Station 1

1. D
2. Leaves are a allochthonous source while algae and other microbes are autochthonous sources; allochthonous sources dominate for streams and small lakes
3. Higher than; lower (1.5 points each)
4. Beavers, fiddler crabs, certain types of plants
5. C, E, F
6. B, C, E
7. A, E, F

Station 2

1. 3
2. Through a top-down trophic cascade, the amount of piscivorous fish should be increased, thus decreasing zooplanktivorous (in this case the amphipod assumes the role of a zooplankton) fish biomass, increasing herbivorous zooplankton biomass, and decreasing phytoplankton biomass.
3. The pyramid should be shaped regularly but with the phytoplankton level smaller than the amphipod level.
4. There are 80 * (2.5/3.5) males and 80 * (1/3.5) females. $N_e = (4 * N_m N_f)/(N_m + N_f) = 65.31$.
5. $dN/dt = rN(1 - N/K)$. $-7 = r * 1100 * (1 - 1100/500)$ so $r = 0.0053$ individuals/(individuals * year).
6. Phosphorus (0.5 point), nitrogen (0.5), potassium (1). Phosphorus is limiting in freshwater (1) because [nitrogen compounds are more mobile and tend to accumulate in water, while phosphorus compounds tend to be bound up in soil and aquatic sediments] (1). Due to Liebig's Law (1), only the scarcest nutrient controls population growth. *Note: a maximum of 3 points may be given if Liebig's Law is not mentioned or if more than just phosphorus is listed.*
7. No; Redfield ratio is the ratio of C:N:P, and continuing off of question 6 clearly the ratio of N:P should be reversed.
8. A

Station 3

1. C, F
2. (see below)
    a. Limestone (calcium carbonate, $CaCO_3$) in lake beds forms bicarbonate (HCO_3^-) ions in the reaction $CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$. *Note: if an equilibrium arrow is not present, subtract 0.5 points. State symbols are not required.*
    b. $CO_3^{2-} + H^+ \rightarrow HCO_3^-$; $HCO_3^- + H^+ \rightarrow H_2CO_3$. *Note: accept H_3O^+ instead of H^+ if H_2O is added on the product side. If an equilibrium arrow is present, subtract 0.5 points (this is not an equilibrium reaction). Both reactions must be present for any credit to be received.*
    c. $CO_2 + H_2O \rightleftharpoons H_2CO_3$. *Note: if the equilibrium arrow is not present, subtract 0.5 points.*
    d. Because K_{a2} is so much smaller than K_{a1}, we can safely ignore the equilibrium calculation for K_{a2}. If x = final concentration of H^+ = final concentration of HCO_3^-, then $4.3e\text{-}7 = x^2/(1 - x)$. If we substitute 0 for x in the denominator because x is miniscule in comparison to 1M, then $4.3e\text{-}7 = x^2$ and x = 6.6e-4M. $pH = -\log[H^+] = 3.18$ or thereabouts (accept anything between 2.5 and 3.5). *Note: if no work is shown, give no credit. If pH = -log(1) is shown, give one point (although it is incorrect). For each correct equilibrium equation shown, give one point.*

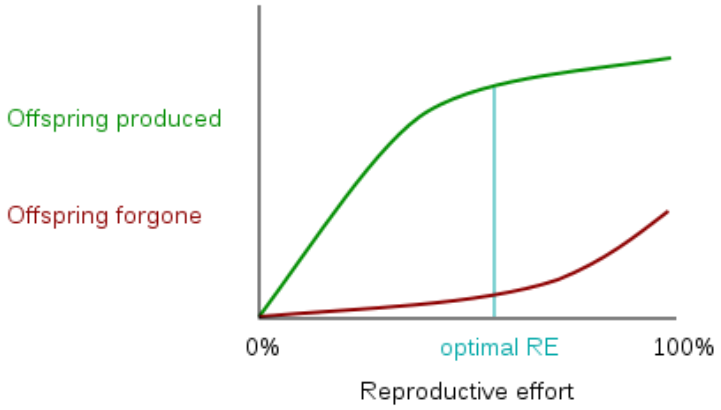
3. (see below)
    a. Canopy interception
    b. Advection
    c. Subsurface flow
4. Shortest: d; longest: f (1.5 points each)

Station 4

1. (one point for each column; all or nothing for each column)

Year (x)	Population (a_x)	Survivorship (l_x)	Mortality (d_x)	Mortality Rate (q_x)	Fecundity (m_x)	… (l_xm_x)
1	1000	1000/1000 = 1	1 - 0.8 = 0.2	0.2/1 = 0.2	0.50	0.5
2	800	800/1000 = 0.8	0.8 - 0.3 = 0.5	0.5/0.8 = 0.625	3.50	2.8
3	300	300/1000 = 0.3	0.3 - 0.175 = 0.125	0.125/0.3 = 0.417	5.50	1.65
4	175					
5	150					
6	100					
7	20					
8	0					

2. Cohort
3. Multiple definitions; accept either (1) average number of offspring per female or (2) the contribution of each age class to the overall population growth rate
4. Accept either answer: it weighs l_xm_x by life stage; it is often used for the calculation of population parameters
5. R_0 = sum of l_xm_x = 4.95 (1 point). This represents the net reproductive rate, or the average number of offspring produced by an individual in its lifetime (either is fine; 1 point). Because R_0 is positive, the population is increasing in size (1 point; note that the change in the population of this cohort does not represent the growth or decline of the population at large).
6. True; there are many resources available online regarding the construction of a Leslie matrix so I will not discuss it here.
7. Type III
8. (see below)
    a. Iteroparous
    b. See image below; optimal RE is when the difference between offspring produced and offspring forgone is at a maximum.



c. False; salmon are semelparous
d. K selection

Station 5

1. (see below)
    a. Decreases
    b. Faster
    c. More
2. Thermal shock
3. (see below)
    a. ln[final] = ln[initial] - kt; ln[final] = ln[0.60] - 0.025(48); [final] = 0.18 µg/mL
    b. The half life of permethrin is approximately 40 days in soil due to less exposure to sunlight and a decreased rate of hydrolysis (other explanations are accepted). As a result, the rate constant (0.693/half life) decreases.
    c. Restricted use pesticide
4. (see below)
    a. Siltation (NOT sediment pollution). *Note: siltification is accepted in place of siltation.*
    b. This is very clearly a rural area so dredging can be ruled out as a cause. As a result, we need to address erosion from intensive agriculture (1 point). Acceptable answers (1 point each) include soil fixation (through shelterbelts, woodlots, windbreaks), contour trenching, etc.
    c. Answers may vary depending on interpretation; I was going with sediment control, which includes methods such as check dams, sandbag barriers, sediment basins, silt fences, etc.
    d. Siltation is sometimes caused by raw sewage sludge, resulting in increased cases of waterborne infectious disease (1.5); silt can also act as a vehicle for pesticides and industrial waste, both of which may be toxic (1.5)

Station 6

For questions 1 to 3, subtract 1 point for each incorrect or missing answer (up to 2 points).

1. 1, 3, 5, 7
2. 1, 3
3. 2, 5
4. A, C
5. Microfilters (1) combined with sand or activated carbon filters (1). Both organisms are resistant to chlorine. *Note: 0 points are given for this question if chlorination is mentioned at all.*
6. Secondary (1); any three of the following (1 point each): degrading organic contaminants, flocculation, fixed-film systems (must mention biofilm), activated sludge systems, anaerobic sludge digesters

7. B
8. A, D

Station 7

1. 22 (accept 20 to 24 for full credit)
2. The four categories are supporting, provisioning, regulating, and cultural (1 point each). You can find a list on Wikipedia under "Ecosystem services," but I have also provided a list below (0.5 points per service identified). *Note: I apologize for this question not being very creative, but ecosystem services are a part of the rules and this was the most efficient way of addressing the topic.*

Water Supply
Drinking, cooking, washing, and other household uses
Manufacturing, thermoelectric power generation, and other industrial uses
Irrigation of crops, parks, golf courses, etc.
Aquaculture

Supply of Goods Other Than Water
Fish
Waterfowl
Clams and mussels
Pelts

Nonextractive or Instream Benefits Flood control
Flood control
Transportation
Recreational swimming, boating, etc.
Pollution dilution and water quality protection
Hydroelectric generation
Bird and wildlife habitat
Soil fertilization
Enhanced property values
Non-user values

3. A, B, D, E, F
4. A, D, F
5. (see below)
    a. Blackwater river (as opposed to whitewater)
    b. In slow-moving water, as vegetation decays, tannins leach into the water, making the water darkly stained and acidic
    c. Lower; less; lower

Station 8

1. (see below)
    a. Sorensen's coefficient is 2a/(b + c) where a is the number of species in common between x and y, b is the number of species in x, and c is the number of species in y. Thus, Sorenson's coefficient is 0.57.
    b. The minimum value is 0, indicating no similarity; the maximum value is 1, indicating maximum similarity.
    c. Simpson's index (D) is the sum of p_i^2, and Simpson's index of diversity is 1 - D. For x this is 0.64 (1 point) and for y this is 0.71 (1 point). It is not appropriate to compare the two values due to the small sample size and because not all of the species in each community are represented in the table (explanation must be provided for 1 point to be awarded).
2. (see below)
    a. This is called the Gaarder and Gran technique (1); three bottles are used, where the first is analyzed immediately to determine the initial oxygen concentration (1), the second is incubated under light (1), while the third is incubated in the dark (1).
    b. NPP = GPP - R; 6.39 - 6.24 = GPP - 6.24 - 6.16; GPP = 0.23 mg carbon/L/day

c. Net production efficiency = NPP/GPP = 0.15/0.23 = 0.65 or 65%
d. ^{14}C incorporation

Station 9

1. (see below)
    a. Damselfly
    b. The male is more brightly colored than the female.
    c. The water is relatively unpolluted (1) and acidic (1).
2. (see below)
    a. *Psephenus* (also accept *Ectoparia*)
    b. It cannot live in habitats where rocks acquire a thick layer of algae, fungi, or sediment
    c. 6-10 mm
3. (see below)
    a. *Aedes albopictus*
    b. *Wolbachia*; cytoplasmic incompatibility
    c. Minnows and dragonflies
4. (see below)
    a. *Lythrum salicaria*
    b. Autumn
    c. General
    d. Any two of the following: disruption of water flow, decline in biodiversity (specifically the crowding out of cattails), alteration of life cycles of various organisms
    e. Through biological pest control
5. (see below)
    a. *Bythotrephes longimanus*
    b. Secondary consumer
    c. Daphina zooplankton
    d. Can eliminate zooplankton species (1); zooplankton are the backbone of aquatic food chains (1). *Note: discussion of how it competes with fish of the same trophic level is also acceptable for 1 point.*
6. (see below)
    a. *Dreissena polymorpha*
    b. Through byssal threads (that come out of their dorsal side; optional)
    c. Any two of the following: damage harbors/waterways, ships/boats, water treatment plants; cling to pipes underwater and clog them
    d. Filter feeding; can increase water clarity, but the increased penetration of sunlight results in the growth of submerged macrophytes, which causes water quality problems when the macrophytes decay

Station 10

1. (see below)
    a. Gas chromatography–mass spectrometry
    b. Atomic fluorescence spectroscopy
    c. Electrical conductivity meter
2. Yes; primary standards regulate substances that affect human health, while secondary standards prescribe aesthetic qualities.
3. Answers may vary (0.5 points per precaution). At least five of the following seven precautions should be listed; otherwise, no more than 4 points may be given for this question.
    a. Dechlorinating agent (such as sodium thiosulfate) should be added to stop chlorine reactions
    b. Volatile organic compounds should be preserved using hydrochloric acid, which reduces microbial

activity

c. Water sample should be kept between 4 and 6 degrees celsius (mentioning “cold” also suffices)
d. Depending on state, the sample should be analyzed within six or thirty hours (mentioning overnight or express delivery to the lab fulfills this precaution)
e. When collecting the bacteria sample, gloves should be worn and the sampling point should be sterile
f. Documentation and sample identification
g. Sampling containers must be made of materials with minimal reactivity