**Investigating the Ecological Value of Migratory Fishes on Stream Ecosystems in Southern Appalachia**



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| Ecological Question | What is the value and impact of inland fish migration to stream ecosystem dynamics? |
| Case Study Overview | Lesson 1: The role of Pacific salmon in adding energy and nutrients to streams  Lesson 2: The contribution of inland fish migrations to headwater stream productivity  Lesson 3: Discerning patterns in redhorse migration through data analysis  Lesson 4: Climate change and phenological mismatches in the timing of fish migrations |
| Audience | Undergraduate students in introductory biology courses |
| Timeline | 4 lessons over 4 50-minute class sessions |

**Summary**

Using the Ecological Society of America’s Four-Dimensional Ecology Education (4DEE) framework, students apply ecological concepts such as energy flow, nutrient cycling, migration, and climate change and practice interpretation and analysis of ecological data through a multi-class case study focusing on an inland migration of a group of freshwater fishes in headwater streams of southern Appalachia.

The ecological processes of small streams are a critical component of the network of streams in a watershed. In small, headwater streams, organic matter and nutrients that support the living biomass comes mostly from allochthonous materials. Energy and nutrients derived from organic material affects downstream production and nutrient availability for organisms. To maintain the ecological health and productivity of a network of streams, ensuring proper connectivity of headwaters to downstream segments is important. Movement by migrant organisms in the other direction, from downstream to upstream, is also critical. Small streams are important spawning habitat for species that live in larger streams but migrate upstream to reproduce. Various fish species migrate upstream to headwaters, and many studies have documented the importance of migratory fishes as transporters of energy and nutrients (e.g. N, P, K, and Ca). Recent research suggests that upstream inland migration of freshwater fishes may deliver nutrients at a critical time when headwater streams have low nutrient availability. This exercise investigates the importance of inland migrations by redhorse suckers (*Moxostoma spp.*) in headwater stream ecosystems, using a redhorse species of conservation concern in southern Appalachia as an example. Because of their potential to deliver nutrients to inherently low nutrient headwater streams, redhorses and other migratory suckers likely play an important ecological role and, as a result, warrant greater consideration for conservation.

The activity requires students to investigate scientific papers, work with data, and create and interpret graphs. Students produce an annotated bibliography, draw a concept map, construct hypotheses and predictions, and design a poster to communicate the findings of the case study.

**Student Assessment**

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| **Assignment** | **Points** |
| Four “flipped learning assignments” completed before class | 20 |
| Four “in-class inquiry activities” completed during class | 20 |
| Lesson 1 Concept Map | 5 |
| Lesson 1 After-class Activity – Terrestrial migration summary | 5 |
| Lesson 3 After-class Activity – Discussion question summary | 5 |
| Poster communicating findings of the case study | 75 |