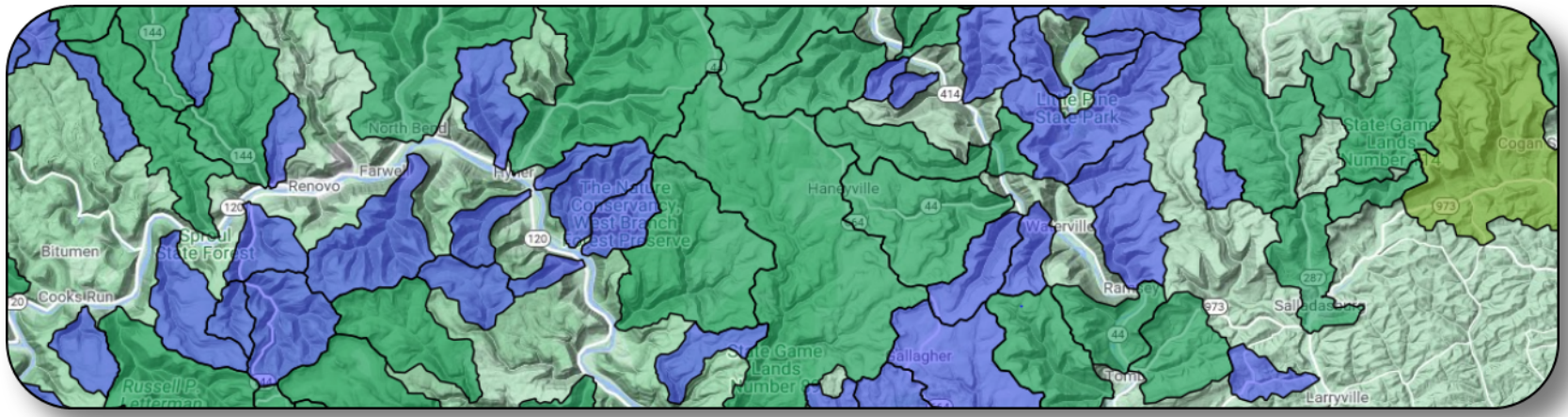
Robust & At-Risk Populations:
Classification & Prioritization



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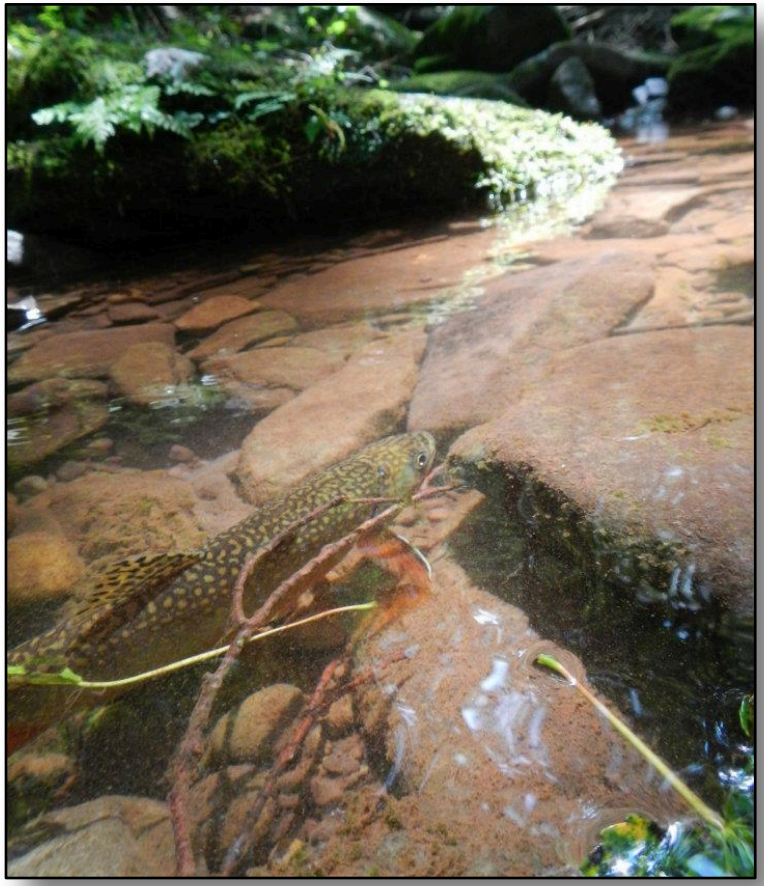
Overview

- Quantify population
  - Genetic metrics
  - Habitat size/quality
- Classify population
  - Inter-population comparison
- Management strategies
  - Habitat restoration
  - Connectivity restoration
  - Transplantation
- Management tools
  - Brook Trout Explorer
    - bte.ecosheds.org
- Prioritization



Quantify populations

- Genetic metrics provide insight into demographics
  - Number of alleles
    - Range: Integer >= 1
    - Higher number indicates:
      - Larger census size
      - No recent bottlenecks or founder's effect
      - Improved potential for adaptation
  - Heterozygosity
    - Range: 0 to 1
    - Higher value indicates:
      - Greater genetic variation
      - Reduced potential of inbreeding

Quantify populations

- Genetic metrics continued…
  - Effective number of breeders (N_b)
    - Estimate of parental contribution to a cohort
    - Combines number of parents & variance of family size
      - Lower values = fewer parents and/or skewed family sizes
    - Provides insight into reproduction

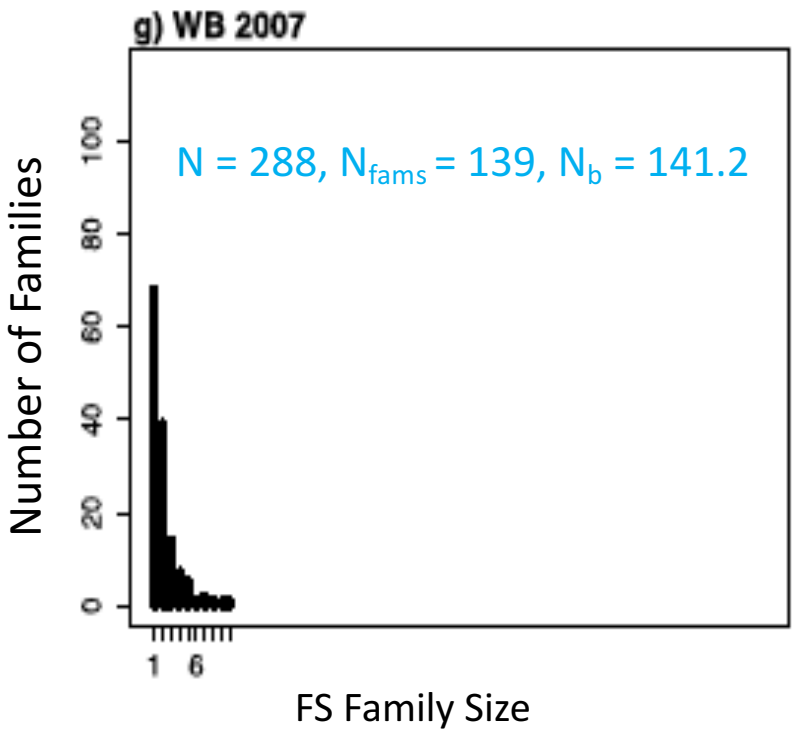
Family	Mom	Dad
1	10	10
2	10	10
3	10	10
4	10	10
5	10	10
6	10	10
7	10	10
8	10	10
9	10	10
10	10	10
N_b = **99.5**		

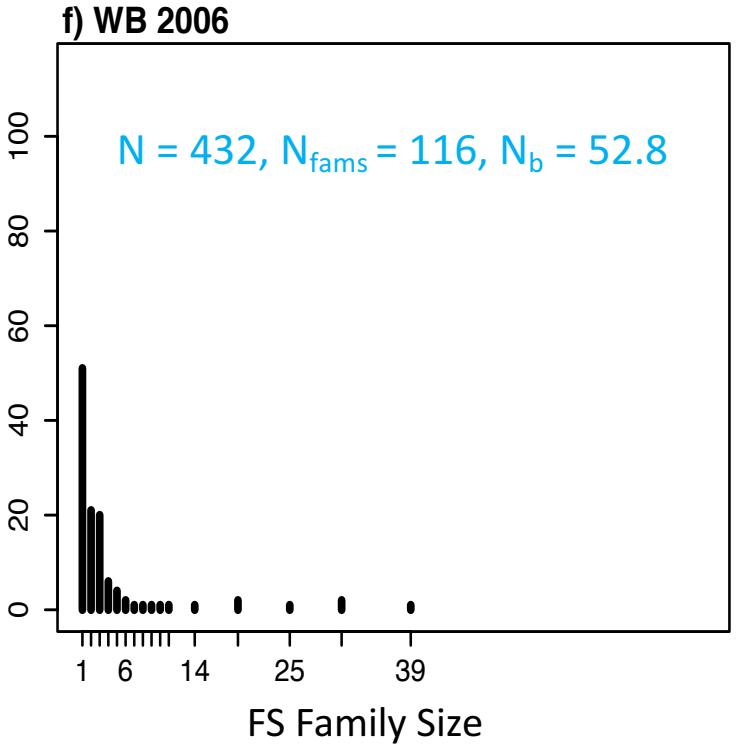
Family	Mom	Dad
1	91	91
2	1	1
3	1	1
4	1	1
5	1	1
6	1	1
7	1	1
8	1	1
9	1	1
10	1	1
N_b = **9.8**		

Family	Mom	Dad
1	10	10
2	10	10
3	10	10
4	10	10
5	10	10
N_b = **49.5**		

Quantify populations

- N_b estimates for 2 cohorts of brook trout
  - Estimates driven by skew in family size related to environmental conditions





Whiteley et al. 2015 *Molecular Ecology*

Quantify populations

- Genetic metrics for 9 cohorts from a single population
  - West Brook, MA

Cohort	N	A_R	H_e	N_{FAMS}	N_b	CI
2001	1094	9.0	0.614	340	124.4	(110.4–139.3)
2002	789	9.2	0.635	219	94.6	(84.7–105.3)
2003	909	8.7	0.614	269	152.7	(131.2–176.8)
2004	816	8.9	0.632	269	108.6	(95.3–123.2)
2005	590	9.5	0.620	242	157.3	(139.6–177.0)
2006	432	9.6	0.631	116	52.8	(45.5–60.9)
2007	288	9.4	0.614	139	141.2	(121.6–164.5)
2008	513	8.3	0.607	143	65.1	(55.8–75.5)
2009	746	9.0	0.610	180	109.3	(95.5–124.6)

Quantify populations

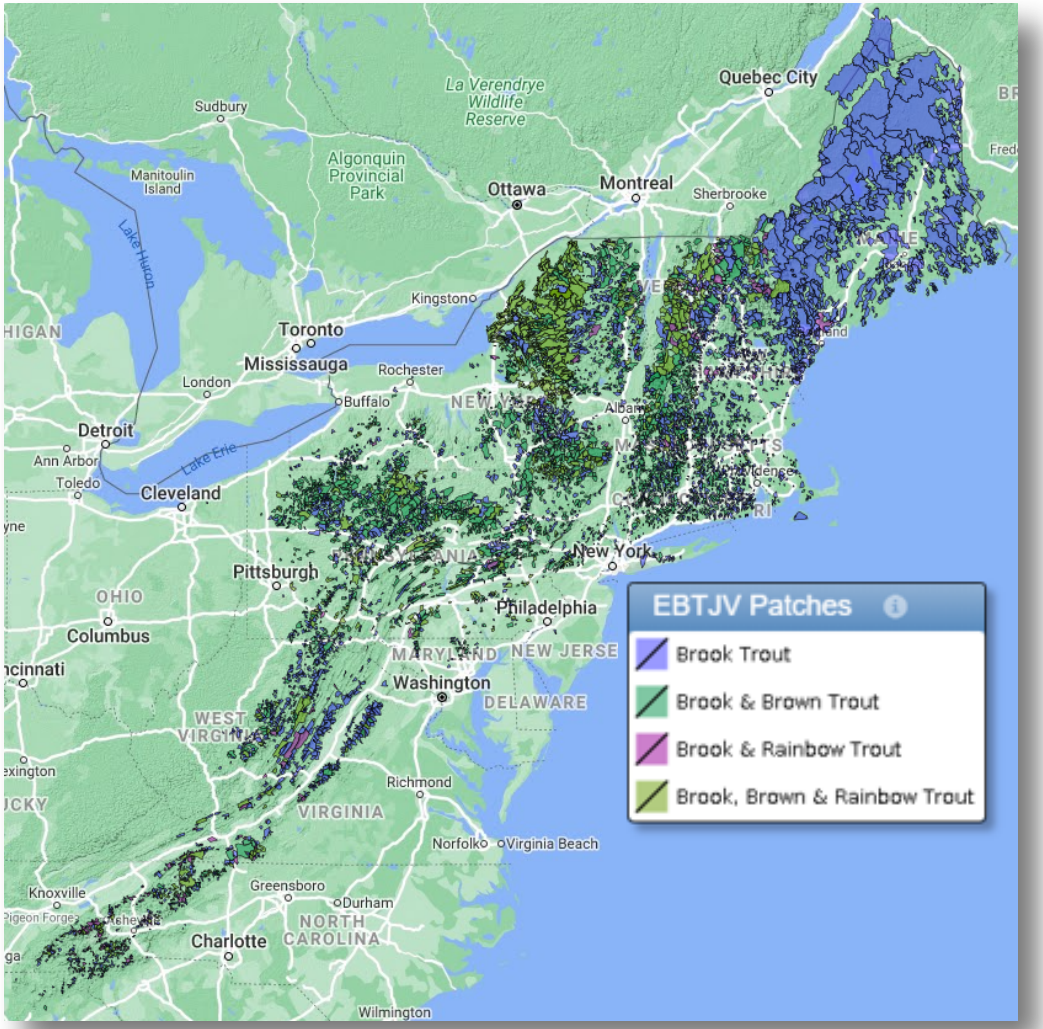
- Genetic results from 5 Pennsylvania populations
  - Provide insights into current population status
    - Past bottleneck in Segloch Run?
    - Genetic drift in Little Plum Run?
    - More/higher quality habitat in Millstone & Shaeffer Runs?

Patch	Samples	Alleles	Ho	Nb (CI)
Little Plum Run	72	6.38	0.55	27.2 (20.6, 35.8)
Millstone Creek	75	9.63	0.75	180.6 (127.2, 285.5)
Roaring Run	66	7.38	0.66	38.2 (31.9, 46)
Segloch Run	65	6.00	0.78	66.7 (46.7, 100.5)
Shaeffer Run	75	9.38	0.71	275.2 (177.4, 536.4)

    - Improve insights by including habitat size & quality metrics

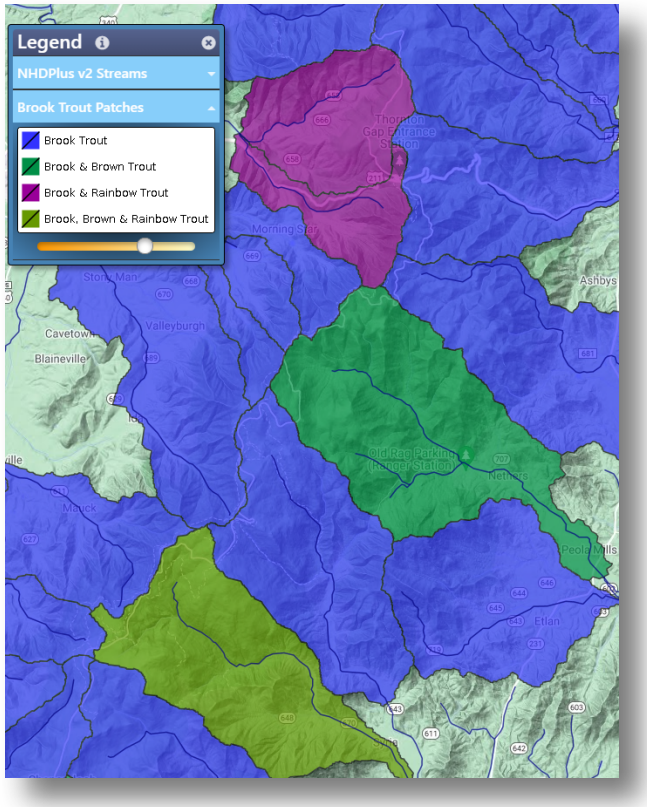
Habitat size & quality

- Size
  - EBTJV patch layer
    - Can be used as a proxy for habitat area of populations
    - 9,964 patches
    - Mean size of 1,898 HA
    - Can be viewed & downloaded at ecosheds.org/geoserver/www



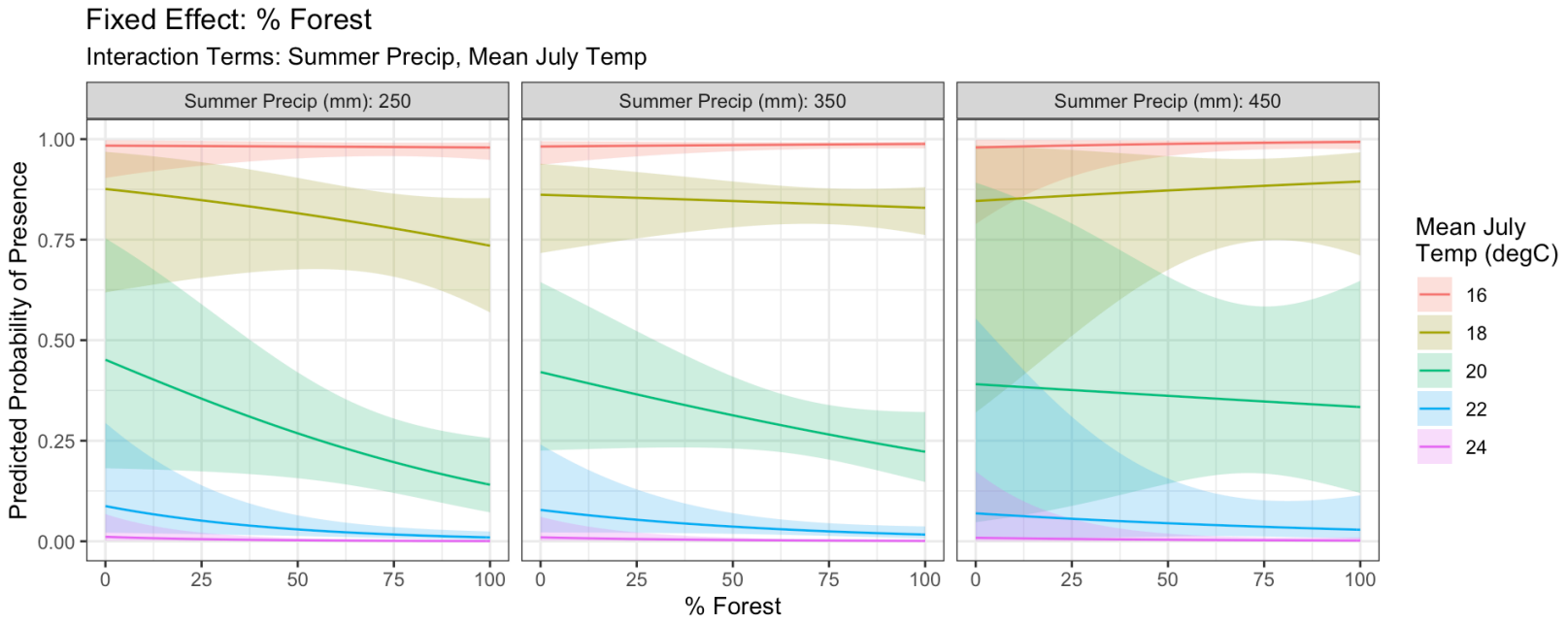
Habitat size & quality

- Patch Rule set
  - Built on NHD+ v2 classified catchments
    - Data collected by state agencies
  - Downstream terminus
    - Absence of target species
    - Presence of barrier (dam, waterfall)
  - Upstream terminus
    - Absence of target species
    - Presence of barrier
    - End of stream
  - Classification
    - Coded by salmonid species present in catchments



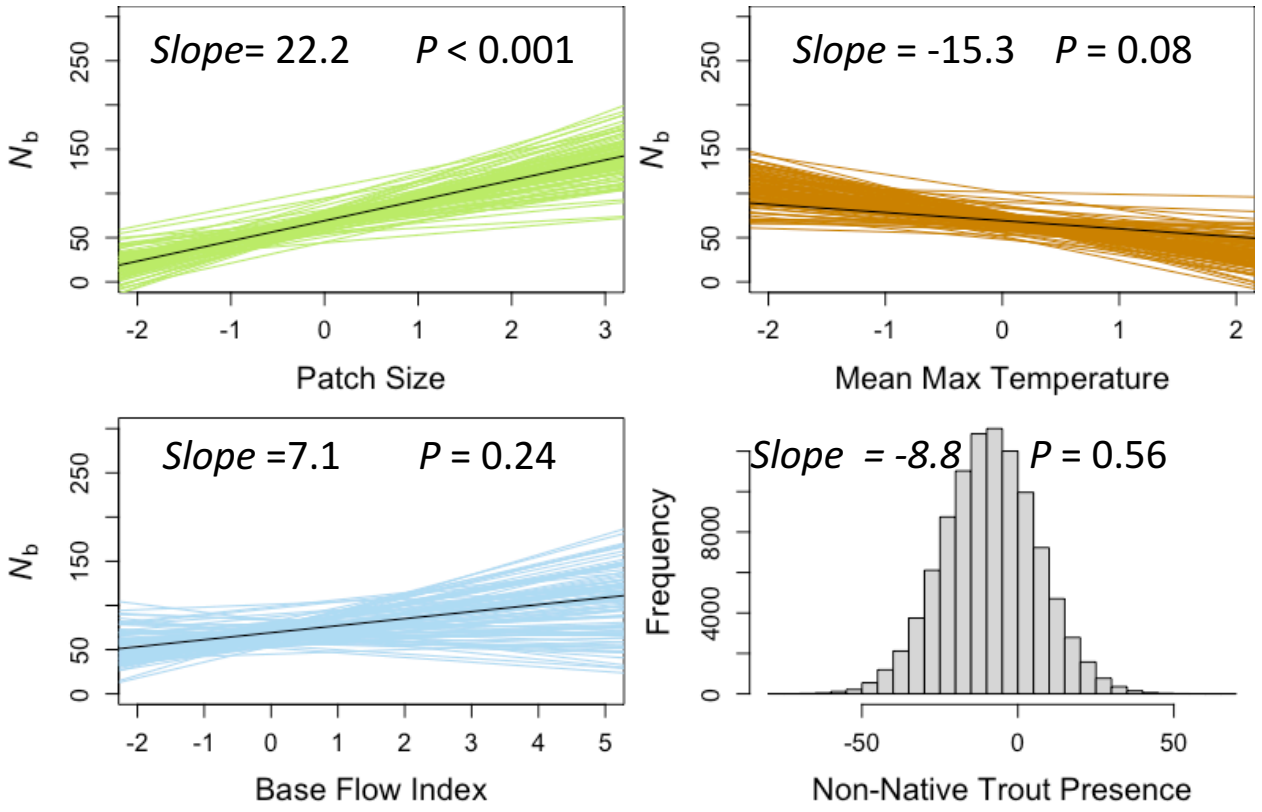
Habitat size & quality

- Quality
  - Brook trout habitat suitability model
    - Only available for Northeast
    - ecosheds.org/models/brook-trout-occupancy/latest/
    - Would need to be spatially joined to patch layer



Habitat size & quality

- Quality
  - Predictive N_b modeling
  - Completed for Chesapeake drainage
  - Provides a baseline for expected N_b



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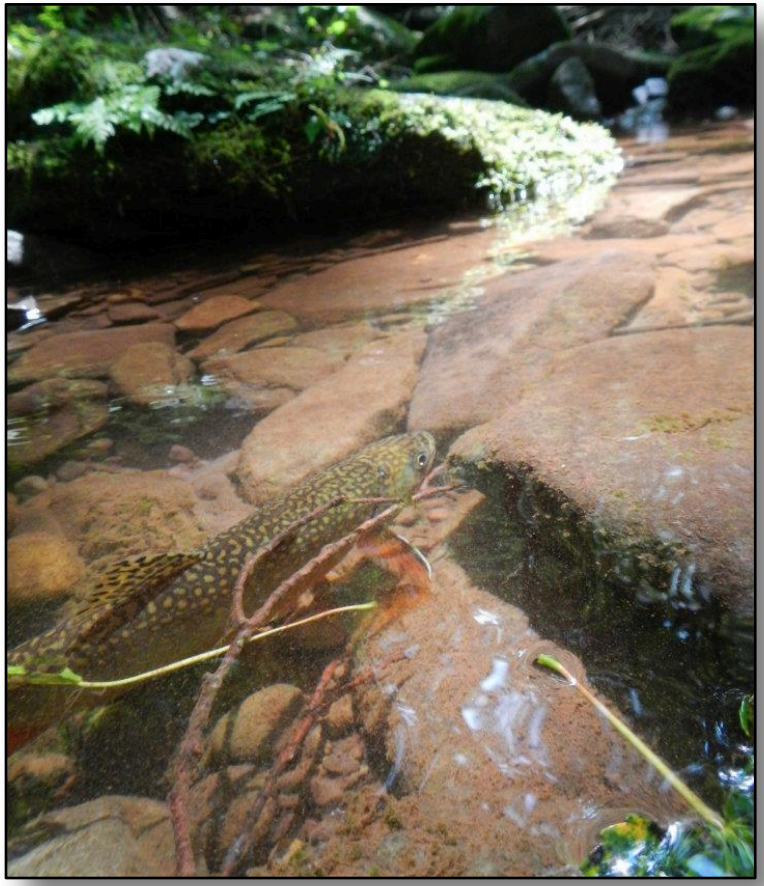
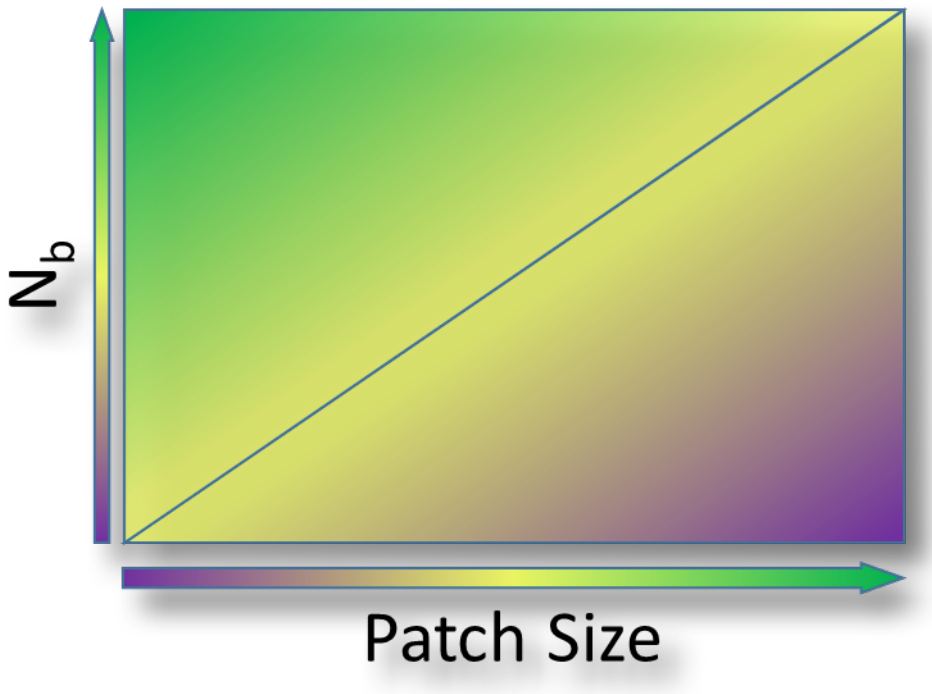


Classification

- Expected increase in N_b with patch size
  - More habitat
  - Greater carrying capacity
- Above diagonal
  - Higher than average N_b
  - Indicates higher quality habitat
  - Higher potential resiliency
  - Lower management needs
- Below diagonal
  - Lower than average N_b
  - Indicates lower quality habitat
  - Higher susceptibility
  - Higher management needs



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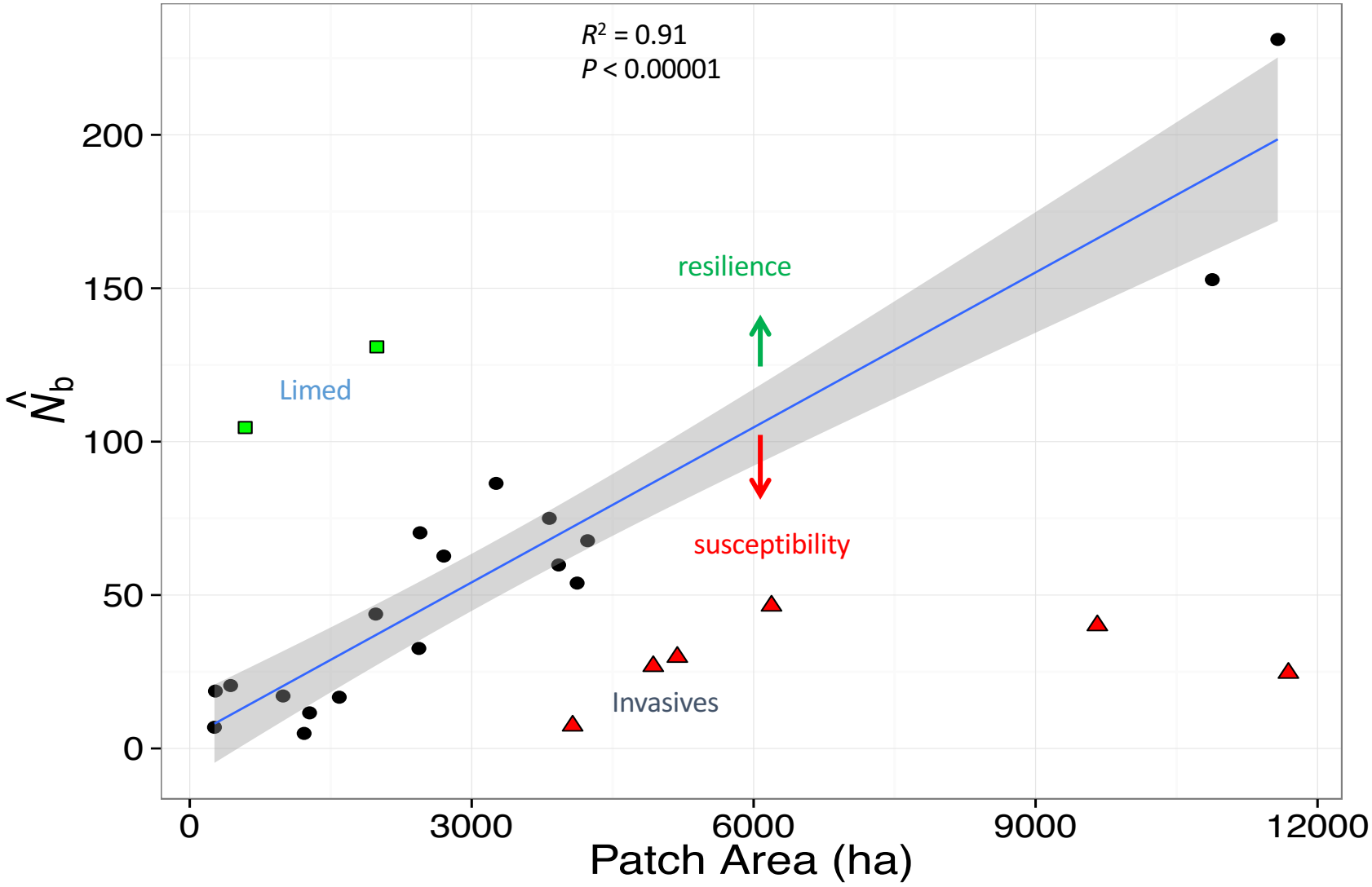

Whiteley et al. 2014, *Wild Trout XI*

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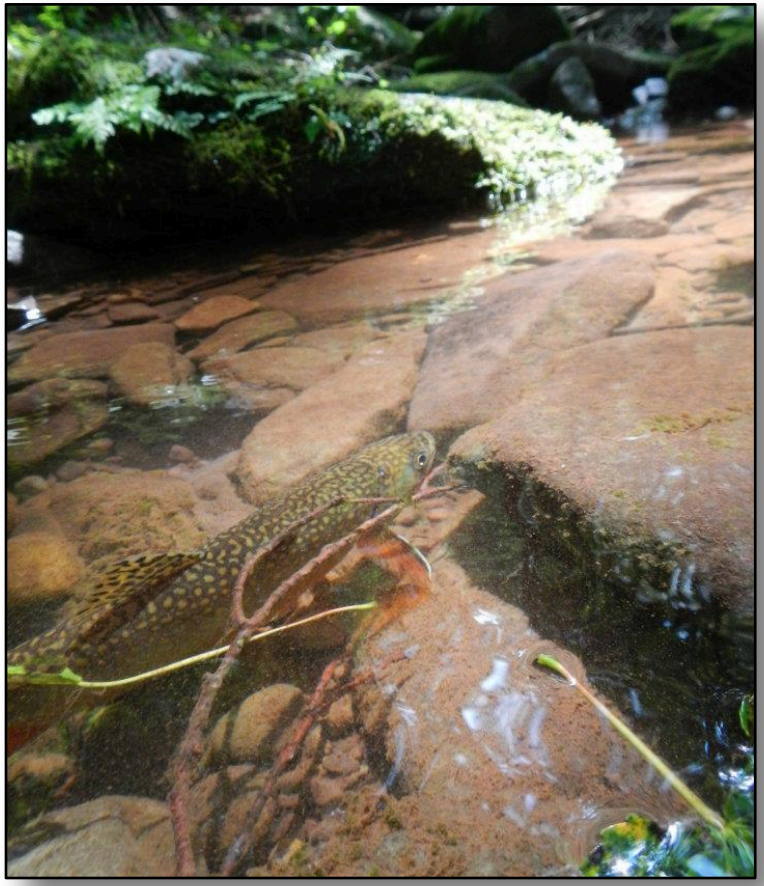
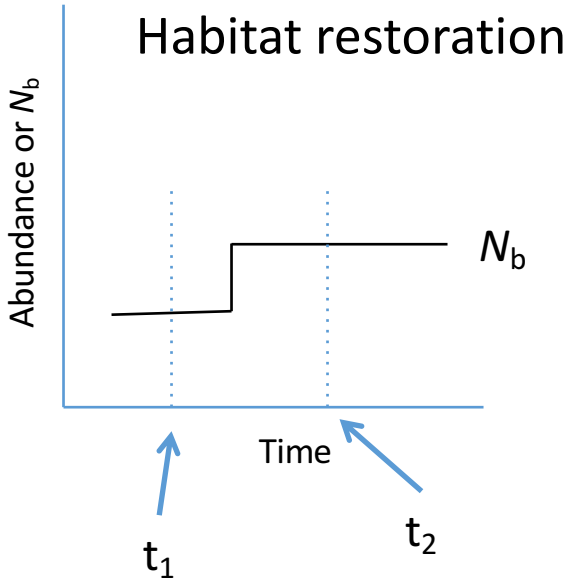


Management strategies

- Habitat restoration
  - Physical or environmental improvement intended to increase population carrying capacity
    - Addition of woody debris
    - Riparian restoration
    - Liming
  - Measure using before/after N_b monitoring
  - Expect an increase in N_b post-restoration
    - Increased carrying capacity
    - Increased spawning habitat

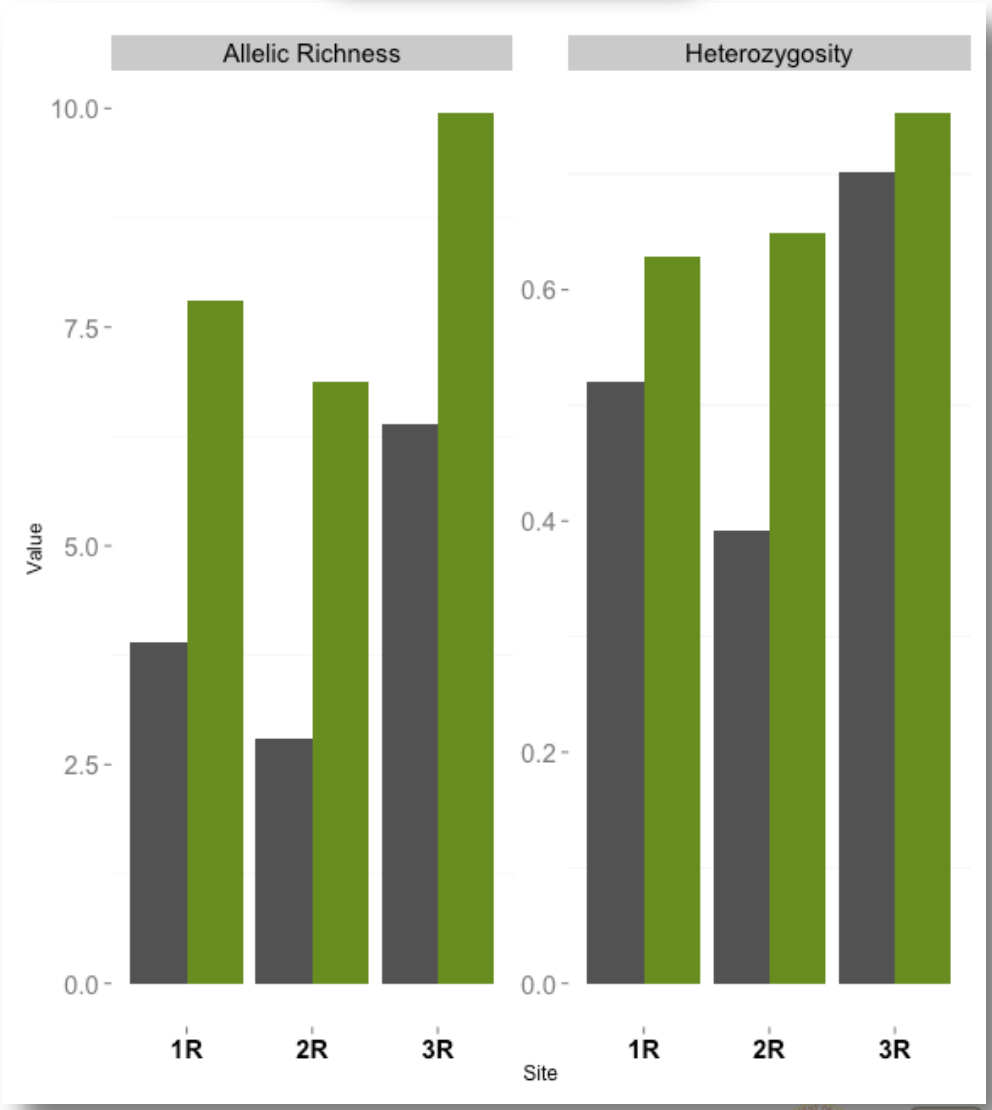


Management strategies

- Connectivity restoration
  - Enable migration between adjacent patches
    - Culvert replacement
    - Dam removal
  - Measure using gene flow monitoring
    - Presence of unique alleles
    - Decreased differentiation (F_{st})
    - Sib-split (Whiteley et al 2014)
  - Expect allelic diversity in above/below barrier populations to become more similar

Management

- Transplantation
  - Population restoration
  - Genetic rescue
  - Variables
    - Source
    - Number to move
    - Age
    - Sex ratio
    - Timing
  - Monitor allelic diversity
  - Expect increase in number of alleles & heterozygosity



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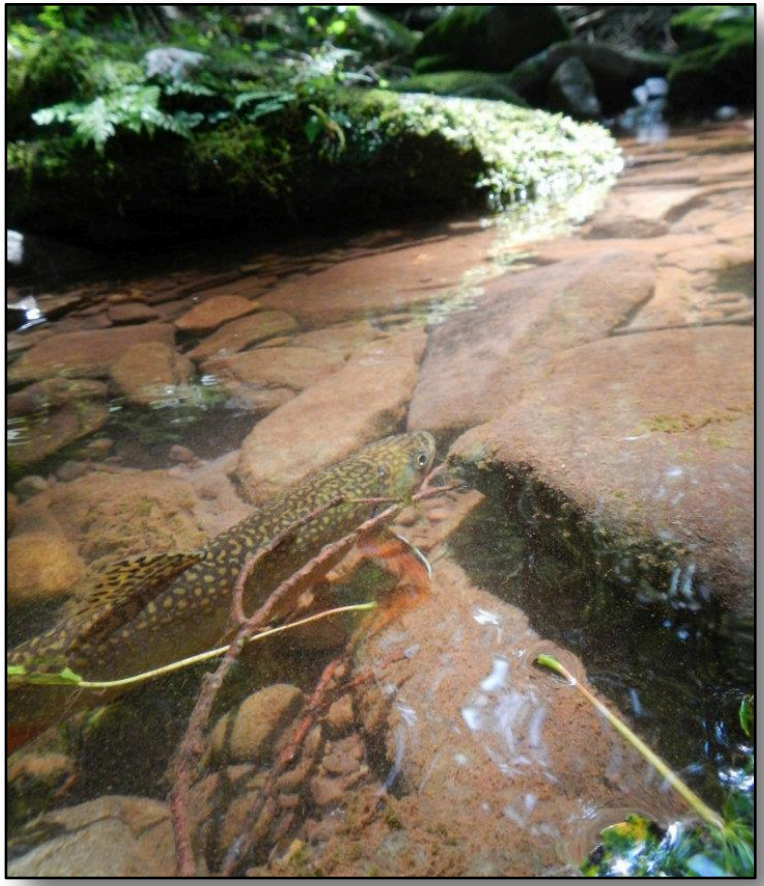
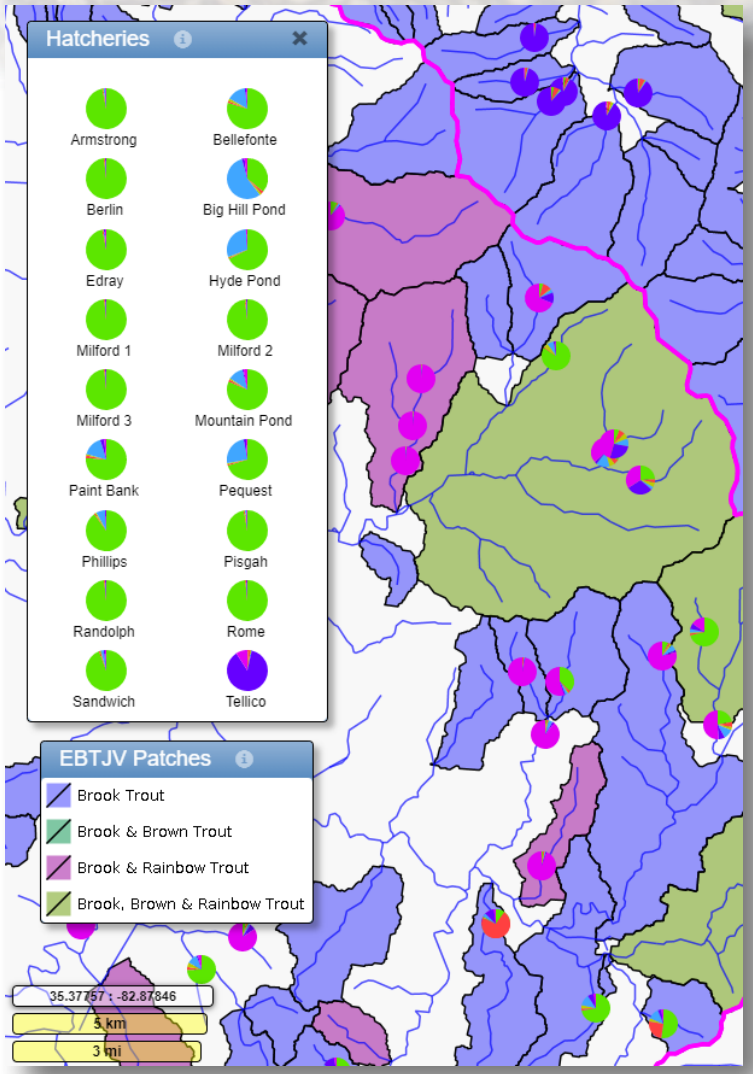


Management Tools

- Brook Trout Explorer
  - bte.ecosheds.org
  - Range-wide analysis
  - Spatial exploration of genetic data
    - Microsatellite genetic panel
    - Genetic metrics
      - Allelic diversity
      - Heterozygosity
      - Effective population size (N_e)
    - Population assignment
      - Structure
      - DAPC
    - Hatchery introgression
    - Benefits of using standardized panels



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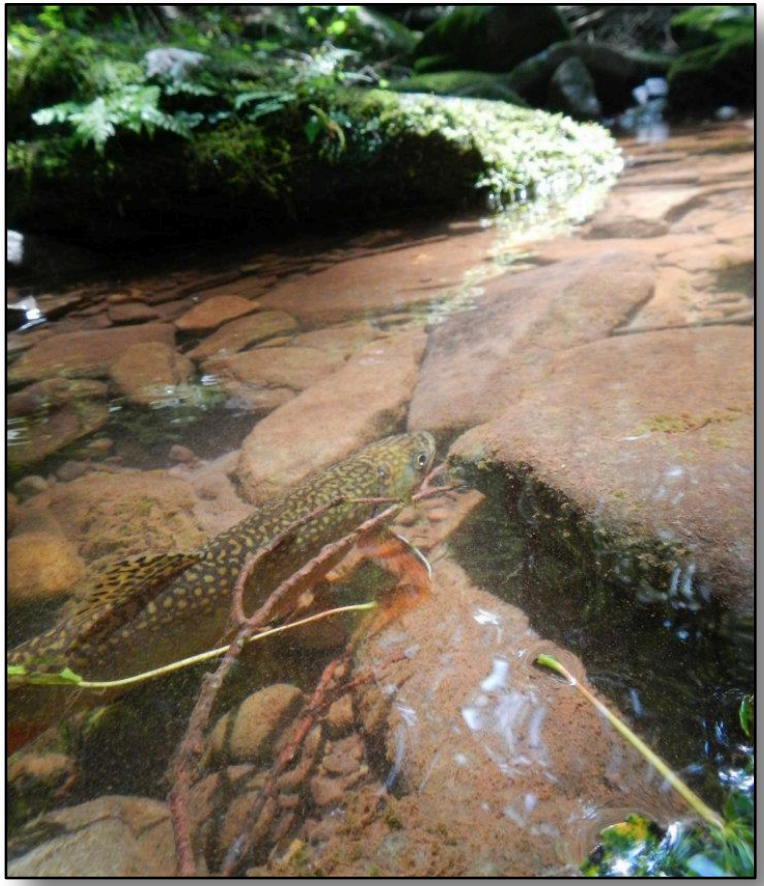


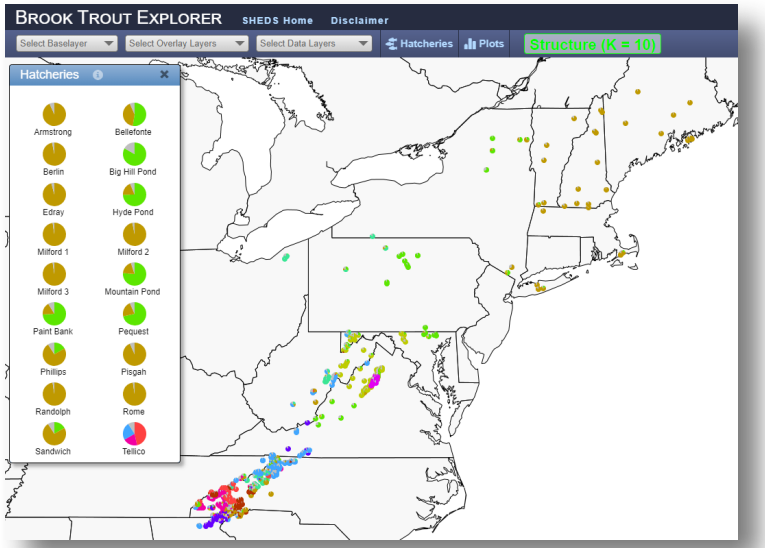
Prioritization

	Small Patch	Large Patch
Resilient	• More vulnerable to stochastic events • Lesser impact potential of management actions • Benefit from habitat conservation	• Lesser impact potential of management actions • Most stable genetic diversity • Potential source for transplants • Benefit from habitat conservation
Susceptible	• Genetic drift/inbreeding • Greater likelihood of extirpation • Greater impact potential of management actions • Benefit from habitat restoration	• Reduced genetic diversity • Lesser impact potential of management actions • Greater cost of management actions • Benefit from habitat restoration

- Limited resources
  - Justification for large-resilient patches
    - Source populations
    - Life-history variation
  - Justification for small patches
    - Portfolio effect
    - Local adaptation

Questions

- What are your current prioritization strategies?

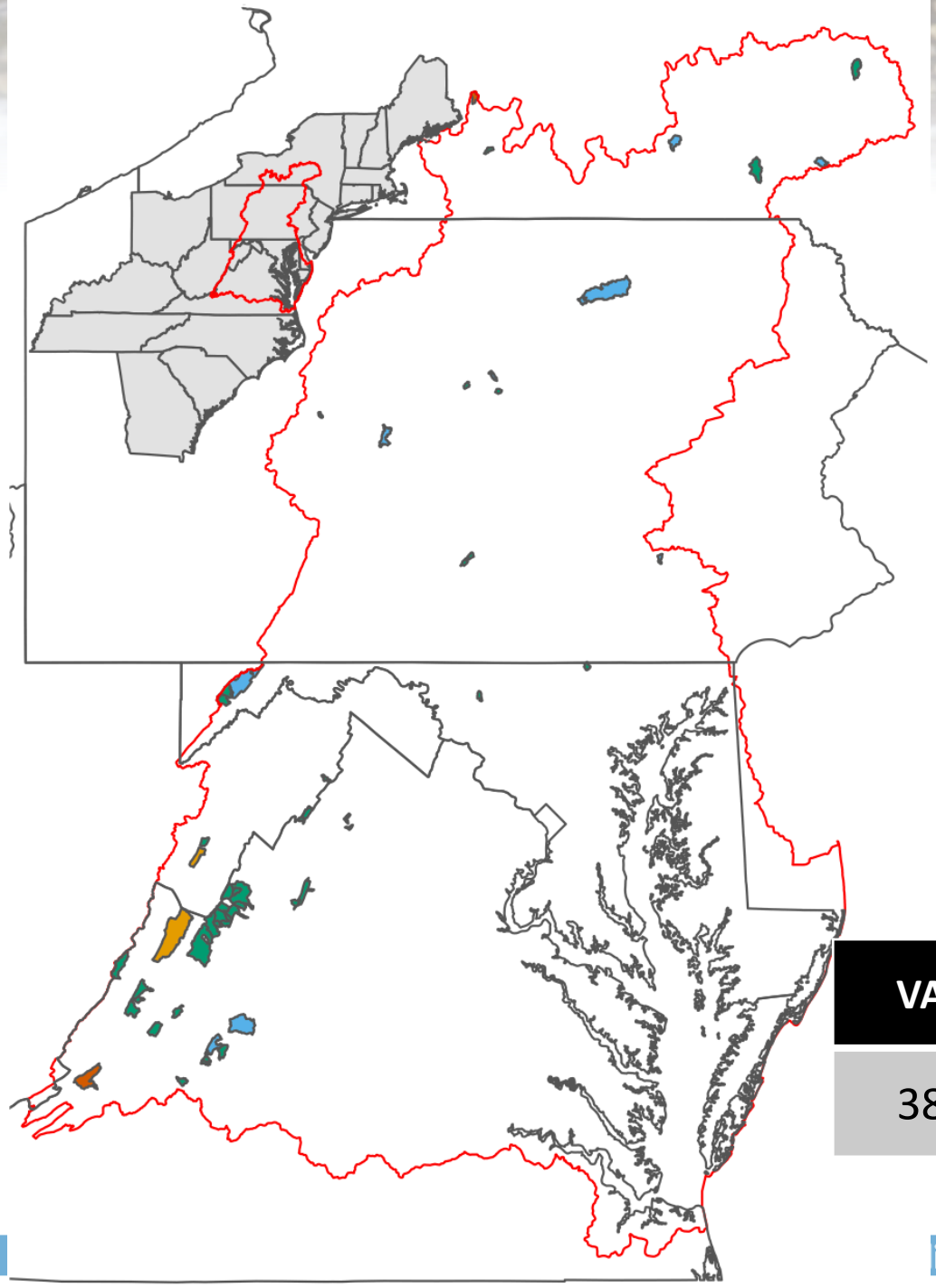


- What further information/tools are needed to incorporate genetics into management decisions?

Acknowledgments

- Eastern Brook Trout Joint Venture
- State Natural Resource Agencies
- Ben Letcher, US Geological Survey
- Keith Nislow, US Forest Service
- Mark Hudy, USFS|USGS|EBTJV

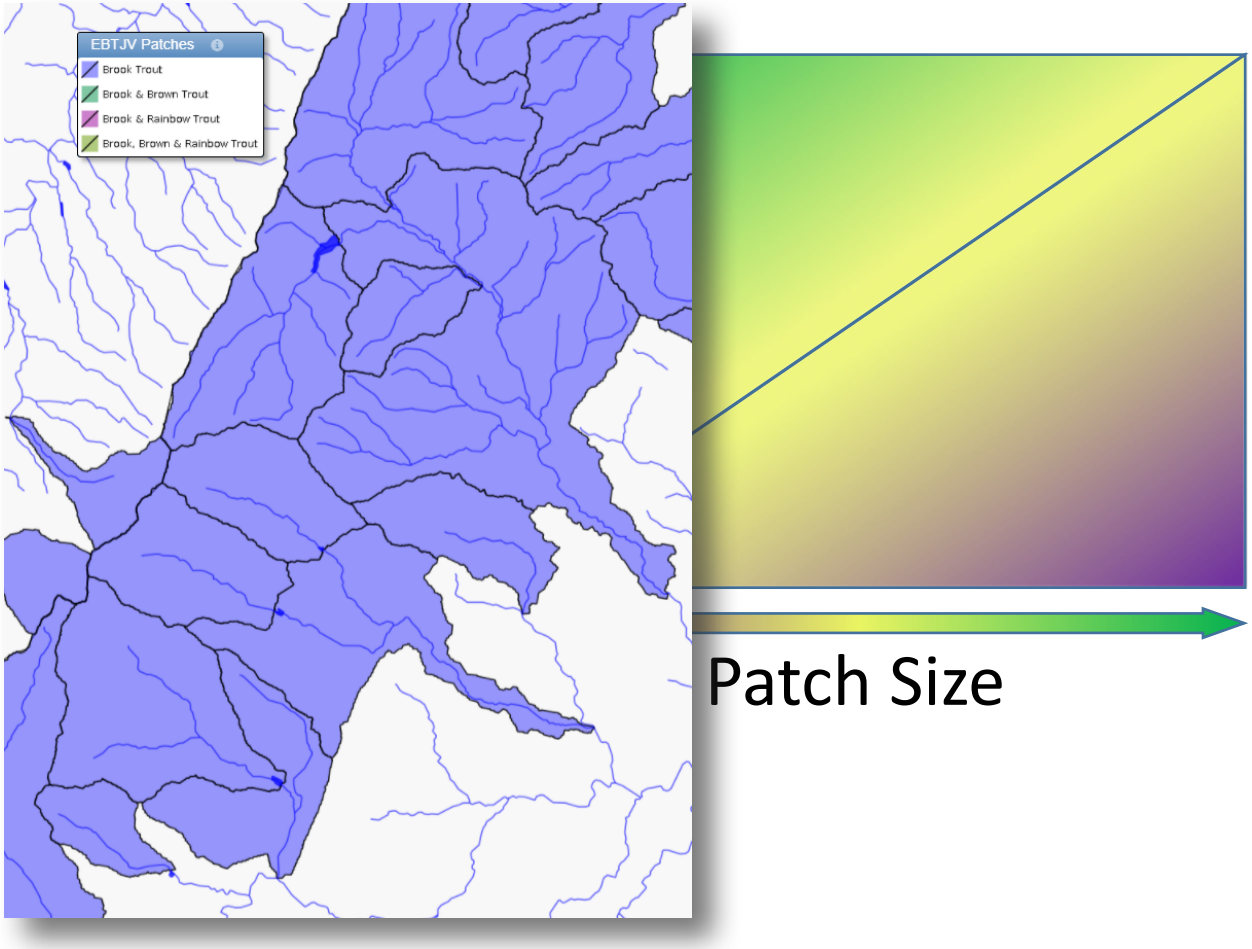
USGS
science for a changing world



Species Present

- Brook
- Brook+Brown
- Brook+Rainbow
- Brook+Brown+Rainbow

VA	WV	MD	PA	NY
38	12	5	20	7


EBTJV Patches
Brook Trout
Brook & Brown Trout
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Brook, Brown & Rainbow Trout
Patch Size