Joe Kosack/PGC Photo

![The Nature Conservancy logo — Protecting nature. Preserving life.]

Defining Flow Needs for Pennsylvania's Riverine Ecosystems
Tara Moberg

Wednesday, Nov. 7, 2012 – WRA of the Delaware Basin's 53RD Annual Conference

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- Recent developments in instream flow management

- Overview of ecosystem flow studies in Pennsylvania's river basins

Riverine Scour and Shrubland Community
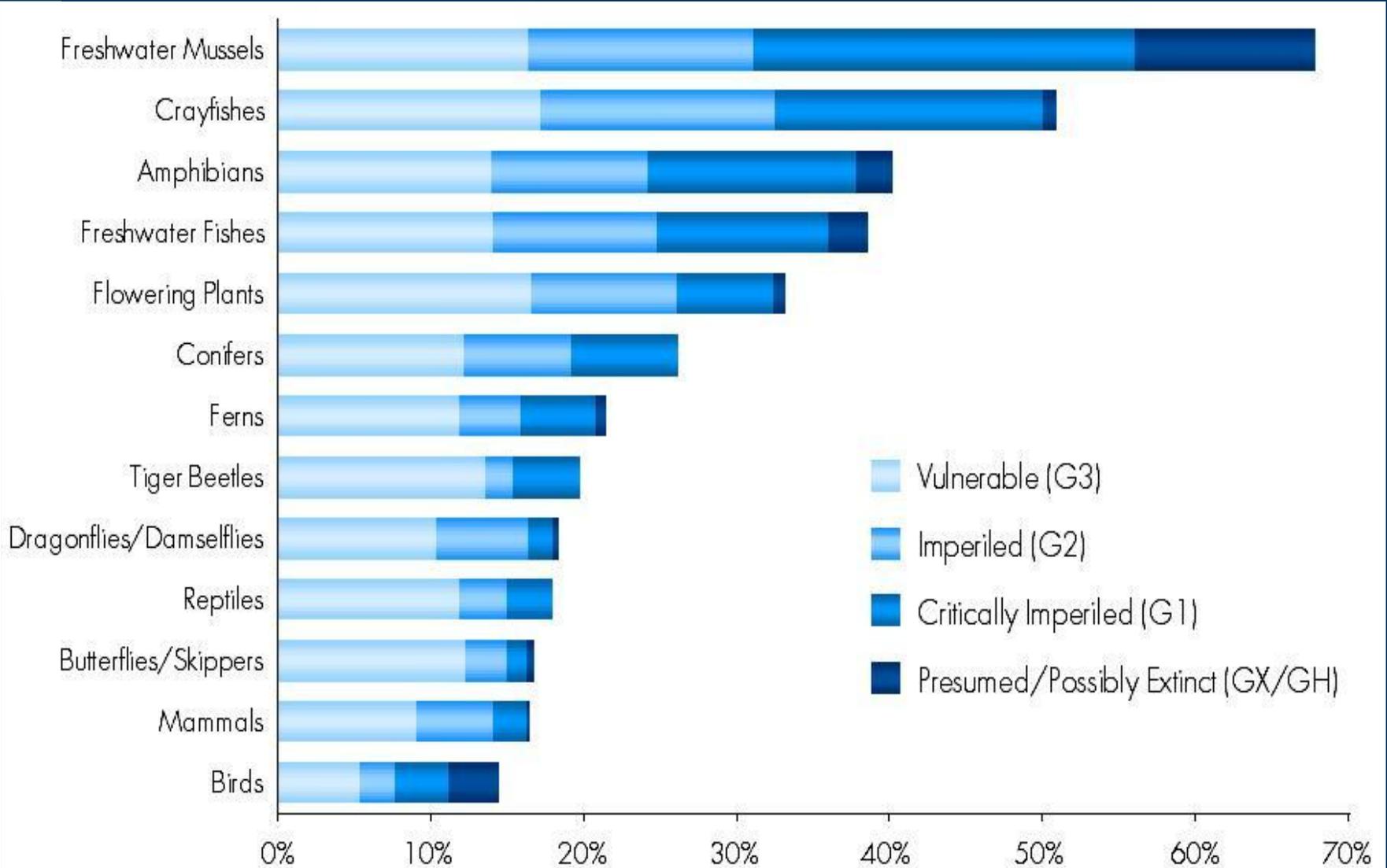*Upper Delaware River*   © Gregory Podniesinski

The Nature Conservancy

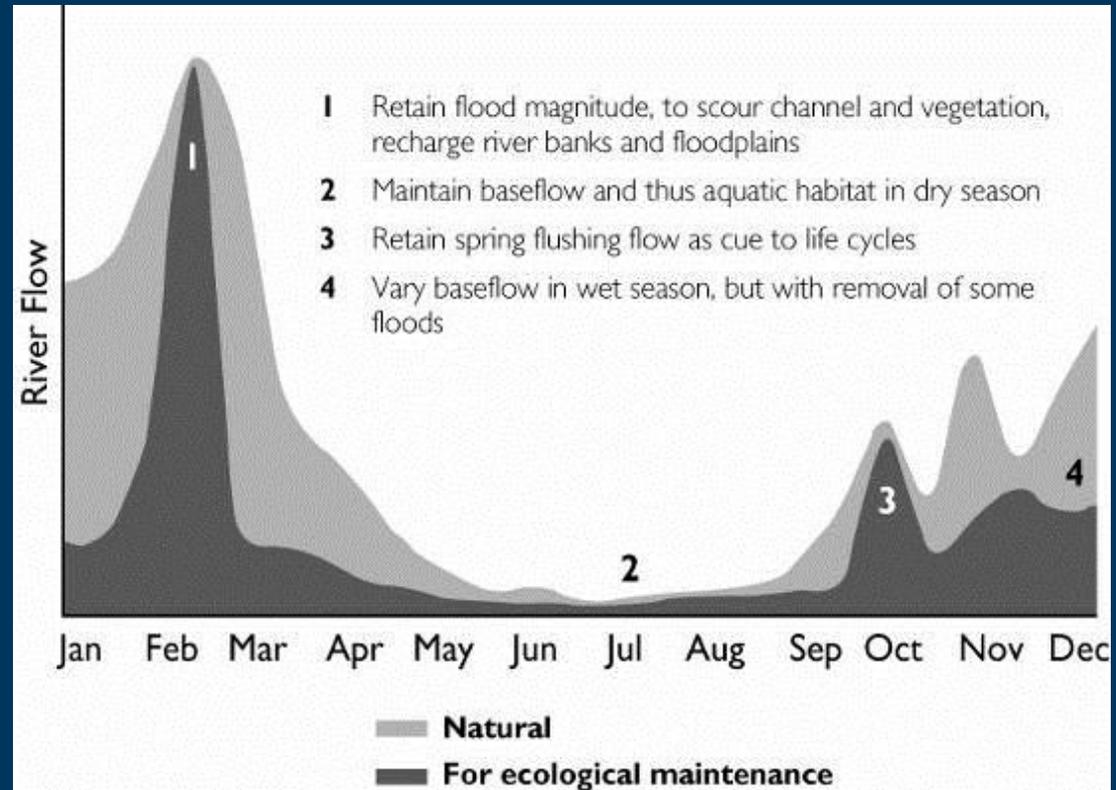*To conserve the lands and waters on which all life depends.*

The flow of water that sustains healthy ecosystems and the goods and services that humans derive from them.

The goal is *not* to create optimal conditions for all species all of the time; rather, adequate conditions *enough* of the time

1   Retain flood magnitude, to scour channel and vegetation, recharge river banks and floodplains
2   Maintain baseflow and thus aquatic habitat in dry season
3   Retain spring flushing flow as cue to life cycles
4   Vary baseflow in wet season, but with removal of some floods

Natural
For ecological maintenance

Rivers for which environmental flows have been or are being prescribed

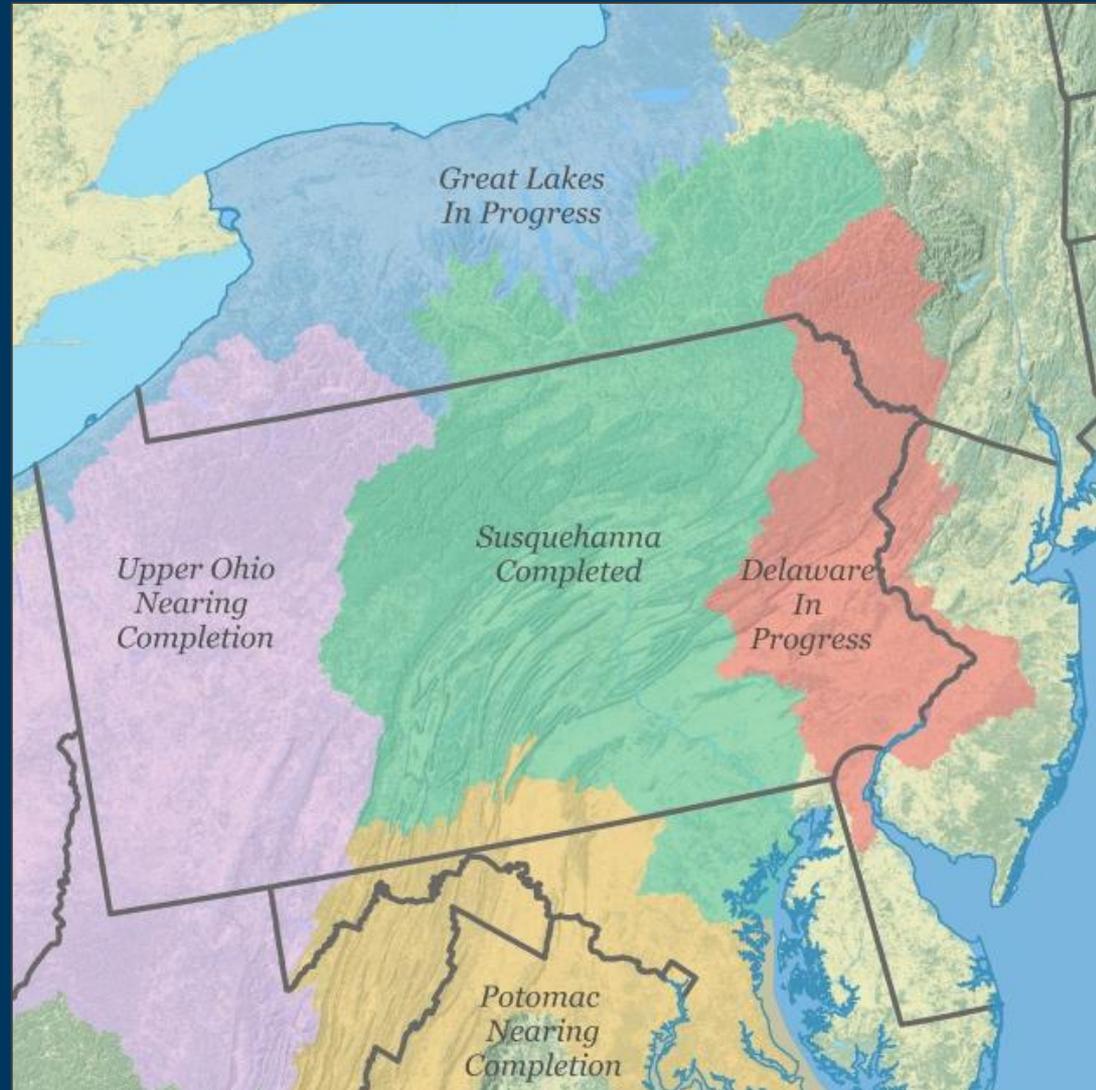*Headwaters Pond Run Creek
Pike County*

© George Gress

The Ecological Limits of Hydrologic Alteration (ELOHA, Poff et al. 2010)

A framework for assessing environmental flow needs over broad geographic areas when site-specific studies cannot be conducted for all rivers
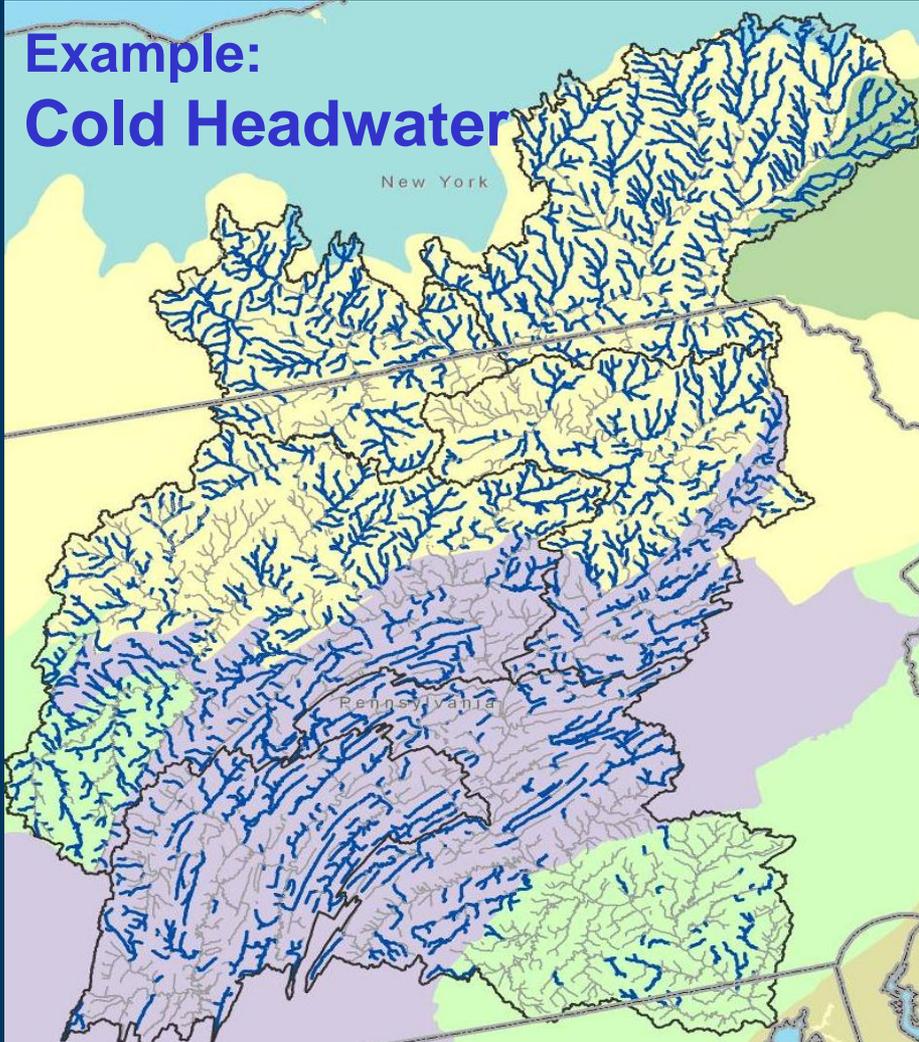
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Objective:

develop science-based flow recommendations based on existing information that are useful to water managers.
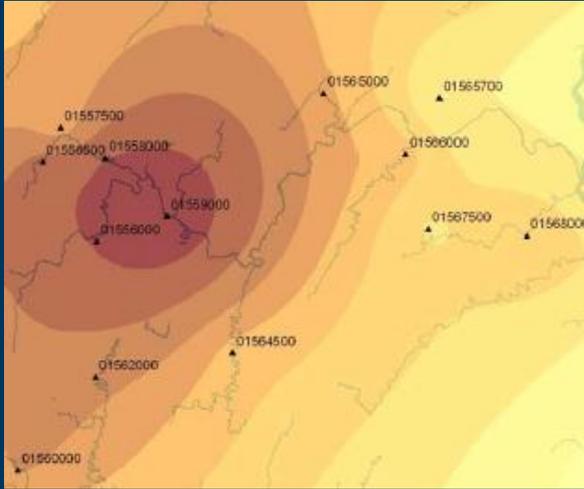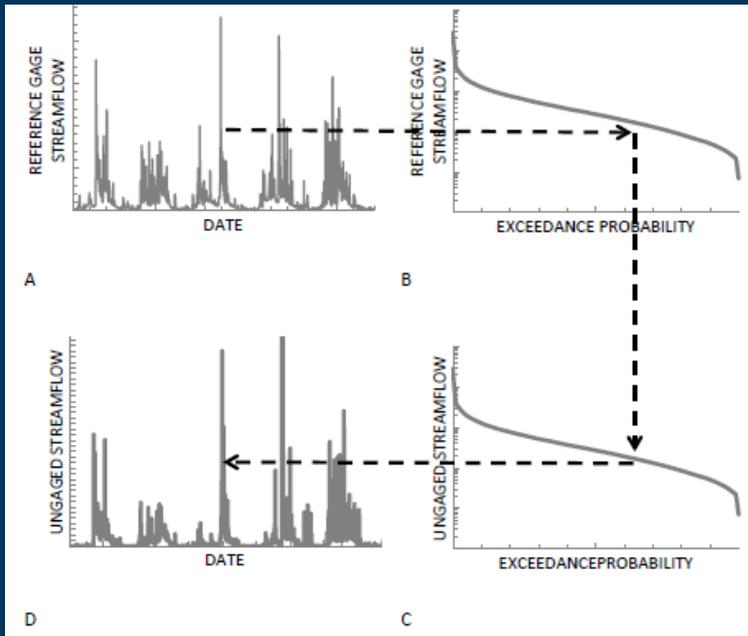
Example:
Cold Headwater

What are the variety of hydro-ecological settings (river types)?

Within each, how do flow conditions affect species and ecological processes throughout the year?

- Minimally altered stream gages

- USGS BaSE tool to estimate daily streamflow at ungaged locations

- TNC's Indicators of Hydrologic Alteration software

Small, warm river: South Fork Tenmile Creek at Jefferson, PA (180 sq mi)

Flood (2 yr rec)
3,510 cfs

High Pulse (≥ Q10)
491 cfs

Seasonality
(monthly median)
March: 294 cfs
Sept: 9 cfs

Low Pulse (≤ Q90)
4.1 cfs

10th to 90th percentile range of Average Daily Discharge
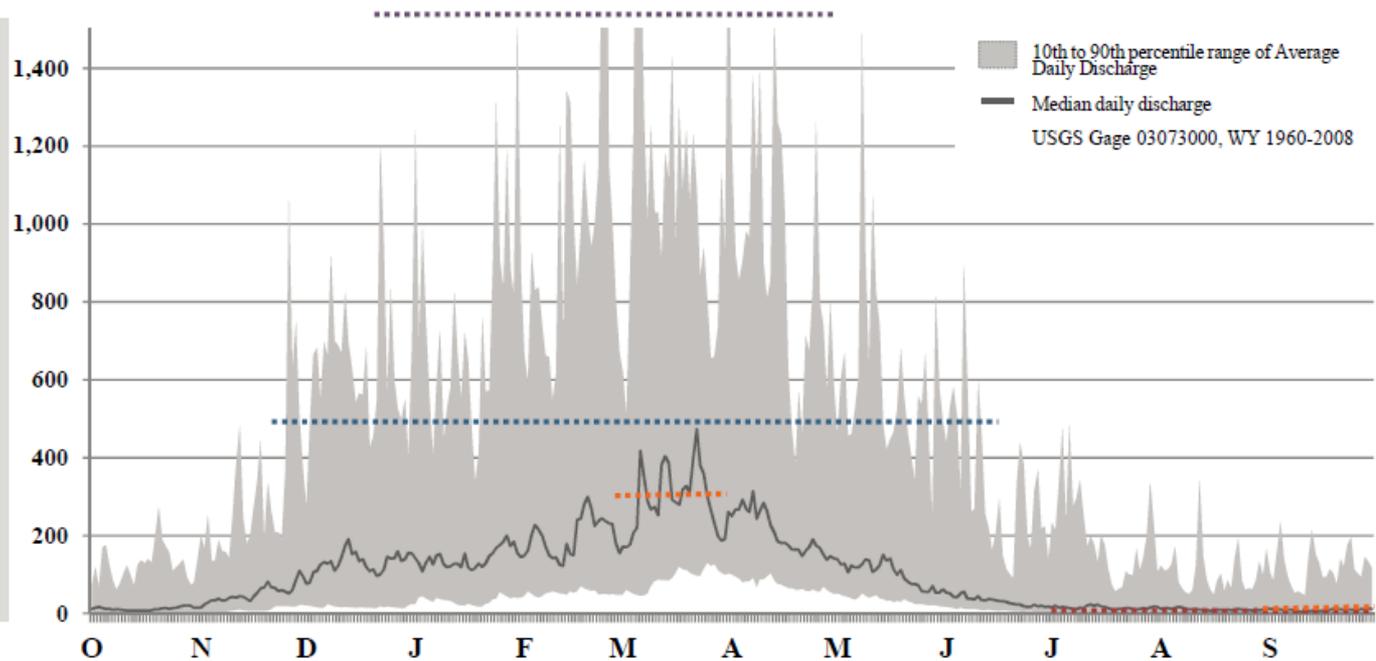
Median daily discharge

USGS Gage 03073000, WY 1960-2008

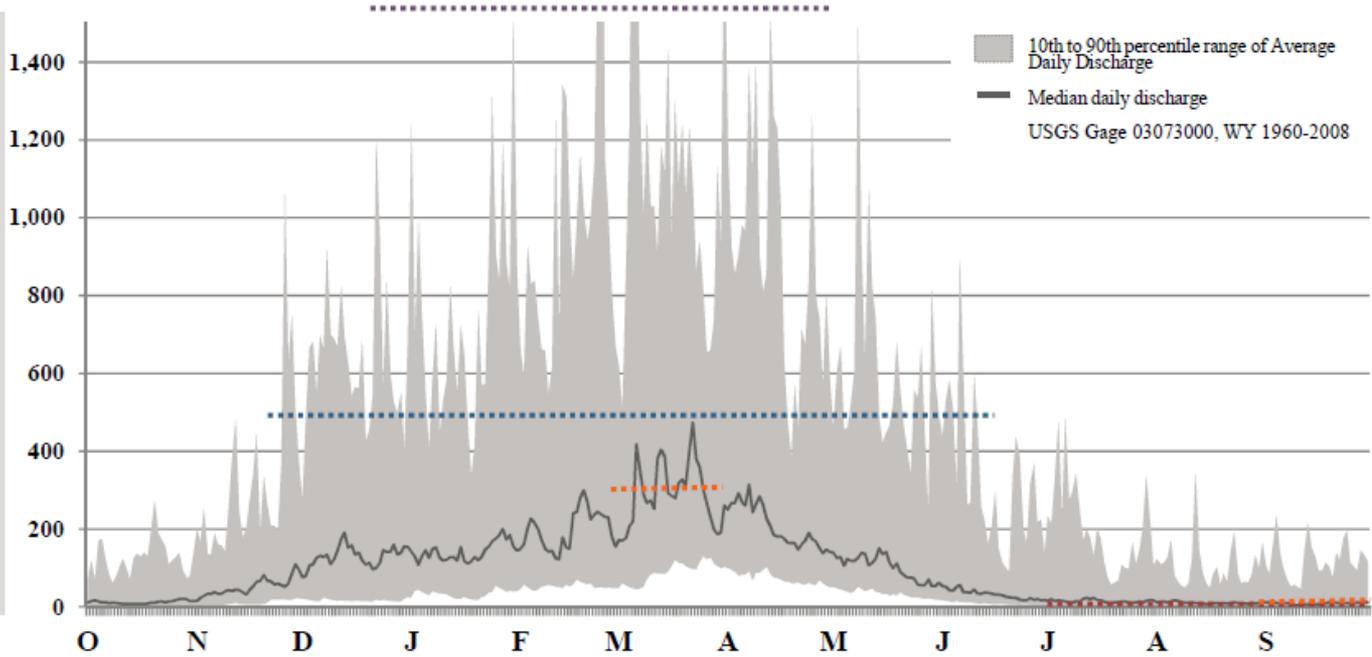**Small, warm river:** South Fork Tenmile Creek at Jefferson, PA (180 sq mi)

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10th to 90th percentile range of Average Daily Discharge

Median daily discharge

USGS Gage 03073000, WY 1960-2008

Flow Components and Needs: Cold and Cool Headwaters and Small Streams

Example: 01547700 Marsh Creek at Blanchard, PA (44.1 sq mi)

Flow Components (Daily Exceedance Probability)
- High Flow Events (Q_{10} to Q_5)
- Seasonal Flow (Q_{75} to Q_{10})
- Low Flow (Q_{95} to Q_{75})
- Minimum to Q_{95}

- High Flow-related needs
- Seasonal Flow Needs
- Low Flow-related Needs

SPRING

SUMMER

WINTER

FALL

Channel maintenance and floodplain connectivity

Organic Matter and Fine Sediment Transport

Vegetative growth

Aquatic Insects Spring Emergence, Mating and Egg laying

Egg, Larval, and Juvenile Growth for Fishes and Amphibians

Fall Spawning Habitat and Egg Incubation for Salmonids

Egg, larval and juvenile development for fall-spawning salmonids

Habitat Persistence and Connectivity for all taxa

Aquatic Insects winter Emergence

Unionid Spawning and Glochidia release

Hibernation Habitats for Reptiles, Amphibians, and Small Mammals

Resident fish spawning including migration and nest construction

Groundwater Connectivity and Hyporheic Habitats

Overwinter Habitat for Resident Fish and Macroinvertebrate Insects

Water Quality

Discharge (cfs)

O N D J F M A M J J A S

Flow Components and Flow Statistics

Example: 01555500 East Mahantango Creek near Dalmatia, PA (162 sq mi) – Warm headwater stream

Flow Component	Flow Statistic
High flows	Bankfull, small and large flood magnitude and frequency
	Frequency of high flow events (>Monthly Q10)
	Monthly Q10
Seasonal flows	Monthly Median
	Monthly Range[1]
Low flows	Monthly Low Flow Range[2]
	Monthly Q95
	Monthly Q75*

Monthly Q10

Monthly Median

Monthly Q75

Monthly Q95
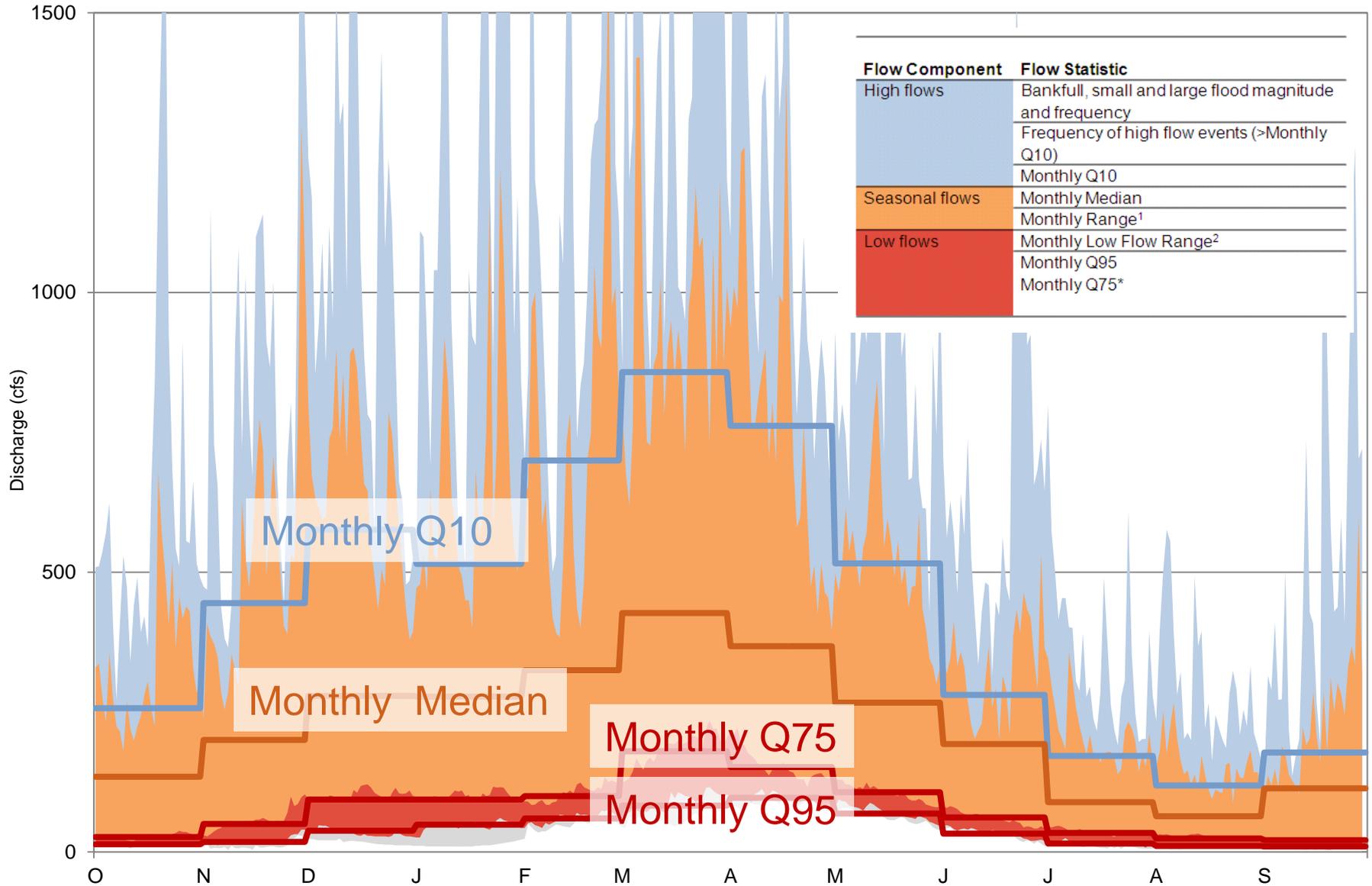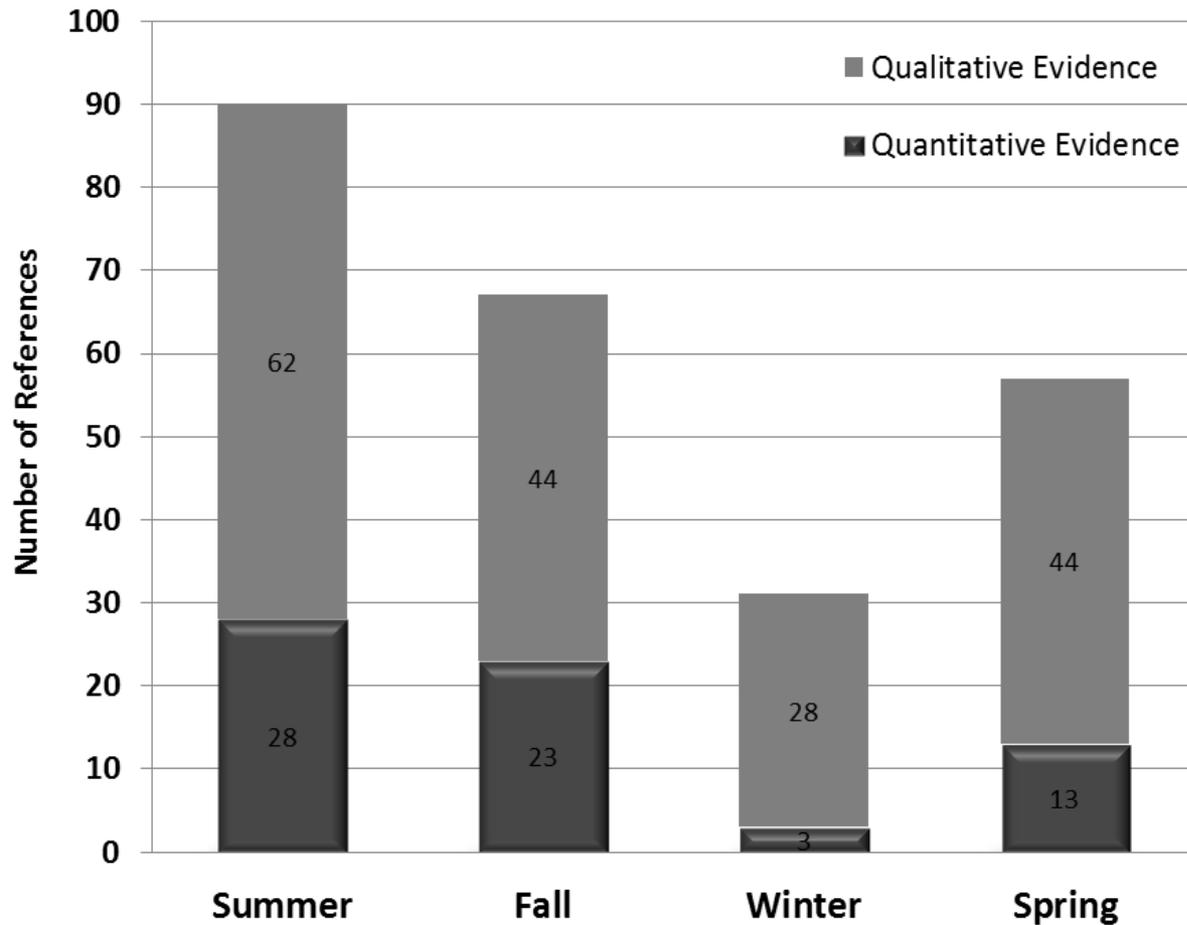
Table 5.1 Flow recommendations for the Susquehanna River ecosystem.

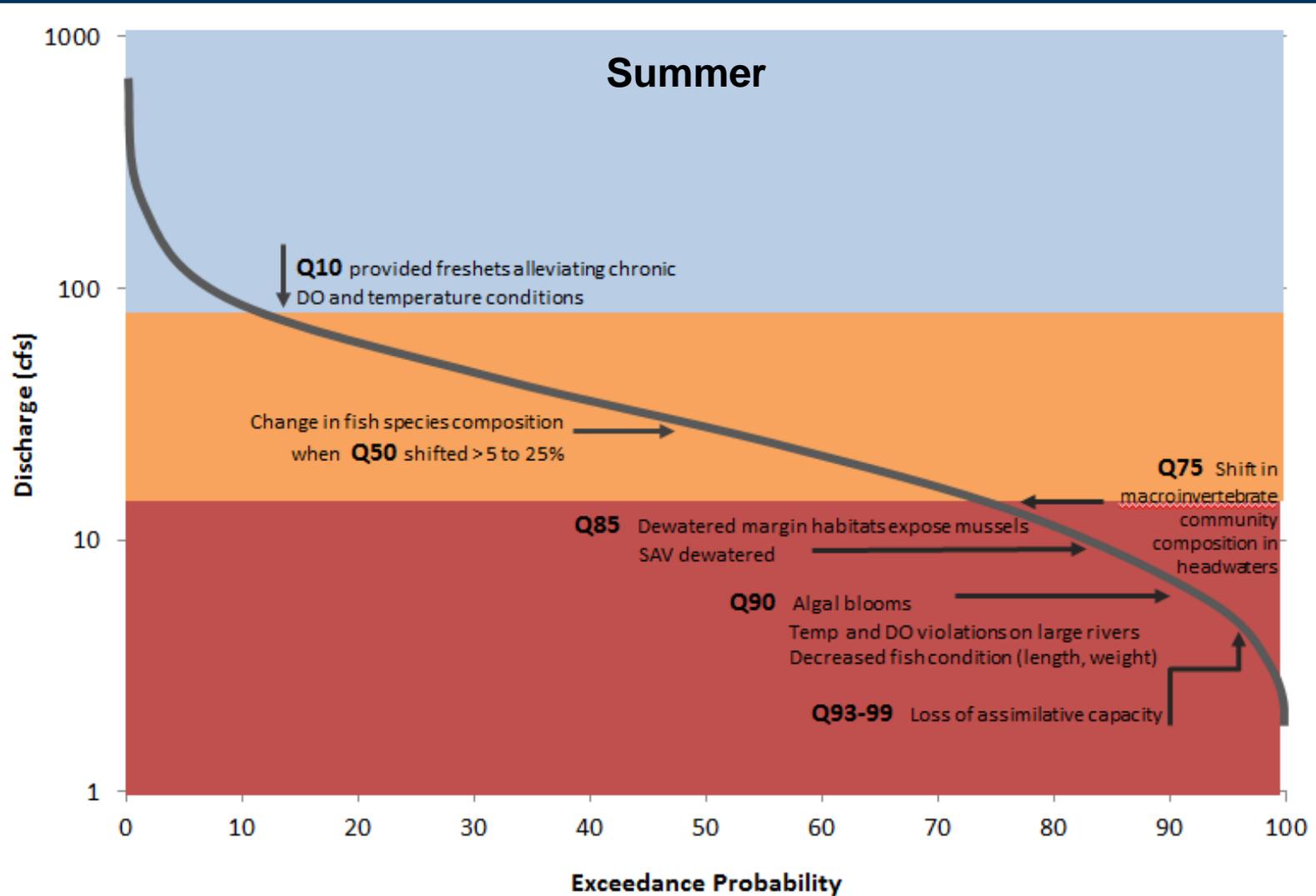| Season	Flow Component	Flow Statistic	Flow Recommendations		
			Headwater streams < 50 sq mi	Streams and small rivers (50 – 200 sq mi)	Major tributaries and mainstream (>200 sq mi)
Annual and Interannual Events	High Flows	Large flood	Maintain magnitude and frequency of annual Q0.05 (20-yr flood)	Same for all streams	Same for all streams
		Small flood	Maintain magnitude and frequency of annual Q0.2 (5-yr flood)	Same for all streams	Same for all streams
		Bankfull	Maintain magnitude and frequency of annual Q0.5 (Approx. 1 to 2-yr flood)	Same for all streams	Same for all streams
All Months	High flows	Monthly Q10	<10% change to magnitude of monthly Q10	Same for all streams	Same for all streams
	Seasonal flows	Monthly Median	Between 45th and 55th percentiles	Same for all streams	Same for all streams
		Monthly Range	≤ 20% change to area under curve between Q10 and Q75	Same for all streams	Same for all streams
	Low flows	Monthly Low Flow Range	No change to area under curve between Q75 and Q99	≤ 10% change to area under curve between Q75 and Q99	≤ 10% change to area under curve between Q75 and Q99
		Monthly Q75 Monthly Q95	No change	No change	No change
Fall	High flows	Frequency of events > Monthly Q10	NA	NA	1-5 events
Summer		Frequency of events > Monthly Q10	2-8 events	2-8 events	2-8 events

How does a given policy support ecosystem flow recommendations?

Legend:
- 🟢 less than 10% change OR Within
- 🟡 10 to 20% change
- 🔴 20 to 50% change
- ⚫ more than 50% change OR Outside

What is the effect of withdrawing a specific amount of water each day?

What is the effect with a 20% ADF passby requirement?

	Statistic	High Flows	Seasonal Median	Seasonal Range	Low Flow Range	Flow Magnitude
	Statistic	Monthly Q10	Monthly Median — Median of Monthly Medians	Monthly Range (Q75 to Q10)	Monthly Q75 to Q99: Sheds > 50 sqmi	Monthly Q95 — Sheds > 50 sq mi
	Flow Recommendation	≤ 10% change to Q10	Between the 45th and 55th Percentiles	≤ 20% change to area under curve between Q10 and Q75	≤ 10% change to area under curve between Q75 and Q99	No Change
Scenarios	Month	% change to Q10	Within/Outside	% change to area	% change to area	Within/Outside
Headwater	Oct	🟢	🟢	🟢	⚫	⚫
188 sqm	Nov	🟢	🟢	🟢	🔴	⚫
5.35 mgd	Dec	🟢	🟢	🟢	🟡	⚫
withdrawal - no min	Jan	🟢	⚫	🟢	🟡	⚫
	Feb	🟢	🟢	🟢	🟡	⚫
	Mar	🟢	🟢	🟢	🟢	⚫
	Apr	🟢	🟢	🟢	🟢	⚫
	May	🟢	🟢	🟢	🟡	⚫
	Jun	🟢	⚫	🟢	🔴	⚫
	Jul	🟢	⚫	🟡	⚫	⚫
	Aug	🟢	⚫	🔴	⚫	⚫
	Sep	🟢	⚫	🔴	⚫	⚫
Headwater	Oct	🟢	🟢	🟢	🟢	🟢
188 sqm	Nov	🟢	🟢	🟢	🟢	🟢
5.35 mgd	Dec	🟢	🟢	🟢	🟢	🟢
20% ADF passby	Jan	🟢	⚫	🟢	🟢	🟢
	Feb	🟢	🟢	🟢	🟢	🟢
	Mar	🟢	🟢	🟢	🟢	⚫
	Apr	🟢	🟢	🟢	🟢	⚫
	May	🟢	🟢	🟢	🟡	⚫
	Jun	🟢	⚫	🟢	🟢	🟢
	Jul	🟢	🟢	🟢	🟢	🟢
	Aug	🟢	🟢	🟢	🟢	🟢
	Sep	🟢	🟢	🟢	🟢	🟢

Delaware River Basin Ecosystem Flow Study

Headwater stream, Pike County © George Gress

- Funded by DRBC
- Technical study
- Project area
- Based on existing information
- Complete 2013
- WaterSmart

Thank you

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Flow-sensitive groups and processes

Fishes
Cold headwater
Slow spring fed
Riffle-obligates
Riffle-spawners
Nest builders
Potadromous
Great river

Mussels
Mod gradient, small river
Moderate to swift
Slow, low gradient
Great rivers (mainstem)

Reptiles and Amphibians
Aquatic lotic
Semi-aquatic lotic
Riparian and floodplain habitat spp.

Floodplain and Aquatic Vegetation
Submerged and emergent beds
Riparian forest and shrub
Low scour floodplain
Scour-dependent floodplain

Aquatic Insects and Crayfish
Habitat associations
Trophic traits
Species assemblages

## Birds and Mammals
Rely on stream-derived food and habitat

Water Quality

Floodplain and Channel Maintenance

Table X. Long-term median monthly streamflows (1960-2008) at index gages across stream types

Type	Stream name	Drainage area	Median Monthly Streamflow (cfs)											
		sq mi	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Headwaters	North Fork Bens Creek at North Fork	3.5	7.3	6.4	7.5	13	11	7	3.6	2.2	1.7	1.4	1.8	4.9
	Clear Run near Buckstown, Pa.	3.7	5.4	5.1	6	12	9.2	5.5	2.7	1.3	0.8	0.6	0.9	3.6
	Lick Run at Hopwood, Pa.	3.8	6.4	5.6	7.2	11	9.4	5.4	2.2	1.0	0.7	0.5	0.9	3.7
	Abers Creek near Murrysville, Pa.	4.4	4.1	4	5.3	8.3	6.2	3.9	2.1	1.3	0.9	0.9	1.3	2.6
Creeks	Little Pine Creek near Etna, Pa.	5.8	4.2	4.2	6	9.1	7	4.1	1.8	1.0	0.6	0.6	0.9	2.2
	Little Yellow Creek near Strongstown	7.4	12	11	13	23	18	10	5.4	3.0	2.1	2.0	2.7	8.4
	Big Run nr Sprankle Mills, Pa.	7.4	13	9.2	10	20	16	9.4	4.8	2.7	2.0	2.0	3.2	8.5
	Sevenmile Run near Rasselas, Pa.	7.8	13	9	9	18	20	12	5.3	2.4	1.9	1.6	4.8	12.0
	Poplar Run near Normalville, Pa.	9.3	18	16	19	33	27	15	5.7	2.7	1.7	1.8	2.6	13.0
Cool-cold	Brush Run near Buffalo, PA	10	8	9.4	13	19	14	8.7	3.8	2.0	1.0	0.8	1.3	3.8
	Jackson Run near North Warren, Pa.	13	23	15	15	32	29	15	6.6	4.1	3.5	3.5	6.5	19
	Georges Creek at Smithfield, Pa.	16	19	19	25	35	29	16	6.4	3.4	2.1	1.7	2.6	9.6
	Montour Run at Scott Station	25	24	25	34	50	43	29	16	11	7.4	6.5	8.5	15
	Woodcock Creek at Blooming Valley, Pa.	31	51	37	40	72	63	35	17	9.5	7.4	7	14	37
Small Rivers	French Creek near Wattsburg, Pa.	92	190	127	139	296	240	106	46	26	22	25	55	169
	Oswayo Creek at Shinglehouse, Pa.	99	147	98	97	218	243	125	60	33	21	18	30	109
Glaciated	Little Shenango River at Greenville, Pa.	104	130	103	110	195	150	92	45	27	20	20	30	79
	Sugar Creek at Sugarcreek, Pa.	166	280	203	219	399	350	210	110	66	54	48	76	202
	Pymatuning Creek near Orangeville, Pa.	169	203	144	163	353	247	128	49	25	18	18	30	108
	Kinzua Creek near Guffey, Pa.	39	76	56	52	104	109	64	33	20	15	15	25	61
Cool	Casselman River at Grantsville	63	105	105	118	198	155	95	45	23	16	12	18	65
	West Branch Clarion River at Wilcox, Pa.	63	121	83	76	174	185	106	52	31	24	21	36	100
	Laurel Hill Creek at Ursina, Pa.	121	235	210	233	418	341	199	89	49	35	30	44	176
	Deckers Creek at Morgantown	63	115	115	130	186	152	96	45	23	17	11	19	65
Warm	Tenmile Creek near Clarksville, Pa	133	106	125	170	238	191	111	47	24	13	12	19	50
	Buffalo Creek near Freeport, Pa.	137	170	140	170	280	204	128	63	33	22	19	31	84
	South Fork Tenmile Creek at Jefferson, Pa	180	219	189	229	476	344	163	55	23	14	11	21	134
Medium Tributaries	Tionesta Creek at Lynch, Pa	233	440	300	265	620	648	370	174	100	79	68	125	341
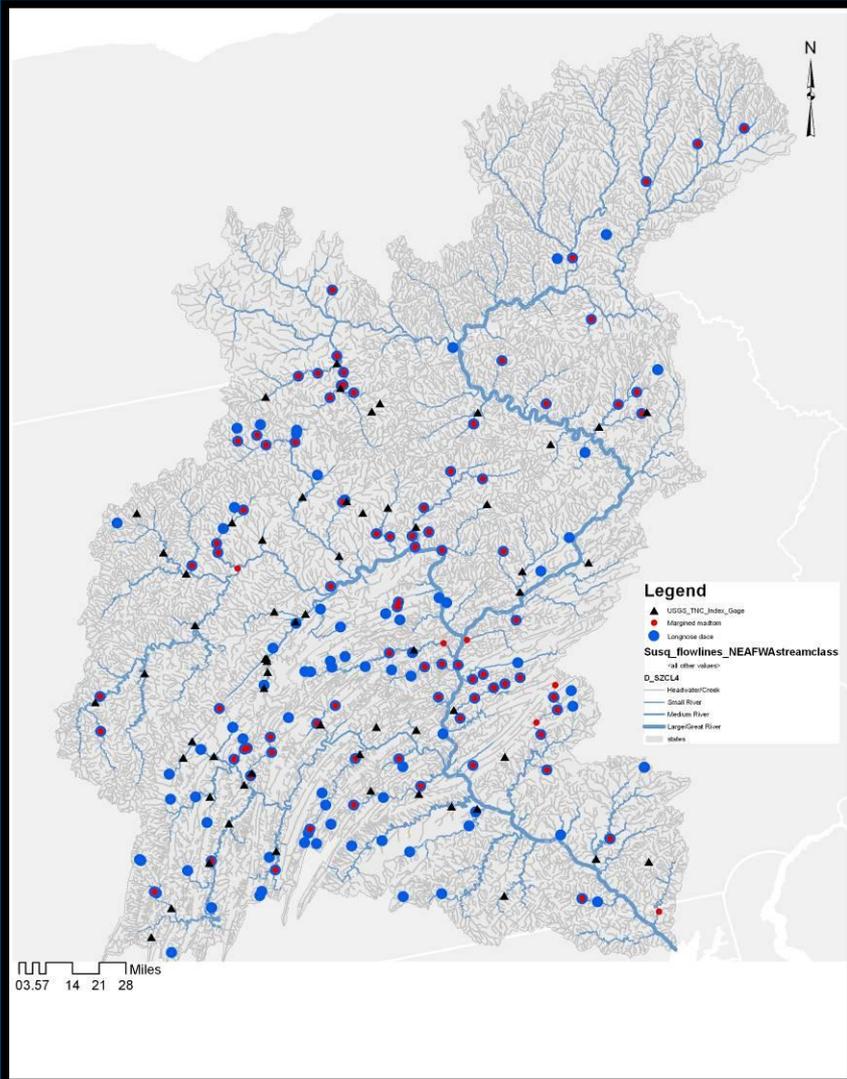
Riffle-obligates – Margined madtom, longnose dace, central stoneroller, northern hog sucker, fantail darter

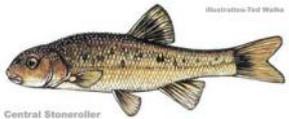**Riffle-spawners**– White sucker, shorthead redhorse

Selected more than 60 species (20 species groups)
and 7 Physical and Chemical processes

- Fishes

illustrations by Ted Walke, PFBC

Cold headwater – brook trout, brown trout, *Cottus* spp

Riffle-obligates – Margined madtom, longnose dace, central stoneroller, fantail darter

Riffle-associates – White sucker, northern hog sucker, shorthead redhorse

Nest-builders – Fallfish, creek chub, river chub, redbreast sunfish, smallmouth bass

Diadromous – American shad, alewife, American eel

How does the ecosystem depend on flow?

- Represent taxa, communities, and habitats characteristic of basin stream types

- Group species with shared flow-dependencies

- Capture range of traits
  - distribution
  - mobility
  - habitat associations
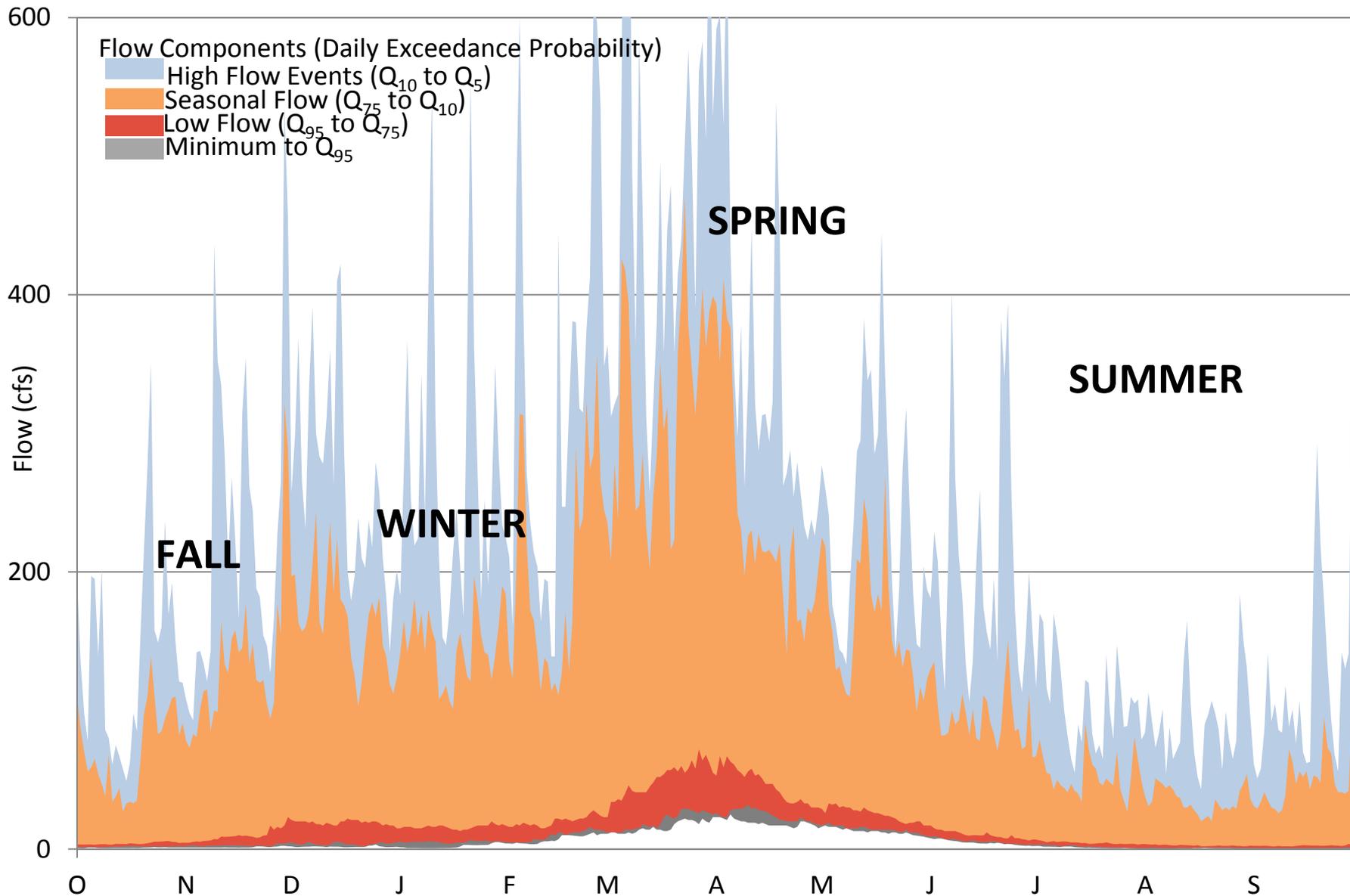 - feeding and spawning habits
  - longevity
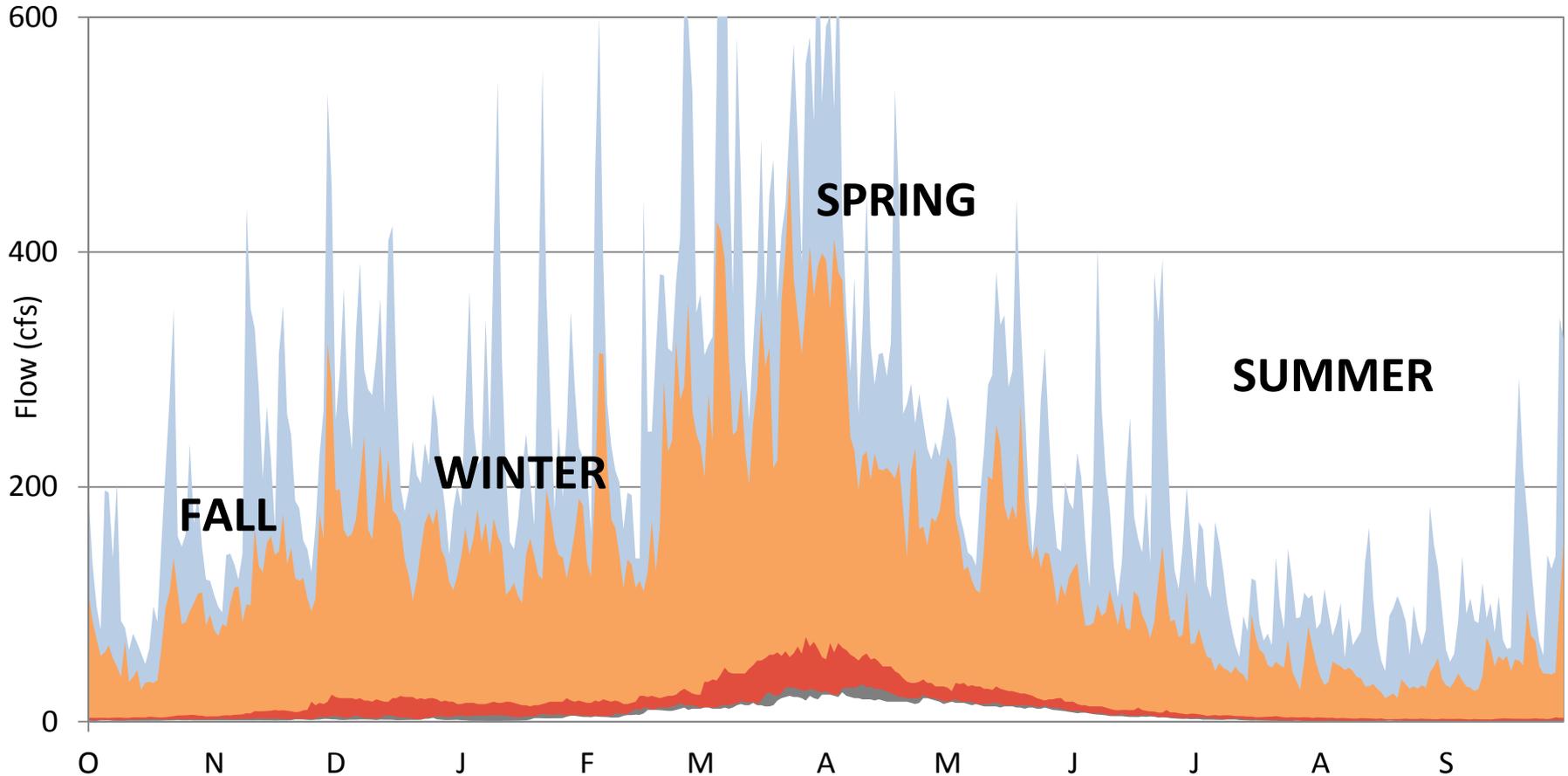

Photo by Western Pennsylvania Conservancy

Photo by P. Petokas

Legend: 5th to 95th percentile range of average daily discharge

Proposed passby: Class I Aquatic Resource
Example: 01547700 Marsh Creek at Blanchard, PA (44.1 sq mi)

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Legend:
— Proposed Alternative A, Jul.-Oct P50, Other P70
···· 20% Average Daily Flow

Y-axis: Discharge (0.0, 25.0, 50.0, 75.0, 100.0)
X-axis: O N D J F M A M J J A S
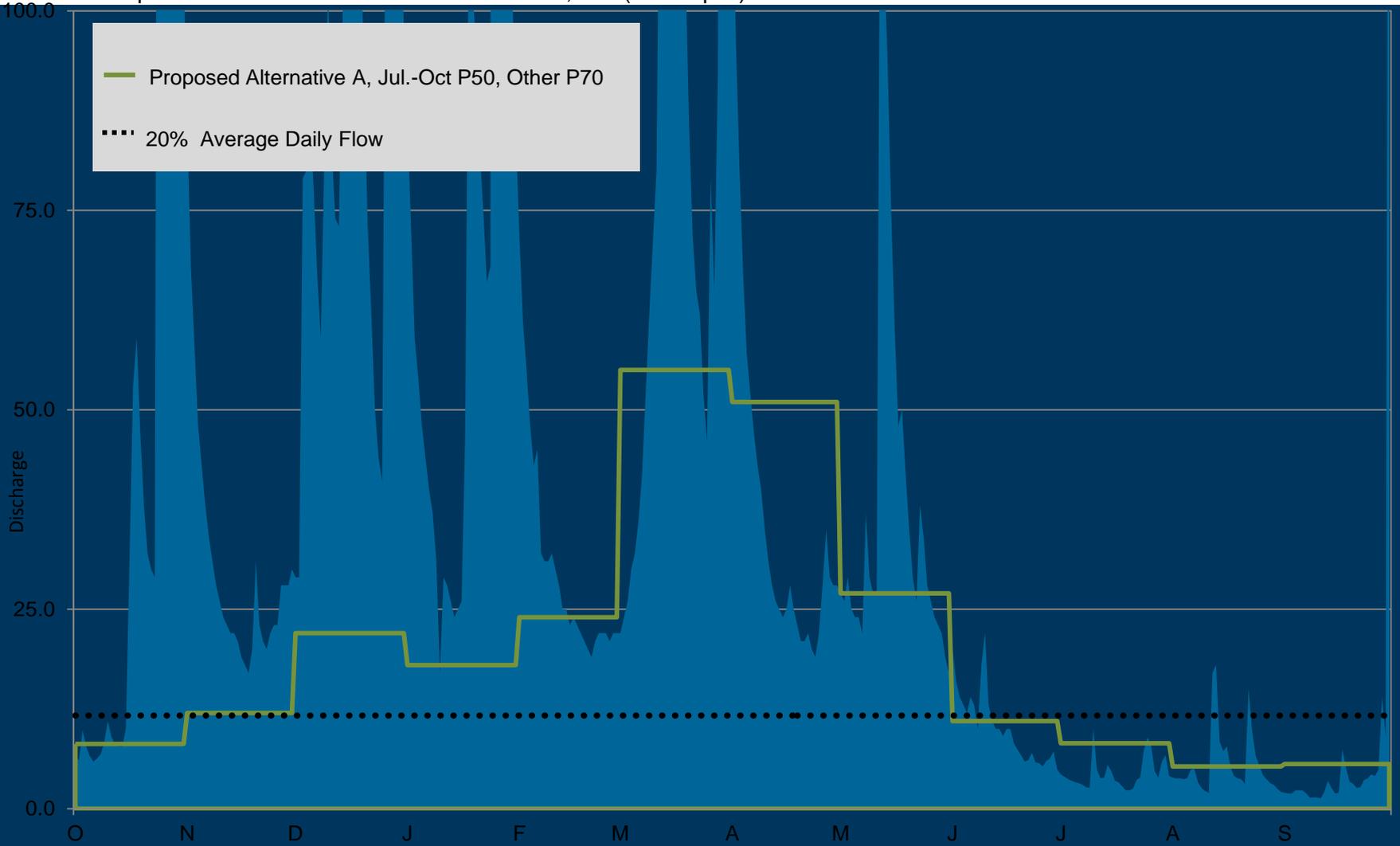
Table 2. Monthly Passby Flow/Conservation Release Schedule

MONTH	AQUATIC RESOURCE CLASS 1	AQUATIC RESOURCE CLASS 2	AQUATIC RESOURCE CLASS 3
January	Monthly P70	Monthly P80	Monthly P90
February	Monthly P70	Monthly P80	Monthly P90
March	Monthly P70	Monthly P80	Monthly P90
April	Monthly P70	Monthly P80	Monthly P90
May	Monthly P70	Monthly P80	Monthly P90
June	Monthly P70	Monthly P80	Monthly P90
July	Monthly P50	Monthly P70	Monthly P85
August	Monthly P50	Monthly P70	Monthly P85
September	Monthly P50	Monthly P70	Monthly P85
October	Monthly P50	Monthly P70	Monthly P85
November	Monthly P70	Monthly P80	Monthly P90
December	Monthly P70	Monthly P80	Monthly P90

http://www.srbc.net/pubinfo/businessmeeting.htm
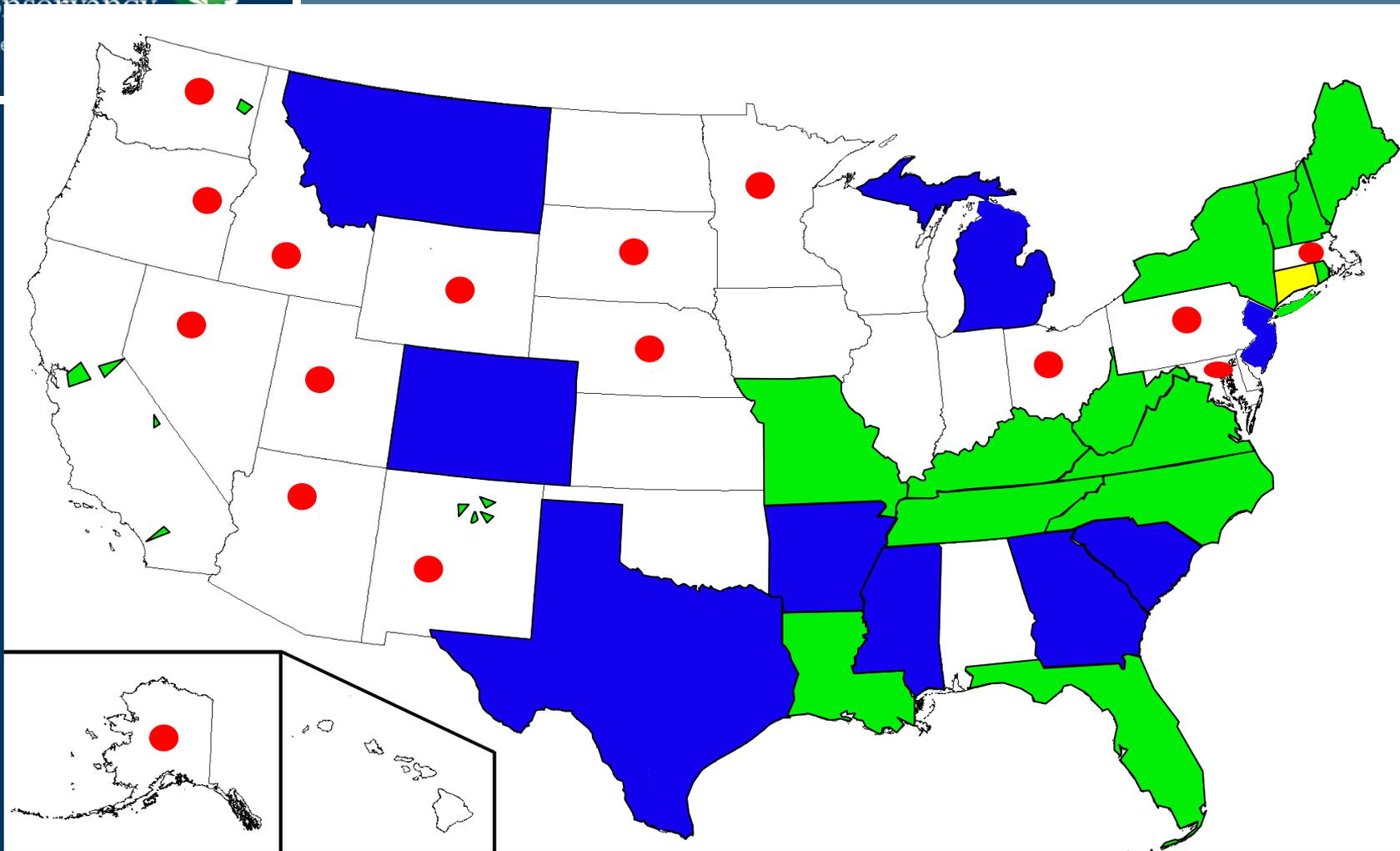
- Green States/Tribes = Narrative or Numeric Water Quality Standards that address Flow
- Yellow States/Tribes = proposing Ecological Flow language for Water Quality Standards
- Dark Blue States = statewide Programs include Ecological Flows, not in CWA Programs
- **Red circle = States that have Ecological Flow projects underway**

Restore and maintain the natural hydrologic regime and its natural variability to the greatest extent possible