Are Restoration Goals and Timelines Consistent with Aquatic Invertebrate Life History Traits?

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Objectives

- Examine Restoration Goals and Timelines
- Discuss role of dispersal in stream restoration, possibility of using faunal reintroduction / *in-situ* bioassay

Restoration Project Goals - Problems

- Not defined *a priori* or tied directly to measurable monitoring goals
- Unrealistic or inappropriate scale of restoration
- Lack of or inadequate baseline data

Restoration Project Grant Timelines

- Short timelines, typically 2-3yrs, rarely 5yrs.
- May include one or more phases, *e.g.*, concept design, final design, construction, or monitoring
- Monitoring rarely falls within grant window

Restoration Project Monitoring

- Monitoring effort inconsistent
- Projects included in NPDES permit have obligation to monitor
- Institutional “short term memory”
  - Partners cannot help past funding deadline
  - Push to implement new projects

Stream Restoration Project Goals

- Increase Habitat Heterogeneity
- Improve Biological Integrity
- Protect Sewer Infrastructure
- Urban BMP / Natural Stream Channel Design Demonstration Project
- Enhance Aesthetics of Park

Practical Goal – PA 303(d) list

- Urban Stream Restoration part of Watershed Management Plan
- Regulatory-based Goal
- 63% PADEP IBI for attaining aquatic life use
- Mechanism(s) for meeting goal not explicitly stated

“Field of Dreams” Hypothesis[1]

- “If you build it, they will come.”
  - Some taxa already present at site (or nearby)
  - Some taxa locally extirpated and will need time to disperse to the site

1.)Palmer *et al*. 1997

Restoration Site Monitoring

- Macroinvertebrate, Habitat, Fish RBPs
- Cross-sectional and longitudinal profiles
- Bank pins, bar samples, sediment sampling
- 3D total station survey w/ velocity observations

Results to Date

- Construction disturbance impact
- Observed re-establishment of pre-existing macroinvertebrate community
  - Refugia within site
  - Drift from sites upstream
- Failure to achieve further improvement, likely due to additional abiotic stressors
  - Urban hydrology
  - Water quality impairment

Evaluate Ecological Success w/ Bioassessment

- Compare pre- and post- construction bioassessment results (metrics)
  - Only 2 samples: variability unaccounted for
  - Rapid protocols underestimate local species pool
- Monitoring timeframes
  - When (or how frequently) to monitor?
  - Rate of expected changes within community
- Biotic factors

Types of Dispersal[2]

- Passive dispersal
  - Phoresis – “Stowaways” Waterfowl, Anglers, Fish
  - Wind
- Active dispersal
  - Aerial dispersal by flying adults
- Dispersal through time
  - Diapause, resistant life stages

2.)Bilton, *et al*. 2001

Evidence for Dispersal of Stream Invertebrates

- Terrestrial collection of moving adults
  - Malaise[3,4,5], light[6,7], and sticky traps[8]
- Mark-recapture
  - Stable isotopes[9,10,11]
- Virgin, newly created habitats[12]
- Recovery from disturbance[13]
- Inferential evidence (*i.e.*, gene flow) from molecular techniques[14,15]

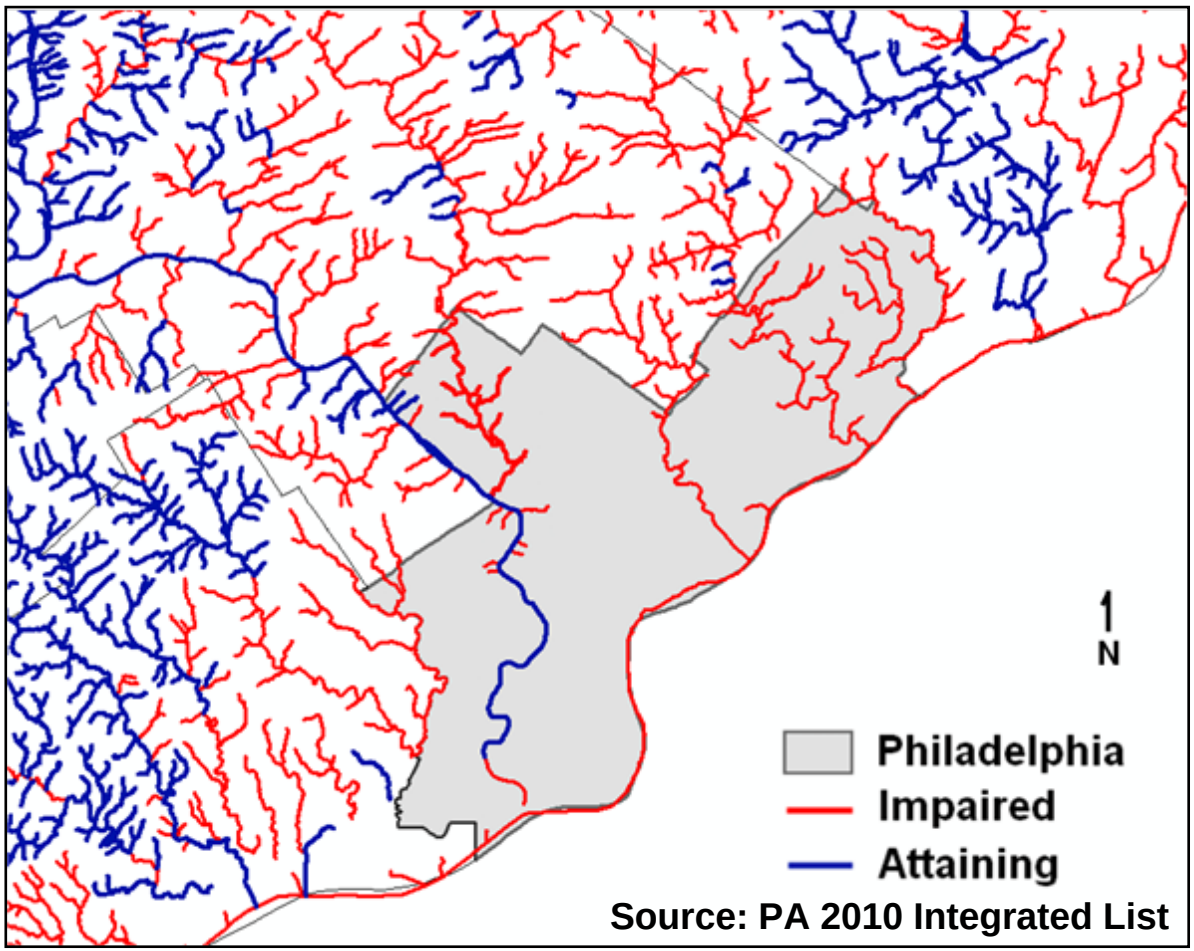
3.)Griffith et al. 1998 4.)Blakely et al. 2006 5.)Petersen et al. 1999 6.)Svensson 1974 7.)Collier & Smith 1997 8.)Jackson and Resh 1989 9.)Coutant 1982 10.)Hershey et al. 1993 11.)Baldwin et al. 1975 12.)Flory and Milner 2000 13.)Wallace 1990 14.)Sweeney et al. 1986 15.)Kelly et al. 2001

Abiotic Factors Affecting Dispersal

- Regional species pool and population status
- Biogeography – location & distance of colonists
  - upstream, downstream, in-basin, out of basin
- Geology, climate, land use in intervening space between site and sources of colonists

Abiotic Factors Affecting Dispersal

- Conditions very unfavorable for colonization of restored habitats in Philadelphia area



	Any taxon	Taxa PTV<4
Mayflies	**0.26**	**0.04**
Stoneflies	**0.05**	**0.05**
Caddisflies	**0.91**	**0.09**

PWD Macroinvertebrate sample results 2000-2010 *n* =177

Biotic Factors Affecting Dispersal

- Species-specific traits, some generalization is possible
- Flight ability and behavior
- Mating and oviposition behavior
  - Ovary development and length of pre-oviposition period
  - Feeding requirements
- Voltinism
- Some groups have traits unfavorable for dispersal and colonization

“Moving” Forward

- Based on present geographic distribution and poor dispersal ability factors, we should not assume that all taxa are prone to colonization of restored sites within 2-5yrs.
- Continue to implement stream restoration projects, collecting habitat and biological data
- Increase focus on headwaters (less susceptible to hydrology and water quality constraints)
- Consider faunal reintroduction and(or) *in-situ* bioassay at restoration sites

Faunal Reintroduction

- Release life stages of taxa not present at site, “wait and see” if they survive and reproduce
- No commercial sources
- If collected from wild
  - Risk of harm to natural populations
  - Undesired consequences, *e.g.*, invasive species
- If data are collected to follow fate of released individuals, does not save much time relative to *in-situ* bioassay

In-situ bioassay

- Determine survivability under more controlled field conditions
- Collect accompanying water quality data
- May be useful in identification of other stressors
- One local example: Partnership for Delaware Estuary testing suitability of local streams (Brandywine R.) for reintroduction of freshwater mussels

Discussion

Any Questions?

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References

1.)Palmer, M.A., R.F. Ambrose, and N.L.Poff. 1997. Ecological Theory and Community Restoration Ecology *Restoration Ecology* 5:291-300

2.)Bilton, D.T., J.R. Freeland, and B. Okamura. 2001. Dispersal in Freshwater Invertebrates. *Annu. Rev. Ecol. Syst.* 2001. 32:159-81

3.)Griffith, M.B., E.M. Barrows, and S.A. Perry. 1998. Lateral Dispersal of Adult Aquatic Insects (Plecoptera, Trichoptera) Following Emergence from Headwater Streams in Forested Appalachian Catchments. *Ann Entomol. Soc Am*. 91(2):195-201.

4.)Blakely, T.J., J.S. Harding, A.R. McIntosh, M.J. Winterbourn. 2006. Barriers to the Recovery of Aquatic Insect Communities in Urban Streams. *Freshwater Biology* 51:1634-1645.

5.)Petersen, I., Z. Masters, A.G. Hildrew, and S.J. Ormerod. 2004. Dispersal of Adult Aquatic Insects in Catchments of Differing Land Use. *Journal of Applied Ecology* 41:934-950.

6.)Svensson, B.W. 1974. Population movement of adult Trichoptera at a South Swedish stream. *Oikos* 25:157-175.

7.)Collier, K.J., and B.J. Smith. 1998. Dispersal of Adult Caddisflies (Trichoptera) into Forests alongside three New Zealand Streams. *Hydrobiologia* 361:53-65.

8.)Jackson, J.K., and V.H. Resh. 1989. Distribution and Abundance of Adult Aquatic Insects in the Forest Adjacent to a Northern California Stream. *Environ. Entomol.* 18(2) 278-283.

9.)Coutant, C.C. 1982. Evidence for Upstream Dispersal of Adult Caddisflies (Trichoptera:Hydropsychidae) in the Colombia River. *Aquat. Insects* 4:61-66

10.)Hershey, A.E., J. Pastor, B.J. Peterson, G.J. Kling. 1993. Stable Isotopes resolve the Drift Paradox for *Baetis* mayflies in an arctic river. *Ecology* 74:2415-25.

11.)Baldwin, W.F., A.S. West, and J. Gomery. 1975. Dispersal Pattern of Black Flies (Diptera:Simuliidae) Tagged with ^{32}P. *The Canadian Entomologist* 107(2):113-118.

12.)Flory, E.A., and A.M. Milner. 2000. Macroinvertebrate Community Succession in Wolf Point Creek, Glacier Bay National Park, Alaska. *Freshwater Biology* 44:465-480.

13.)Wallace, J.B., 1990. Recovery of Lotic Macroinvertebrate Communities from Disturbance. *Environmental Management* 14(5):605-620.

14.)Sweeney, B.W., D.H. Funk, and R.L. Vannote.1986. Population genetic structure of two mayflies (*Ephemerella subvaria*, *Eurylophella verisimilis*) in the Delaware River drainage basin. *J. N. Am. Benthol.Soc.* 5(4):253-262.

15.)Kelly, L.C., D.T. Bilton, and S.D. Rundle. 2001. Genetic differentiation and dispersal in the Canary Island caddisfly *Mesophylax aspersus* (Trichoptera:Limnephilidae). *Heredity*. 86:370-377.