BZ471, Stream Biology & Ecology

Final Examination

15 December 2025

Total = 47 points plus 4 additional BONUS points possible

MULTIPLE CHOICE 13 points

_____ The export of aquatic insect biomass to terrestrial birds, and the transfer of forest insects to fish is an example of a:

a) descriptive interaction web
b) trophic cascade
c) riparian energy exchange
d) reciprocal subsidy
e) quantitative flow web

_____ The herbivorous caddisfly *Dicosmoecus* is a key species in many food webs of many small coastal California rivers. Which of the following is/are NOT TRUE about this ecologically important caddisfly?

a) *Dicosmoecus* is generally more abundant in dammed versus free-flowing rivers
b) Growth rates of top predators in the system (juvenile steelhead trout) are higher in dammed rivers compared to undammed rivers
c) The abundance of "vulnerable" prey (i.e., soft-bodies mayfly grazers) decreases with *Dicosmoecus* abundance
d) Algae are more abundant in streams that lack *Dicosmoecus* compared to those that have *Dicosmoecus.*
e) All of the above are true.

_____ Which of the following will *increase* the index of biological integrity (IBI) score of a fish community?

a) number of tolerant species in a community
b) percentage of feeding specialists in a community
c) proportion of native fish species in a community
d) a and b
e) b and c

_____ Which of the following is/are generally NOT TRUE about the effects of disturbance on stream species and communities.

a) Species richness declines during disturbance and typically increases with time since disturbance
b) All the species in the community generally show the same level of mortality to a disturbance
c) Individual organisms can seek refuge during disturbance
d) High levels of disturbance in streams are associated with longer food chain lengths
e) b and d

_____ A non-native species that causes economic damage and/or significant ecological harm is known as a(n):

a) exotic
b) non-indigenous
c) invasive
d) alien
e) all of the above

_____ Consider a small river (like the Eel River studied by Mary Power) with 4 trophic levels: (i) large piscivorous fish, (ii) small insectivorous fish and large predatory insects, (iii) herbivorous benthic insects and (iv) benthic algae. Which of the following would you most likely observe if the large piscivorous fish were removed from the system (say, by overfishing)?

a) Insectivorous fish would decrease, algae would increase
b) Insectivorous fish would increase, algae would decline
c) Herbivorous insects would decline, algae would increase
d) Herbivorous insects would decline, algae would decline
e) None of the above

_____ Which of the following are NOT TRUE about the how groundwater inputs into a stream influence that stream?

a) Stabilize the streamflow by causing smaller peak discharge from storms and higher baseflows in non-rainy seasons
b) Provide alkalinity and [OH^-] to help buffer the stream pH against natural and human sources of rainwater acidification
c) Make temperature in the receiving stream cooler in summer and warmer in winter than it would be without the groundwater input
d) Provide dissolved organic matter (DOM) to fuel stream food web
e) All of the above are not true

_____ Environmental flows (e-flows) are defined as "the _____, _____, and _____ of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems." (Note "quantity" is the same as "magnitude" here.)

a) quantity, frequency, duration
b) quantity, quality, duration
c) quality, duration, timing
d) quantity, quality, timing

_____ A species of mayfly species in Colorado's Rocky Mountains are found in streams from the foothills-plains boundary (~1600 m elevation, lower elevation) up into the subalpine zone (~3000 m elevation, upper elevation). Based only on the thermal niche of such species, the largest females are expected to emerge at _____, and the smallest adult females would emerge at _____.

a) lower elevation; upper elevation
b) mid-elevation; mid-elevation
c) mid-elevation; upper and lower elevation
d) upper elevation; mid-elevation
e) lower elevation; mid- and upper elevation

_____ Which of the following are NOT expected in a heavily urbanized stream compared to a reference stream?

a) Fewer EPT taxa
b) Fewer fluvial (flowing water specialists) fish species
c) Less habitat heterogeneity (i.e., less variety of habitat types)
d) More wood in the channel
e) A flashier hydrograph

_____ The highest rates of extinction and species imperilment are in

a) marine systems
b) freshwater systems
c) terrestrial systems
d) all three are equivalent

_____ In the experimental research conducted by Baxter et al. (2004) in a Japanese stream, which of the following was NOT reported?

a) the number of streamside spiders *declined* when non-native rainbow trout were added to the stream
b) rainbow trout caused native fish (Dolly Varden) to switch from eating benthic insects to eating drifting terrestrial insects
c) algae increased on the streambed when rainbow trout were added
d) building a "greenhouse" over the stream had an equivalent effect on the food web as addition of rainbow trout
e) ALL of the above were reported

_____ In research by Bobbi Peckarsky at the Rocky Mountain Biological Laboratory near Gothic, Colorado, in small streams having resident brook trout compared to streams without brook trout, the herbivorous *Baetis* mayflies emerged at a(n) _____ date and at a _____ size in streams with fish versus streams without fish. Accordingly, we would expect algal biomass to be _____ in the stream with fish.

a) earlier, larger, greater
b) later, smaller, less than
c) earlier, smaller, greater
d) later, larger, less than

TRUE-FALSE - Please write the word True or False in the blank 6 points

_____ Kurt Fausch and students experimentally added wood structure to a small stream in Colorado, and they found *more* trout in the 500-meter long stream reaches with experimentally-added wood structures compared to reaches lacking wood additions.

_____ So-called "tie drives" (using river channels to transport felled trees downstream) in the 19th Century widened and simplified the stream channels we observe today for many streams along the Front Range of Colorado.

_____ To effectively assess the impairment of a stream from some stressor(s), a nearby, completely pristine stream (i.e., completely unimpacted by humans) is necessary to provide a useable "reference" condition.

_____ A first response of a stream to onset of urbanization in the watershed through land clearing is to aggrade in response to increased sediment supply.

_____ In a study in a California stream, experimental disturbance of stone surfaces (using toothbrushes to simulate bed scour) showed that a competitive dominant species (caddisfly *Hydropsyche*) was able to dominate over a mobile colonizer species (blackfly *Simulium*) in those patches that were not disturbed.

_____ Diatoms have the lowest food quality of all algal types due to their low C/N ratio.

SHORT ANSWER. For each, provide a succinct yet complete answer. [11 points total]

(1) The *taxonomic* composition of a stream riffle community can change over time due to a variety of reasons provided in class. A) Give two reasons. [2 pts].

1)

2)

(2) In your own words, explain why fish *productivity* (measured in terms of new fish biomass per year) increases in a large river-floodplain ecosystem when there is a "flood pulse." [1 pt]

(3) Give one (and only one!) advantage and one disadvantage of using benthic macroinvertebrates as indicators of biological condition in streams. [2 pts]

Advantage:

Disadvantage:

(4) Even though the taxonomic composition changes, the *functional* composition can remain unchanged. Explain how this is possible? [1 pt]

(5) One of the 3 general principles of Moyle and Light (1996) for successful invasion of a habitat by a non-native species is "matching of life history with flow regime." (a) What does this mean? (b) Give one example from lecture that demonstrates this principle for a particular species. [2 pts]

a)

b)

(6) In a small, open-canopy stream invaded by the exotic, algivorous New Zealand mud snail, growth rates of native fish species are observed to decline. Give a plausible hypothesis that explains this observation based on your understanding of stream food webs as presented in examples in lecture. [1 pt]

(7) Imagine you're hiking in late summer along a trail along a wilderness stream in the sunny Arizona desert. The stream has a typical pool-riffle morphology, and you observe a repeating pattern of increased algal biomass at the downstream ends (tails) of riffles but not at the upstream heads of riffles. Riparian shading is similar all along the stream and the substrate is consistently composed of mostly coarse sand and fine gravel. Offer a hypothesis that can explain this pattern. How would you use the thermometer you just happen to have in your pocket to support this hypothesis? [2 pts]

Hypothesis:

Support:

GRAPH/DATA INTERPRETATION (17 points total)

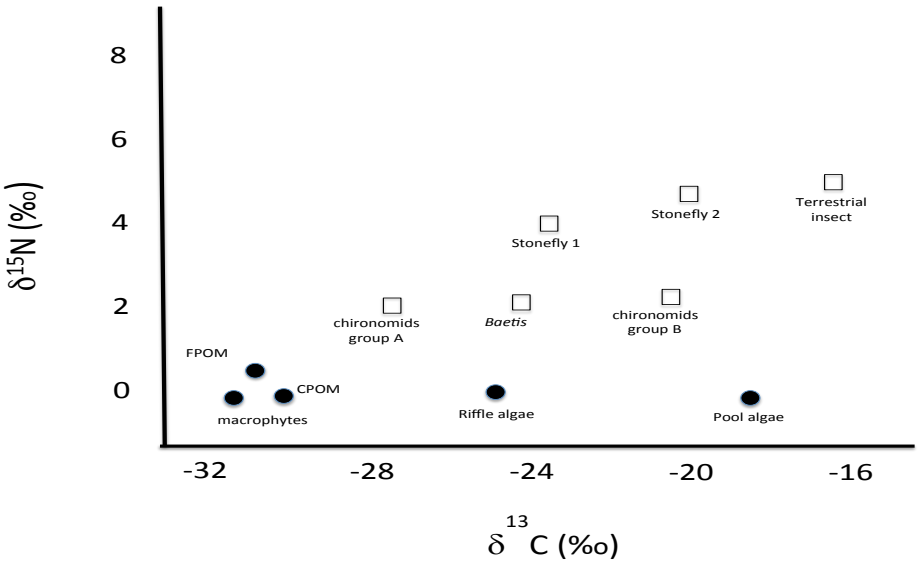
(1) In the isolated pools of an Oklahoma stream studied by Mary Power from previous lectures, the herbivorous minnow, *Campostoma*, is behaviorally capable of tracking and depleting most of the algal biomass in stream pools, but they are preyed upon by piscivorous largemouth bass. At low flows the pool habitats are isolated, but during storm events they are hydrologically connected. You observe 2 pools before and after a flood and note are large differences in the amount of the benthic algal "prey" (filamentous green alga, *Cladophora*) growing in deep versus shallow water in different pools. The table below shows the average (and range) of length of *Cladophora* filaments (i.e., a measure of biomass) in deep and shallow regions of two separate stream pools during one sampling period. [2 pts]

	Deep water average algal height (cm)	Shallow water average algal height (cm)
Before flood		
Pool 1	12 ± 2	2 ± 1
Pool 2	3 ± 1	9 ± 2
After flood		
Pool 1	11 ± 2	2 ± 1
Pool 2	11 ± 2	3 ± 1

a) Which of the two pools is likely to have piscivorous largemouth bass present BEFORE the flood? Why?

b) Several weeks after a major flood occurs, you observe that algal cover in the *deep* water of Pool 2 has increased to 11 cm and that algal cover in the shallow water of Pool 2 has dropped to 3 cm. Provide a hypothesis for what caused this change in algal cover.

(2) You are studying food web structure in a mountain river in Colorado that is now home to a non-native rainbow trout population. You collect samples of several dominant insect groups and primary food sources from the stream and obtain the following information regarding stable isotope ratios (only means shown; error bars left out for simplicity). Answer the following questions. [4 pts]



a) What is likely the main food source for *Baetis* and why? [1 pt]

b) What do you think the "chironomid Group A" are eating and why? [1 pt]

c) Of the *aquatic* insects sampled and recorded, which taxon is at the highest trophic level and why? [1 pt]

d) Place an "x" on the graph where you would predict rainbow trout to appear based on consumption of prey resources shown in this graph and *explain* its position in terms of both the C and N isotope values. [1 pt]

(3) Consider the following figure (presented in lecture), which shows observed fish IBI scores for many streams in each of 5 ecoregions in Ohio. [3 pts]

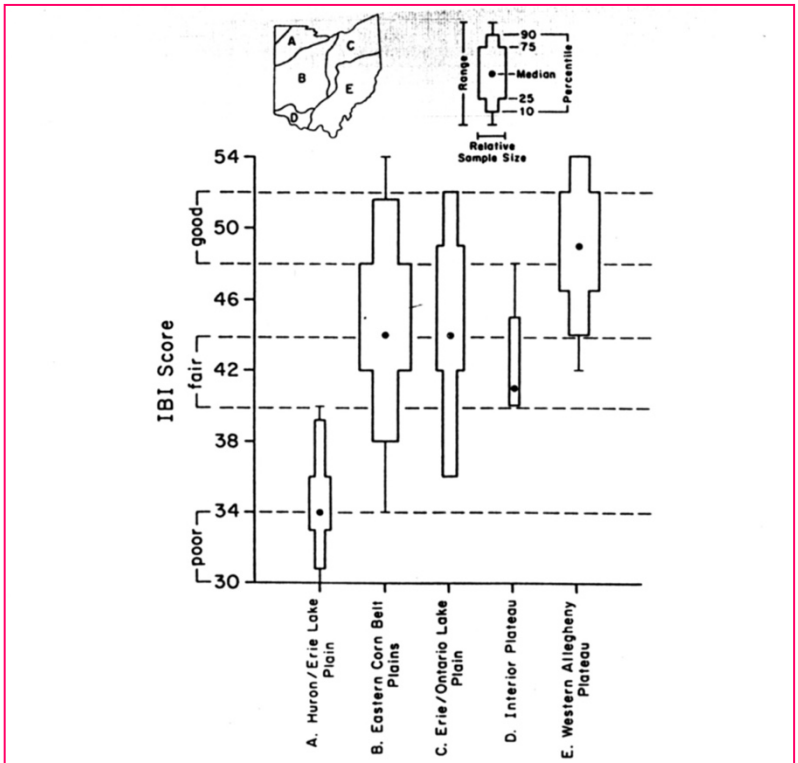


Figure 3. Ecoregional patterns in the index of biotic integrity (IBI) for fish assemblages of Ohio streams (from Whittier an others 1987). See upper right inset for description of box plots. **A,** Huron/Erie Lake Plain, **B,** Eastern Corn Belt Plains, Erie/Ontario Lake Plain, **D,** Interior Plateau, **E,** Western Allegheny Plateau. Greater index values represent greater complexi and health of fish assemblages.

(a) What is the rationale for grouping streams across the state of Ohio in this fashion? [1 pt]

(b) For ecoregion A (Huron/Erie Lake Plain) and ecoregion E (Western Allegheny Plateau), what IBI scores would reasonably be associated with "reference" streams? [1 pt]

A Huron/Erie Lake Plain: _____

E. Western Allegheny Plateau: _____

(c) _____ A stream with an IBI score of 39 in Region A (Huron/Erie Lake Plain) is viewed as having the same degree of impairment as a stream in Region C (Erie/Ontario Lake Plain) with the same IBI score. Write "True" or "False" in the space above. [1 pt]

(4) Use the 3 figures below to answer this question. [4 pts]

Figure 3 (from Fausch et al. 2001) shows the annual hydrograph (left column) and the timing of emergence of small juvenile rainbow trout from their streambed redds (range represented by horizontal bars) in late winter and spring relative to the frequency of high flows in different months of the year (right column) for streams in 5 regions around the world. These graphs can be used to *predict* the successful establishment of rainbow trout outside their native Pacific Coast range (top row of Fig. 3).

Fig. 2A and Fig. 2B in the top right of the panel (from Wenger et al., 2011, discussed last day of lecture) show the probability of capture (a measure of abundance) for 4 species of trout based on capture of species from streams in the intermountain west of the U.S. having these temperature and flow characteristics. The lines in each panel are labeled as Cut (cutthroat trout), Brook trout, RBT (rainbow trout) and Brown trout.

The bottom right figure (labeled b from Stewart et al. 2005) shows that the timing of gauged high-elevation snowmelt runoff across the western U.S. is occurring up to a month earlier at the end of the 20th Century (up to 2002) than it did earlier in the 20th Century (starting in 1948).

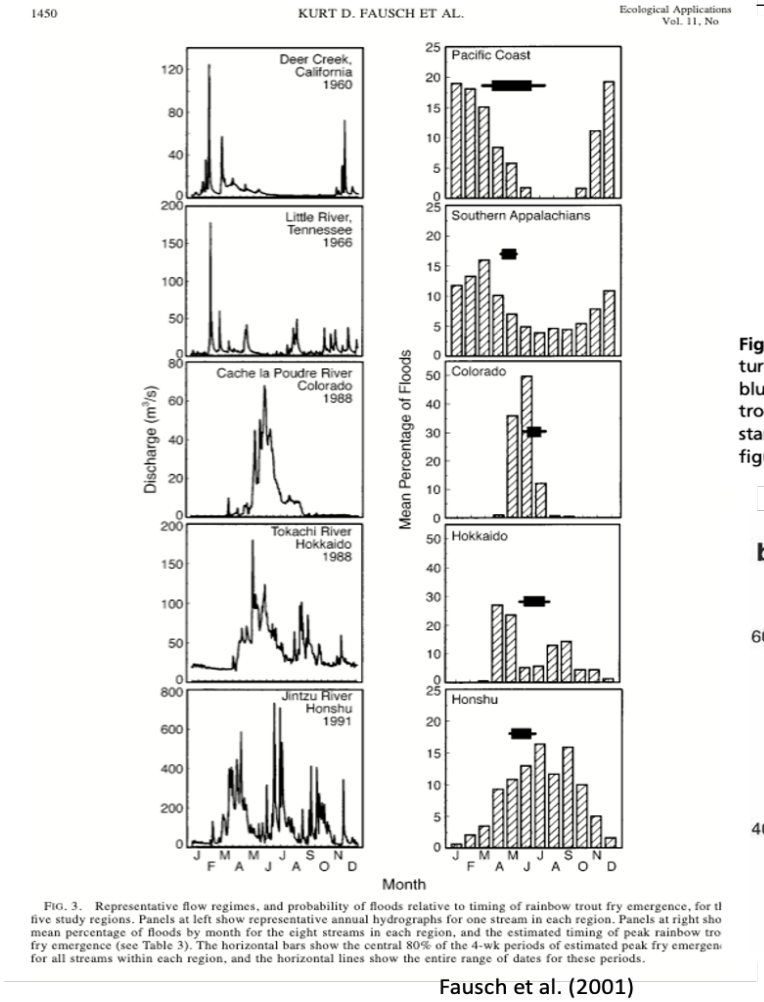


FIG. 3. Representative flow regimes, and probability of floods relative to timing of rainbow trout fry emergence, for th five study regions. Panels at left show representative annual hydrographs for one stream in each region. Panels at right sho mean percentage of floods by month for the eight streams in each region, and the estimated timing of peak rainbow tro fry emergence (see Table 3). The horizontal bars show the central 80% of the 4-wk periods of estimated peak fry emergen for all streams within each region, and the horizontal lines show the entire range of dates for these periods.

Fausch et al. (2001)

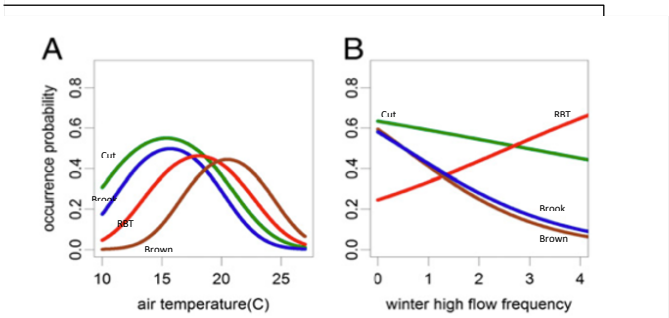
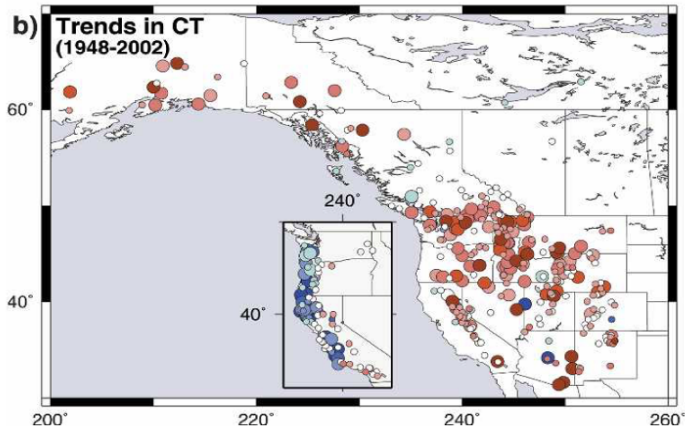


Fig. 2. Occurrence probability of trout species as a function of air temperature (*A*) and winter high flow frequency (*B*). Green indicates cutthroat trout; blue indicates brook trout; red indicates rainbow trout; brown indicates brown trout. The different temperature and flow metrics for different species were standardized to a common *x* axis in each panel to facilitate comparisons; the figures are shown with original axes and with confidence intervals in Fig. S1.

Wenger et al. (2011)



Stewart et al. (2005)

(a) Using these 3 figures, (1) make a prediction and (2) give a reason about how rainbow trout populations in the Cache la Poudre River, Colorado (Figure 3, middle row) would be projected to benefit or to suffer from global warming's effect on snowmelt hydrologic regimes**.**

1. Prediction: **[1 pt]**

2. Reason: **[1 pt]**

(b) Fig. 2A shows likelihood of trout presence as a function of average air temperature (which is correlated to stream temperature). If average air temperature increased in a Colorado stream from an annual maximum of 19°C up to 23°C, how would rainbow trout populations likely be affected, according to Fig. 2A? What would be the reason? **[1 pt]**

(c) Given that native cutthroat trout (green lines) are most often negatively impacted by interactions with non-native brook trout (blue), and these species share the same thermal niche, under what future *temperature and flow conditions* caused by global warming would cutthroat have the greatest advantage (population success) over brook trout? Explain why in terms of temperature and flow conditions. In answering this question, assume that the winter flow frequency (Fig. 2b, x-axis) is defined as 1 event at an air temperature of 10°C, 2 events at 15°C, 3 events at 20°C and 4 events at 25°C. [1 pt]

BONUS QUESTIONS: +4 pts

BONUS #1 Recall how the armored caddisfly grazer, *Dicosmoecus gilvipes*, can dominate in northern California rivers under particular hydrologic conditions. How might you predict (a) *Dicosmoecus* population sizes to change and (b) steelhead salmon growth rates to change in free-flowing (undammed) streams that have converted from snowmelt runoff to winter-rain runoff, if at all? Offer a specific hypothesis and give a specific mechanism that leads you to make this hypothesis. [+2 pts]

a)

b)

BONUS #2 Consider the graph below and ***explain why*** maximum daily temperature range (i.e., diel variation) peaks in "mid-order" streams compared to headwater streams and large-order rivers. [+1 pt]

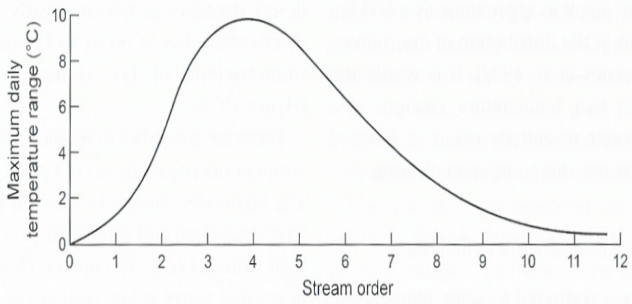


FIGURE 5.12 Maximum daily temperature ranges in relation to stream order in temperate streams. (Reproduced from Vannote and Sweeney 1980.)

BONUS #3 What was the most interesting thing you learned this semester? [+1 pt]