  + delineated watersheds for each feature in 24k hydrography
  + attributed with 100s of characteristics
* Developed hydrologic models to predict stream flow and water temperature (LMEs)
  + 23 metrics for exceedance flows (5-95%)
* Developed statistical models that relate environmental variables to fish presence (RF)
  + SDMs for 79 stream fish species using watershed, riparian, channel, and flow/temp.
  + Used ~750 surveys to build RF models
* Developed fish-flow relationships to assess effect of flow alteration on fish (GAMs)
  + predict species response to changes in median AUG flow yield + July water temp.

**Lyons, Stewart, Mitro 2010*, Journal of Fish Biology***

* Wisconsin precursor to FishVis and Mitro et al. 2019
* CART to predict P/A for 50 species using 69 variables
* Predicted out using 4 climate sceneries to look at reduction in habitat

**Lyon et al. 2009, *NAJFM***

* Coolwater streams and fish assemblages
* Used modeled water temp. data and fish assemblage samples from 371 (119 in WI) sites to define, describe, and map thermal stream classes and their fish assemblages.
* Surveys from 1996-2000; 99 species
* Classified streams into thermal classes
  + Coldwater
  + Coolwater
    - Cold transitional
    - Warm transitional
  + Warmwater

**Steen at el. 2008, *TAFS***

* Basically, pre-curser to Steward et al. (2016) FishVis
* builds on shift from local to landscape-scale analyses
* CART to predict P/A for 93 species in Michigan streams (72% accuracy)
  + First on water temp (<= 18.66 C)
  + Then, % urban, downstream linkage, course substate, flow

**Wehrly et al. 2003, *TAFS***

* changes in community compositions and richness occurred across temperature gradients
* 3 temp groups and 3 temp variation groups = 3 x 3 = 9 thermal regime classes

**Lyons 1996, *Environmental Biology of Fishes***

* patterns in species composition of fish assemblages among Wisconsin streams
* CCA; sites distributed along fish-environment gradients, BUT also segregated into stream temperature and geographic groups
* Proposed hierarchical classification of stream sites based on:
  + first classify on trout stream type (class 1/2/3 = coldwater and 4 = warmwater
  + then on ecoregion (4 groups)
  + then on basin area (less than vs greater than 50 km2)
  + then on gradient (less than vs greater than 3 m/km
* Yields 32 classes; but not all exist, so functionally only 20 classes

**Modde et al. 1991, *NAJFM***

* Black Hills, SD
* Evaluated a habitat-based (reach-scale) classification systems for small watersheds (trout focus)
* Works, but depends on consistent species response to habitat quality

**Hallwell 1989,**

* Dissertation: Classifying stream in Massachusetts for fisheries management
* 691 streams, 1430 surveys across MA
* Detrended CCA delineated 3 fish faunal regions
* Cluster analysis and LDA on thermal/gradient metrics identified 6 classes
* Analyses fish community structure within identified classes

**Kuehne 1962, *Ecology***

* Classifying stream using fish distributions in Kentucky
* At the time, no good classification for lotic systems; based on geology (young, old)
* Synthesized earlier work to say the Horton/Strahler system is best for streams

**Margalef 1960, *Hydrobiologia***

* synthetic approach to ecology of running waters
* developed a partial classification based primarily on algal associations and communities
* But similar to the youthful/old categories of old geological classifications

**Burton & Odum 1945*, Ecology***

* distribution of fish near a lake in Virginia
* Stream classification based on physical habitat: pools vs riffles
* good treatment of longitudinal succession in streams

**Strahler 1954, 1957**

* Modified Horton (1945) classification by assigning lowest order to all headwaters\
* This added many operational advantages

**Ruttner 1952**

* Book: Fundamental of Limnology
* Stream classification based on water speed: swift vs sluggish (no physical classification)

**Horton 1945**

* Stream classification based on dendritic branching

**Pearse 1939**

* Book: Animal Ecology
* Similar scheme to Klugh (1923)
* But neither gained much acceptance or use because the didn’t help much

**Klugh 1923**

* Divided streams into 4 categories:
  + Temporary stream
    - Pools vs riffles
  + Spring stream
    - Pools vs riffles
  + Warm spring
    - Pools vs riffles
  + Permanent stream
    - swift-flowing (then broken out based on substrates)
    - slow-flowing

**Shelford 1911**

* First treatment of longitudinal succession in streams