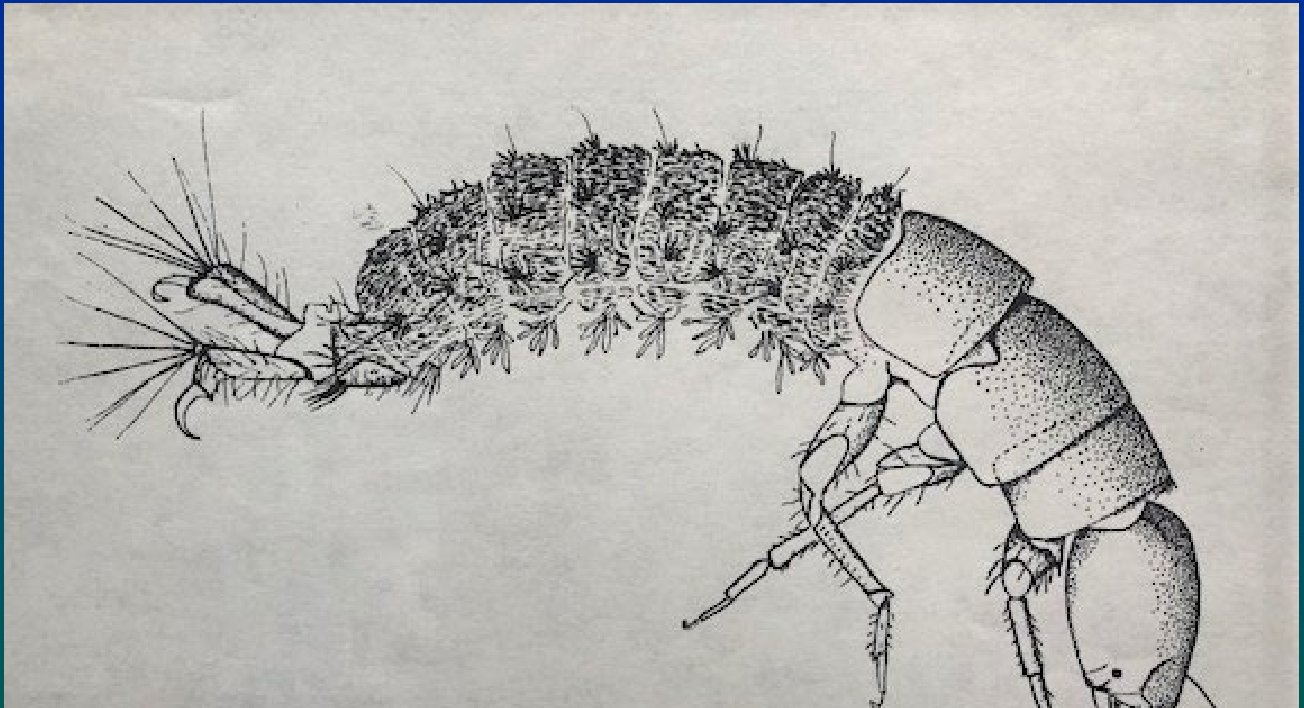
Kinnickinnic River Macroinvertebrate Monitoring: Past, Present, and Future

Kent Johnson, Kiap-TU-Wish Chapter, Trout Unlimited
Clarke Garry, Professor Emeritus, UW-River Falls



Net-spinning Caddisfly (Trichoptera: Hydropsychidae)
Illustration by Janice Nelson Johnson

https://www.kiaptuwish.org/coldwater-science-library/

What's in the not-so-subtle messages we're getting?

Insect decline in the Anthropocene: Death by a thousand cuts

David L. Wagner[a,1], Eliza M. Grames[a], Matthew L. Forister[b], May R. Berenbaum[c], and David Stopak[d]

The World's Oldest Winged Insect Is in Trouble. How Frightened Should We Be?

Mayflies are among nature's best environmental sentinels — and their current message to us is grim

By Robert O'Harrow Jr.

September 19, 2022 at 10:03 a.m. EDT

The caddis aren't alright: modeling Trichoptera richness in streams of the northcentral United States reveals substantial species losses

David C. Houghton[1*] and R. Edward DeWalt[2]

[1]Department of Biology, Hillsdale College, Hillsdale, MI, United States, [2]Illinois Natural History Survey, University of Illinois, Champaign, IL, United States

Declines in an abundant aquatic insect, the burrowing mayfly, across major North American waterways

Phillip M. Stepanian[a,b,c,1], Sally A. Entrekin[d], Charlotte E. Wainwright[c], Djordje Mirkovic[e], Jennifer L. Tank[f], and Jeffrey F. Kelly[a,b]

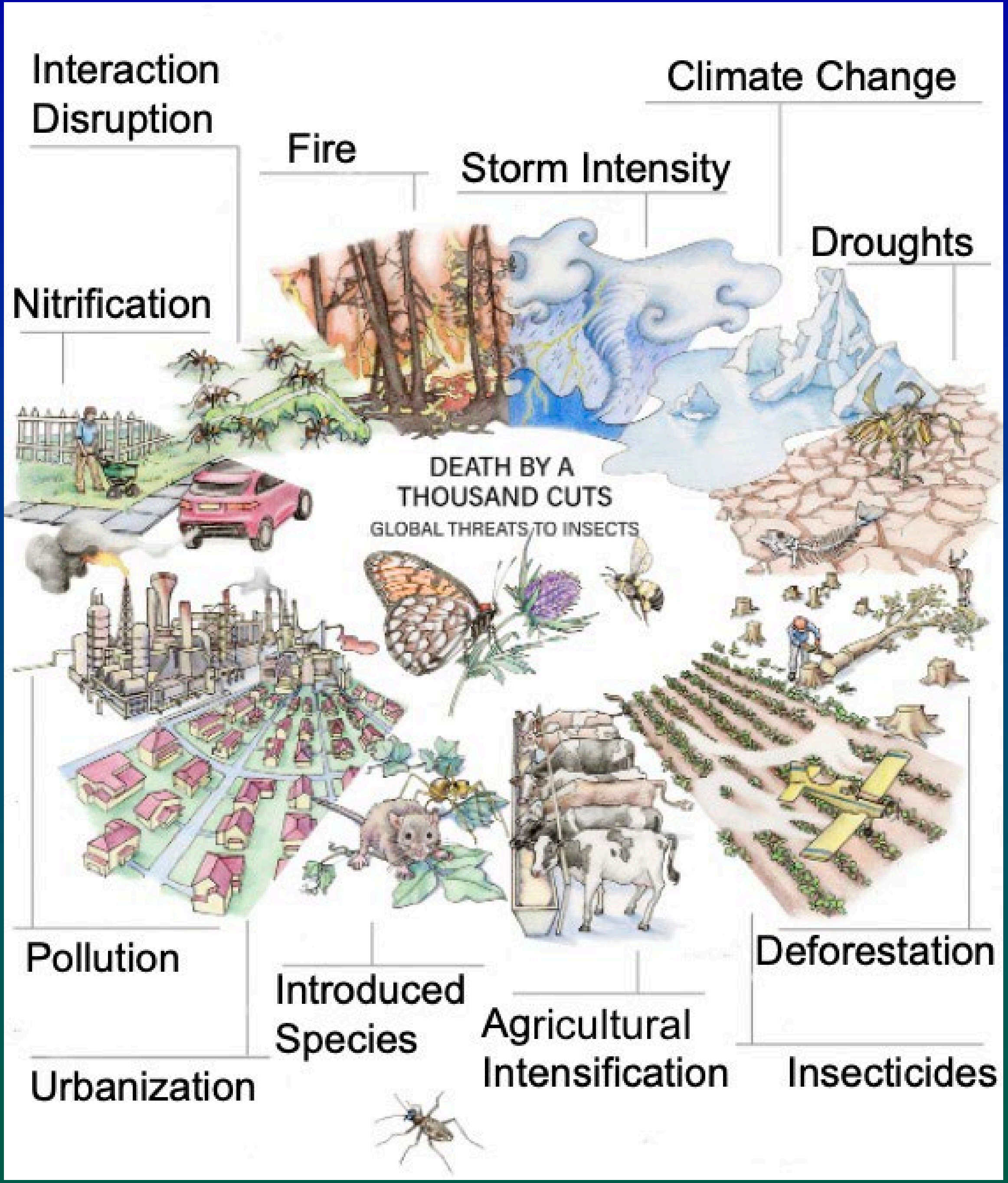
Headed by 11 World Experts, 2019 Entomology Symposium Brings Critical Insect Decline Issues to the Forefront

- The symposium provided a scientifically-grounded assessment of insect population trends.
- Clouding the issue are reports of insect declines (with widely varying levels of accuracy) that have appeared in the popular media.
- Primary topics discussed were:
  - the state of knowledge of insect population trends
  - identifying data gaps and limitations
  - evaluating principal stressors underlying declines
  - targeting activities to mitigate declines
- Assessing insect population trends is difficult and details are important. Data on insect population trends are scant, relative to those for vertebrates. There is an urgent need for data that allow assessment of population trends.

Wagner et al. (Proceedings of the National Academy of Sciences, 2021)

Stressors, almost too many to comprehend, prompt the reality: Death by a Thousand Cuts

- Climate Change
- Storm Intensity
- Droughts
- Fire
- Interaction Disruption
- Introduced Species
- Deforestation
- Urbanization
- Agricultural Intensification
- Nitrification
- Insecticides
- Pollution



A closer look at two stressors . . .

- Habitat destruction

  "The Caddis Aren't Alright: Modeling Trichoptera Richness in Streams of the Northcentral United States Reveals Substantial Species Losses" Houghton and DeWalt 2023

  - Study data indicated a tremendous number of site-level caddisfly losses over a large area, owing principally to watershed-level habitat disturbance. https://www.frontiersin.org/articles/10.3389/fevo.2023.1163922/full

- Neonicotinoids ("Neonics")

  "Risks Posed by Neonicotinoid Insecticides to Wisconsin's Wadeable Streams" Mike Miller, WDNR (2023 Driftless Symposium) https://www.youtube.com/watch?v=rYsy21lNHt0

  - Neonics were detected in 85% of the 100 WI streams sampled in 2022. 55% of these concentrations were at levels causing behavioral effects and long-term or short-term toxicity to aquatic invertebrates (Ephemeroptera, Trichoptera, Diptera are the most sensitive orders).

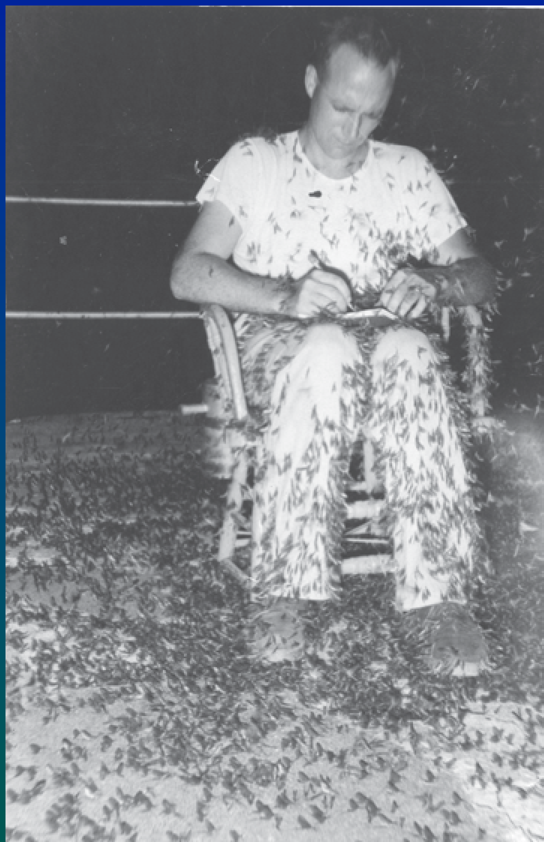
The Ups and Downs of *Hexagenia* Populations

- In the middle of the 20th century, enormous summertime swarms of *Hexagenia* were a common sight across many of North America's largest waterways
- By 1970, these mass emergences had largely disappeared
- Recent Upper Mississippi River radar surveillance studies indicate a 52% decline in *Hex* populations between 2012-2019

Source: Stepanian et al. 2020

Mayflies - Ancient Flash Mobs Seize the Day!

Bizarre Creatures of the Mississippi



Thanks to *Big River Magazine* for captions and photos

Mayflies - Indicators of Good Water Quality

Hexagenia bilineata hatches along the Upper Mississippi River

Red Wing LD3

Photo courtesy of Kent Johnson, MCES

La Crosse, WI

Photo courtesy of John Sullivan, WDNR

Some positive news as well?

No net insect abundance and diversity declines across US Long Term Ecological Research sites

Michael S. Crossley[1], Amanda R. Meier[1], Emily M. Baldwin[2], Lauren L. Berry[2], Leah C. Crenshaw[2], Glen L. Hartman[3], Doris Lagos-Kutz[3], David H. Nichols[2], Krishna Patel[2], Sofia Varriano[2], William E. Snyder[1] and Matthew D. Moran[2]

INSECT POPULATIONS

Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances

Roel van Klink[1,2,3*], Diana E. Bowler[1,4,5], Konstantin B. Gongalsky[6,7], Ann B. Swengel[8], Alessandro Gentile[1], Jonathan M. Chase[1,9]

"Local drivers of decline matter: Recent studies have reported alarming declines in insect populations, but questions persist about the breadth and pattern of such declines….. Patterns of variation suggest that local-scale drivers are likely responsible for many changes in population trends, providing hope for directed conservation actions."

Where from here? Two articles of note.

- *International scientists formulate a roadmap for insect conservation and recovery.* J. Harvey and 58 additional scientists (2020)
  - Propose a global 'roadmap' for insect conservation and recovery, specifying actions needed.
  - These actions emphasize techniques that are: effective, locally relevant, and economically sound, for example, in farming, habitat management, and urban development.

Entire European Union Bans a Bayer Insecticide Modern Farmer (2020) on thiacloprid (neonic)

- *Declines in insect abundance and diversity: We know enough to act now*. M. Forister *et al*. (2019)
  - ". . . the severity of reported insect declines is sufficient to warrant immediate action . . ."
  - "We must act to ameliorate the drivers of declines while basic research proceeds."
  - Paper suggests 4 scales of action: 1) Nations, states, provinces, cities; 2) Working lands (farms, ranches, forests); 3) Natural areas (parks, roadsides, rights of way); and 4) Gardens, homes, and other private property.

Summary of Insect Impacts: What Can We Say?

- Insect population numbers are declining worldwide. Science-based estimates place the ongoing background decline at 1-2 % per year (Wagner 2021). Much larger declines (52% of butterflies, 99% of monarchs, 70% of flying insect biomass) have been reported in distinct populations (Forister et al. 2019).
- Declines are most conspicuous in areas of high human activity, where multiple stressors (“a thousand cuts”) occur simultaneously (Wagner 2021).
- For most insects, high inter-annual variability is the norm rather than the exception (Didham et al. 2020).
- Long-term studies must be used as baselines, documenting abundance, biomass, and diversity.
- Landscape-level habitat disturbance is an important driver of species richness. “In every respect, the valley rules the stream” (Hynes 1975).
- Action can and should be taken to reduce stressor effects in the absence of complete studies.
- Popular media must be assimilated with caution.

Have Kinni Aquatic Insects Been Impacted?

Kiap-TU-Wish and TCTU Member Observations of Kinnickinnic River Macroinvertebrate Trends

TROUT UNLIMITED

UWRF

Kinni River Macroinvertebrate Communities: Angler Comparisons of Past to Present

One of the primary goals of the 2022-2025 Kinnickinnic River Macroinvertebrate Survey is to compare the historical condition of the Kinnickinnic River macroinvertebrate community (based on the Garry/Kiap 2001/2002 river-wide surveys) to the current condition, 20+ years later. To help us make this comparison, we'd like your input, as requested below. If more space is needed, please continue your responses on another sheet of paper.

1. Based on your Kinni angling experiences and/or general river observations, what are your recollections of past Kinni macroinvertebrate species/hatches that may no longer be as prevalent?

   Type of insect(s) (Latin name or common angler name):

   General location(s) where you've noticed a decreased presence:

2. Based on your Kinni angling experiences and/or general river observations, are there any current Kinni macroinvertebrate species/hatches that are more abundant than in the past?

   Type of insect(s) (Latin name or common angler name):

   General location(s) where you've noticed an increased presence:

3. Please let us know if you have any detailed notes on hatch information and/or macroinvertebrate presence/absence that you would be willing to share with us (or feel free to return with the survey).

4. Are there any other observations (past or present) on the condition of the Kinni that you'd like to share with us?

5. As our Trout Unlimited chapters work toward river protection and restoration, what are your concerns about present and future impacts on the Kinni?

Your contact Information (if you care to share; anonymous is also fine):

Name:

E-Mail Address:

Please return the survey to:

Kent Johnson
1403 Birch Drive
Hudson, WI 54016

E-Mail: d.kent.johnson@gmail.com
(Also steer any questions to this e-mail address)

Thanks so much for your observations and feedback!

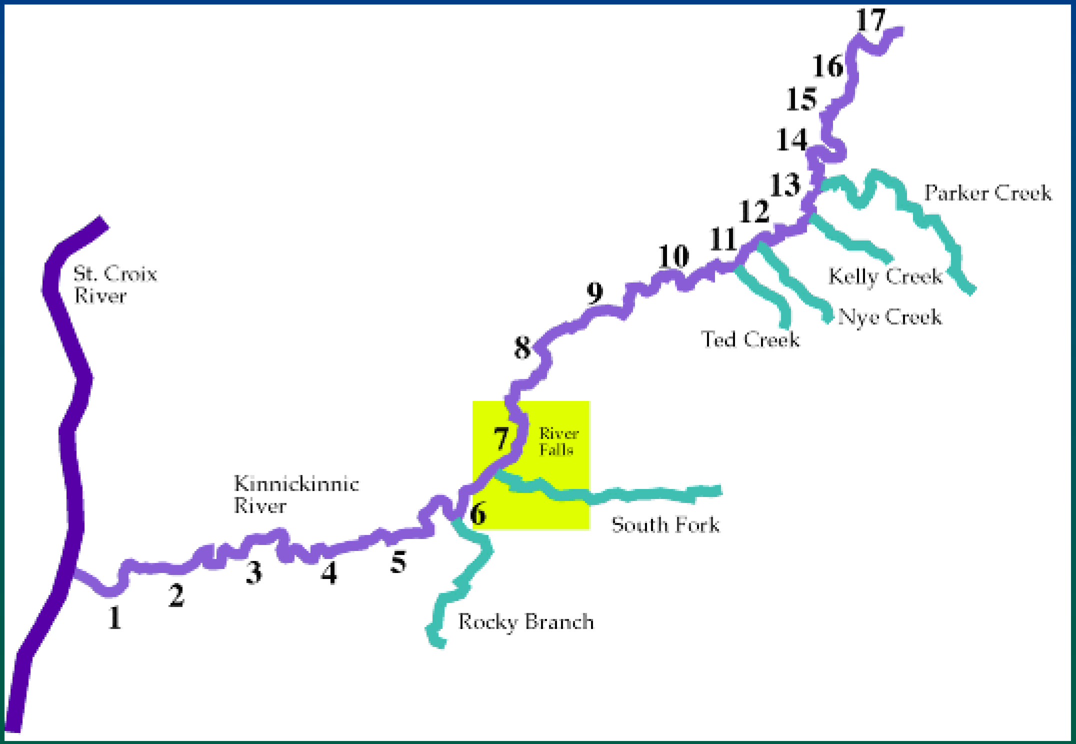
Why Macroinvertebrate Monitoring?

- Biological data (fish, macroinvertebrates, vegetation) add a significant dimension to monitoring procedures, and are often used to complement physical and chemical measurements.
- Aquatic macroinvertebrates (subsurface insects and crustaceans) can provide information on the ecological condition of streams that may otherwise be difficult to measure.
- With limited mobility and a lifespan of months to years, aquatic macroinvertebrates are good indicators of local water quality, integrating multiple environmental stressors.
- The use of aquatic macroinvertebrates for evaluating stream health in Wisconsin was initiated by William L. Hilsenhoff at UW-Madison in 1977, with development of the Hilsenhoff Biotic Index (HBI).

Kiap-TU-Wish/UWRF Macroinvertebrate Monitoring

Kinnickinnic River
Macroinvertebrate Survey
2022-2025

Kinni Macroinvertebrate Monitoring Sites



Kinni Monitoring Site 4: June 2023

Macroinvertebrate Monitoring Protocols

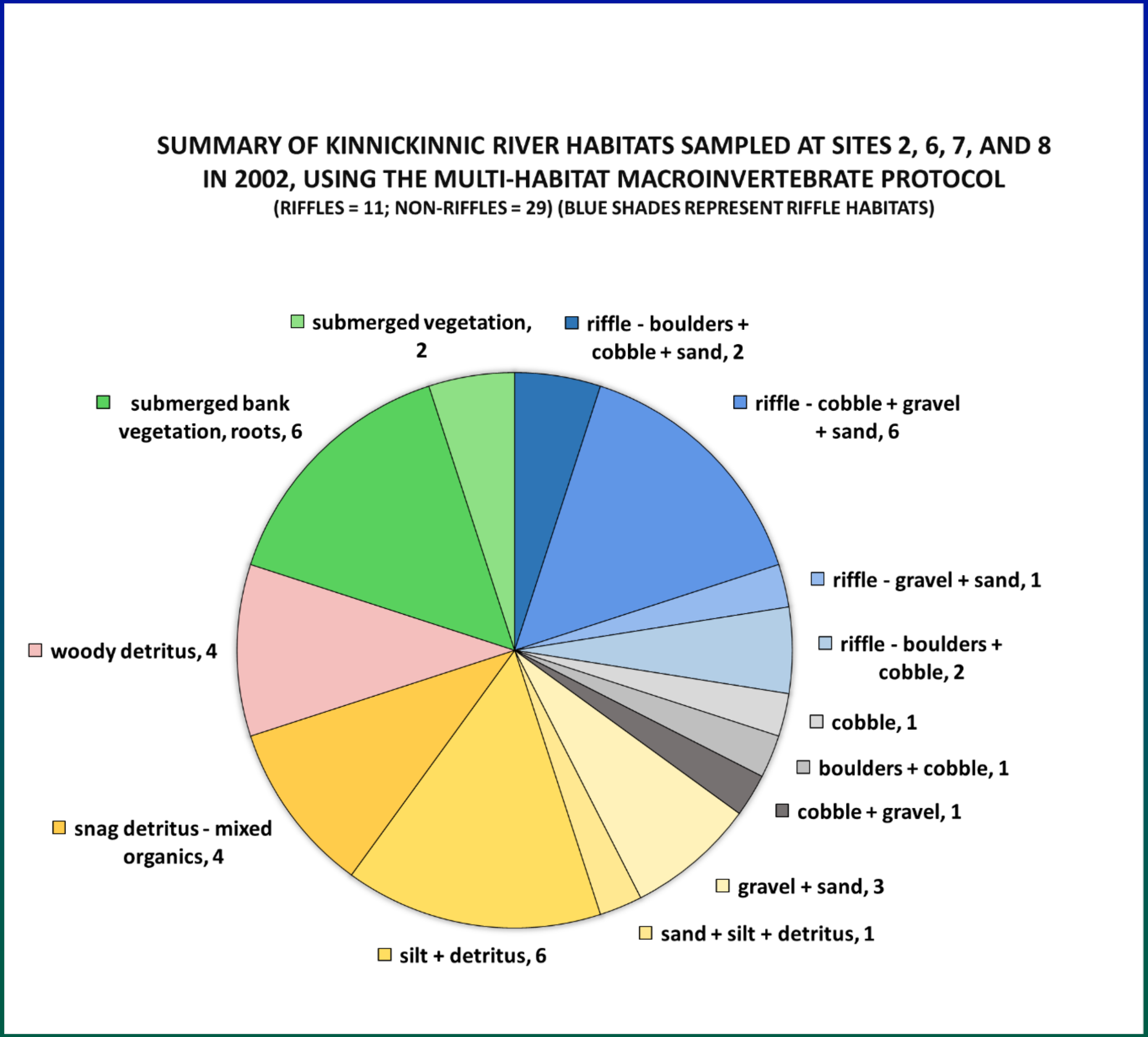
Monitoring Protocol	Habitat(s) Sampled	Outcome Achieved	Previous Usage
Single-Habitat (S-H) Sampling	Riffle areas	Riffle-specific macroinvertebrates; quantitative indices	Widely used by Wisconsin DNR for water quality records; River Falls North Kinni Monitoring Project (2004-2012)
Multi-Habitat (M-H) Sampling	All stream habitats present	Habitat-wide inventory of macroinvertebrates; presence/absence	Used to document macroinvertebrate fauna of entire Kinni River (17 sites) in 2001 & 2002

Single-Habitat (HBI) Sampling Protocol

- Field work
  - A sample consists of 3 netted subsamples to represent the riffle habitat at the site
  - Multiple measurements are obtained to characterize habitat conditions
- Lab analysis
  - 250 specimens are sorted from each sample and all are identified to the lowest practical taxonomic unit

Multi-Habitat Sampling Protocol

- Field work
  - A sample consists of 10 netted subsamples to represent the variety of river habitats at the site
  - Subsamples standardized by substrate area and time
  - Specimens are pooled and preserved for lab analysis
- Lab analysis
  - 300 specimens are sorted from each sample and all are identified to the lowest practical taxonomic unit



Macroinvertebrate Monitoring Protocols

Complementary Use of the S-H and M-H Protocols:

If resources allow, complementary use of the S-H and M-H protocols can maximize the information gained on macroinvertebrate presence and stream health. Both protocols can yield critical quantitative and qualitative data for evaluating stream conditions and assessing temporal and spatial changes.

- The S-H protocol recommended and used extensively (at hundreds of sites annually) by the WDNR allows a direct comparison of macroinvertebrate health in streams and rivers across the state.

- The S-H protocol also allows for the calculation of HBI and macroinvertebrate Index of Biotic Integrity (*m*-IBI) metrics, which WDNR uses to evaluate aquatic ecosystem health in Wisconsin's streams and rivers.

- However, by representing the broader variety of habitats typically present in a stream or river, the M-H protocol provides the best information on the total types and relative numbers of macroinvertebrates present.

Macroinvertebrate Monitoring Protocols

Macroinvertebrate sampling at Kinnickinnic River Site 4 in 2023, using both protocols

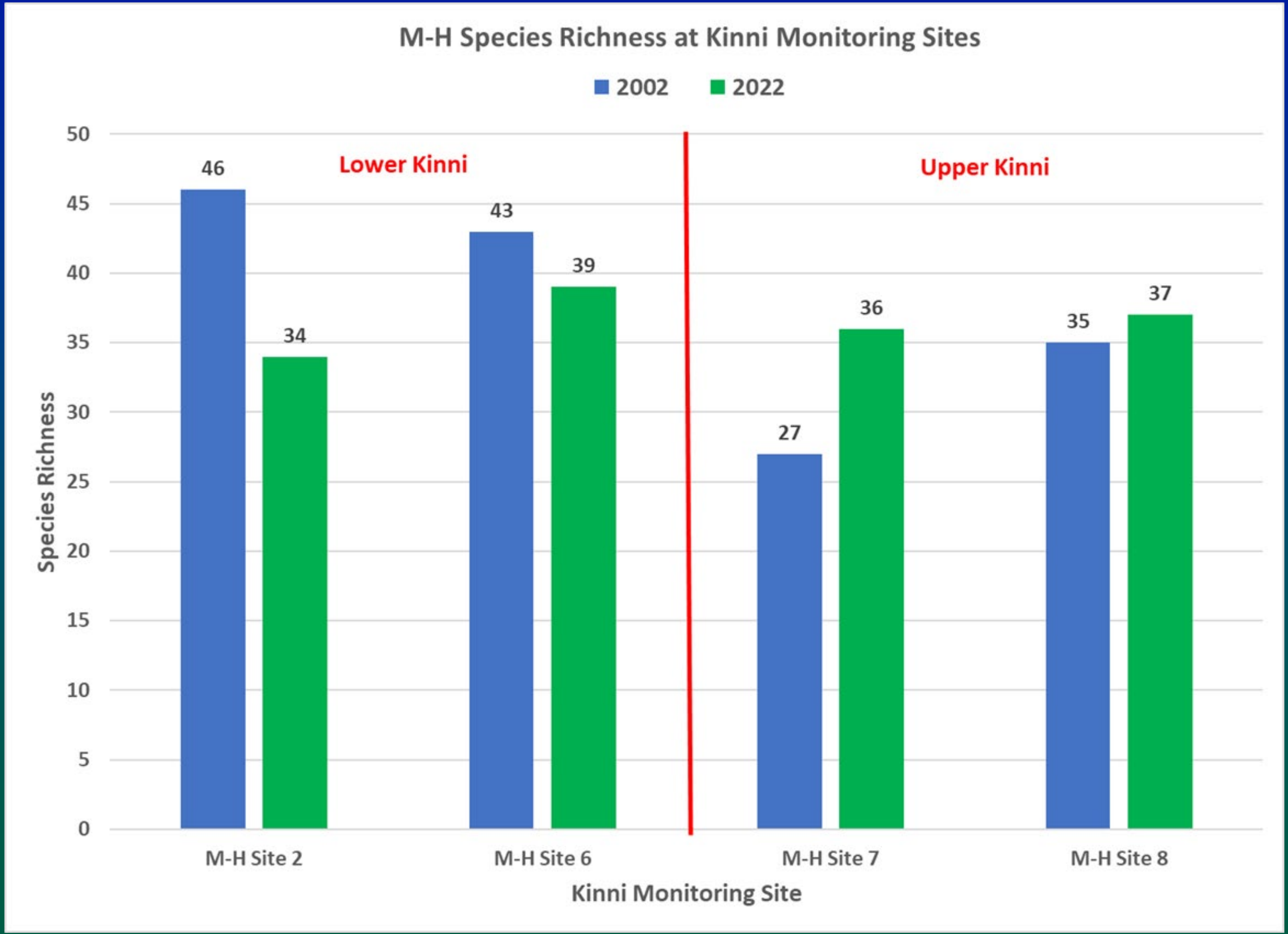
Macroinvertebrate Monitoring Sites Completed in 2022 and 2023

	WDNR Site Designation	Kinni Monitoring Plan Site Designation	River Location
2022:	Site 2	Site 120	Upstream from County Road F
	Site 6	Site 478	Upstream from Rocky Branch Creek confluence
		Site 504	Below Powell Falls Dam
		Site 515	Lake Louise (new Kinnickinnic River channel)
	Site 7	Site 574	Upstream from Division Street in River Falls
	Site 8	Site 652	Upstream from State Highway 35 (Quarry Road)
2023:	Site 4		Lower Canyon near Erickson Property
	Site 10		Upstream from Liberty Road
	Site 12		Upstream from County Road JJ
	Site 14		Upstream from Steeple Drive

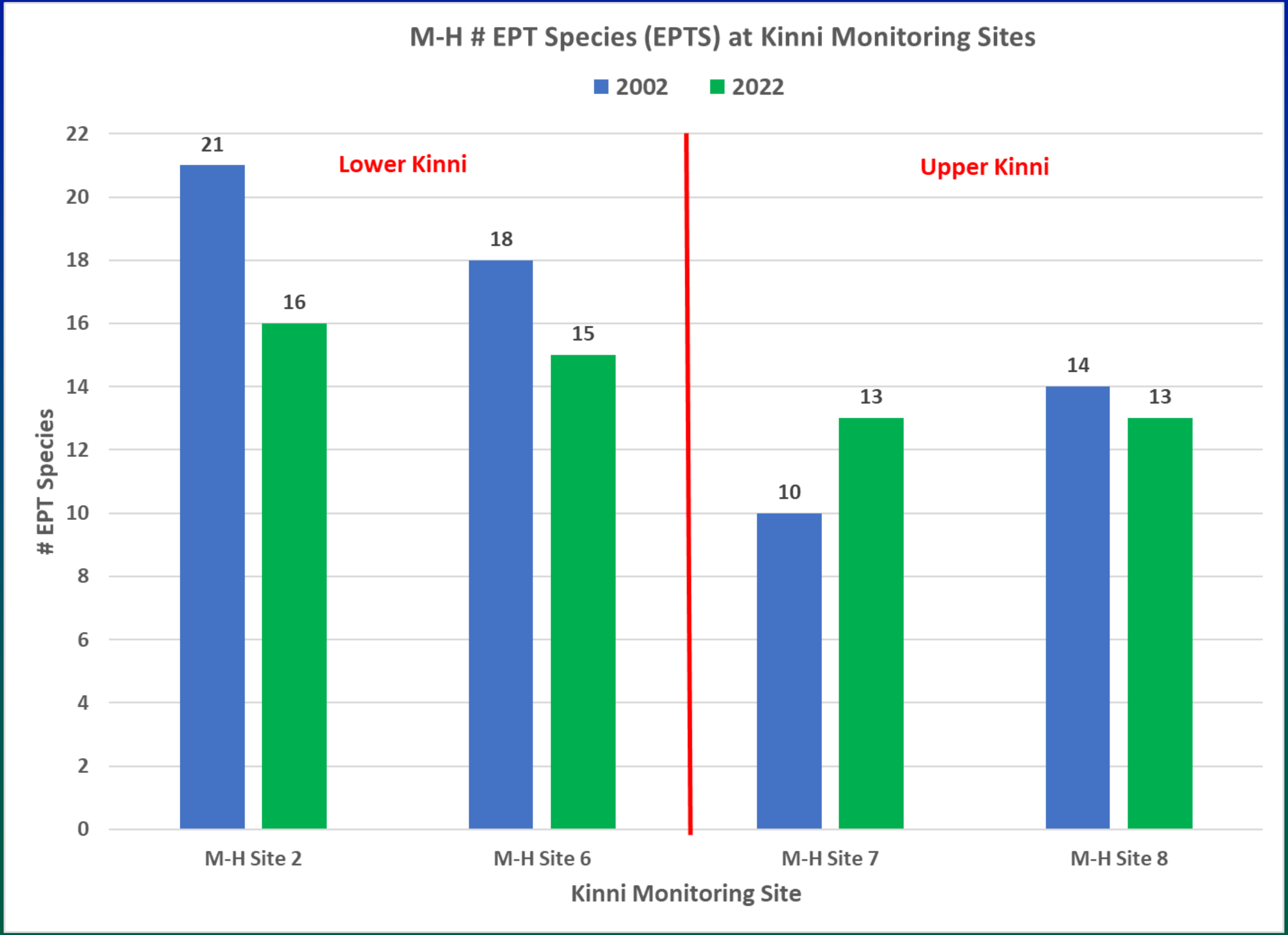
Both M-H and S-H samples were collected at all sites

The 2002 M-H samples collected at all of these sites by Garry were also analyzed

Species richness is a particularly good metric for within-stream comparisons. Note Upper and Lower Kinni as well as 2002-2022 similarities and differences.



Number of EPT species metric indicates relative species stability, 2002 to 2022, in the Upper and Lower Kinni, with suggestions of decreasing EPT species in the Lower Kinni over the same period.



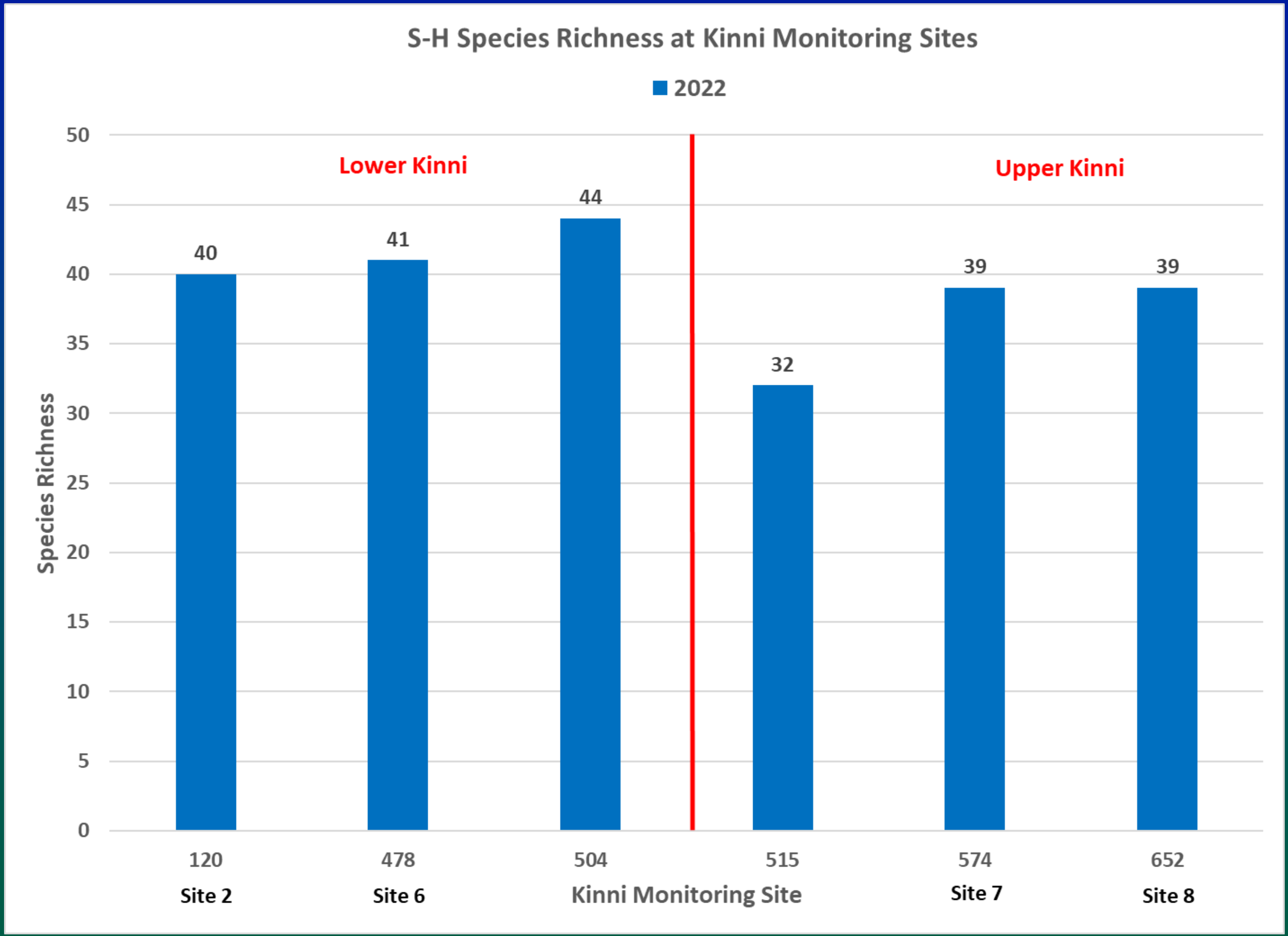
Tracking Kinni Macroinvertebrates Through Time: 3 Mayfly Examples

Taxa: **EPHEMEROPTERA (Mayflies)** **Baetidae (Small Minnow Mayflies)**	**WDNR Site**	**Collected: M-H 2001 and/or 2002** 🟢	**Collected: M-H 2022** 🟢 **and/or S-H 2022** 🟠	**M-H Taxon Re-Occurrence Count**	**M-H Taxon Re-Occurrence %**
Baetis brunneicolor Blue-winged Olive	Site 2	🟢			
	Site 6	🟢			
	Site 7				
	Site 8	🟢			
Baetis flavistriga species complex Dark Blue-winged Olive	Site 2	🟢			
	Site 6	🟢			
	Site 7				
	Site 8	🟢			
Baetis tricaudatus Blue-winged Olive	Site 2	🟢			
	Site 6	🟢			
	Site 7	🟢			
	Site 8	🟢			

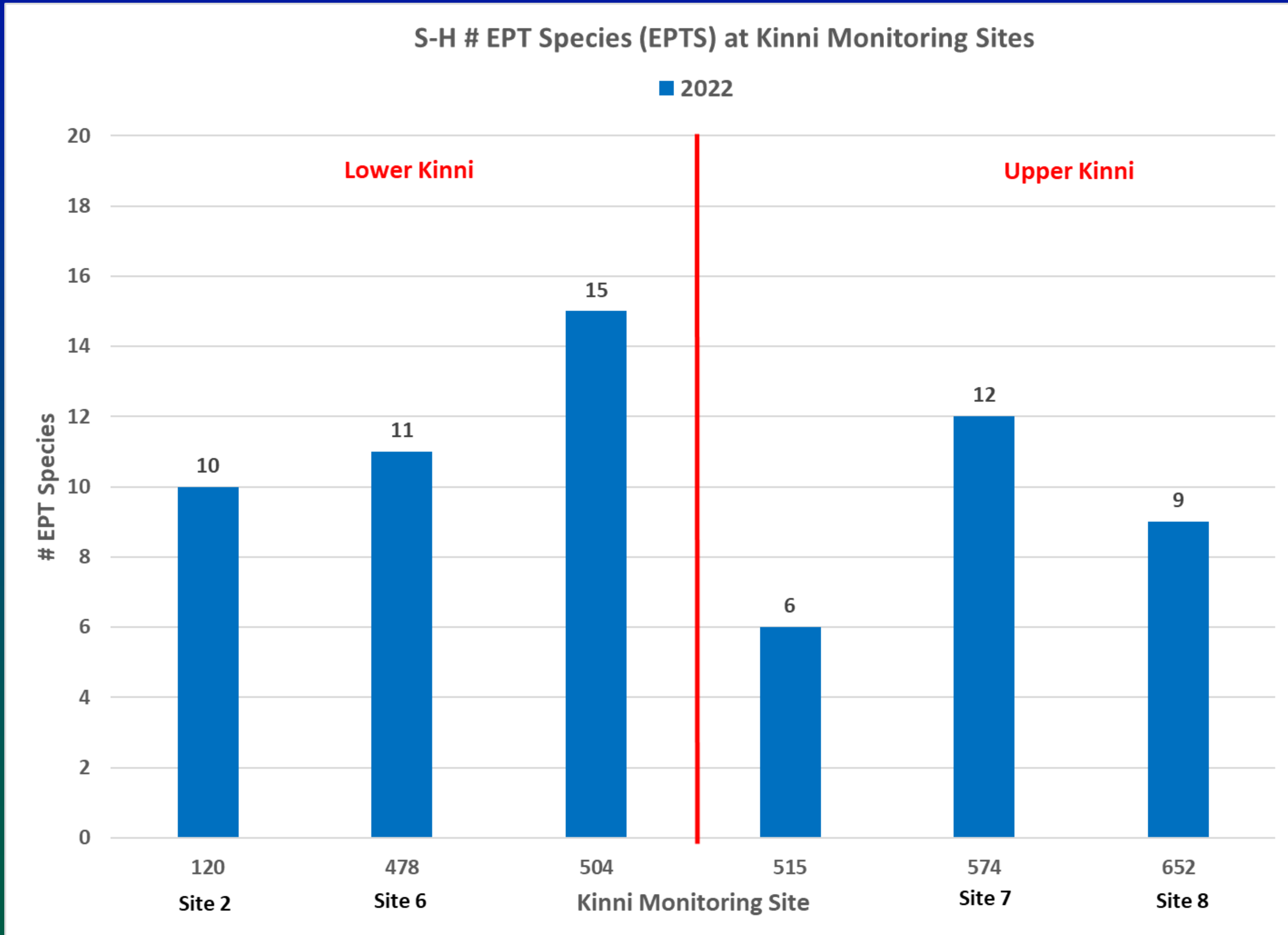
Tracking Kinni Macroinvertebrates Through Time: 3 Mayfly Examples

Taxa: **EPHEMEROPTERA (Mayflies)** **Baetidae (Small Minnow Mayflies)**	**WDNR Site**	**Collected: M-H 2001 and/or 2002 🟢**	**Collected: M-H 2022 🟢 and/or S-H 2022 🟠**	**M-H Taxon Re-Occurrence Count**	**M-H Taxon Re-Occurrence %**
Baetis brunneicolor Blue-winged Olive	Site 2	🟢	🟢🟠	3/3	100%
	Site 6	🟢	🟢🟠		
	Site 7		🟢🟠		
	Site 8	🟢	🟢🟠		
Baetis flavistriga species complex Dark Blue-winged Olive	Site 2	🟢	🟢🟠	3/3	100%
	Site 6	🟢	🟢🟠		
	Site 7		🟢🟠		
	Site 8	🟢	🟢🟠		
Baetis tricaudatus Blue-winged Olive	Site 2	🟢		3/4	75%
	Site 6	🟢	🟢🟠		
	Site 7	🟢	🟢🟠		
	Site 8	🟢	🟢		

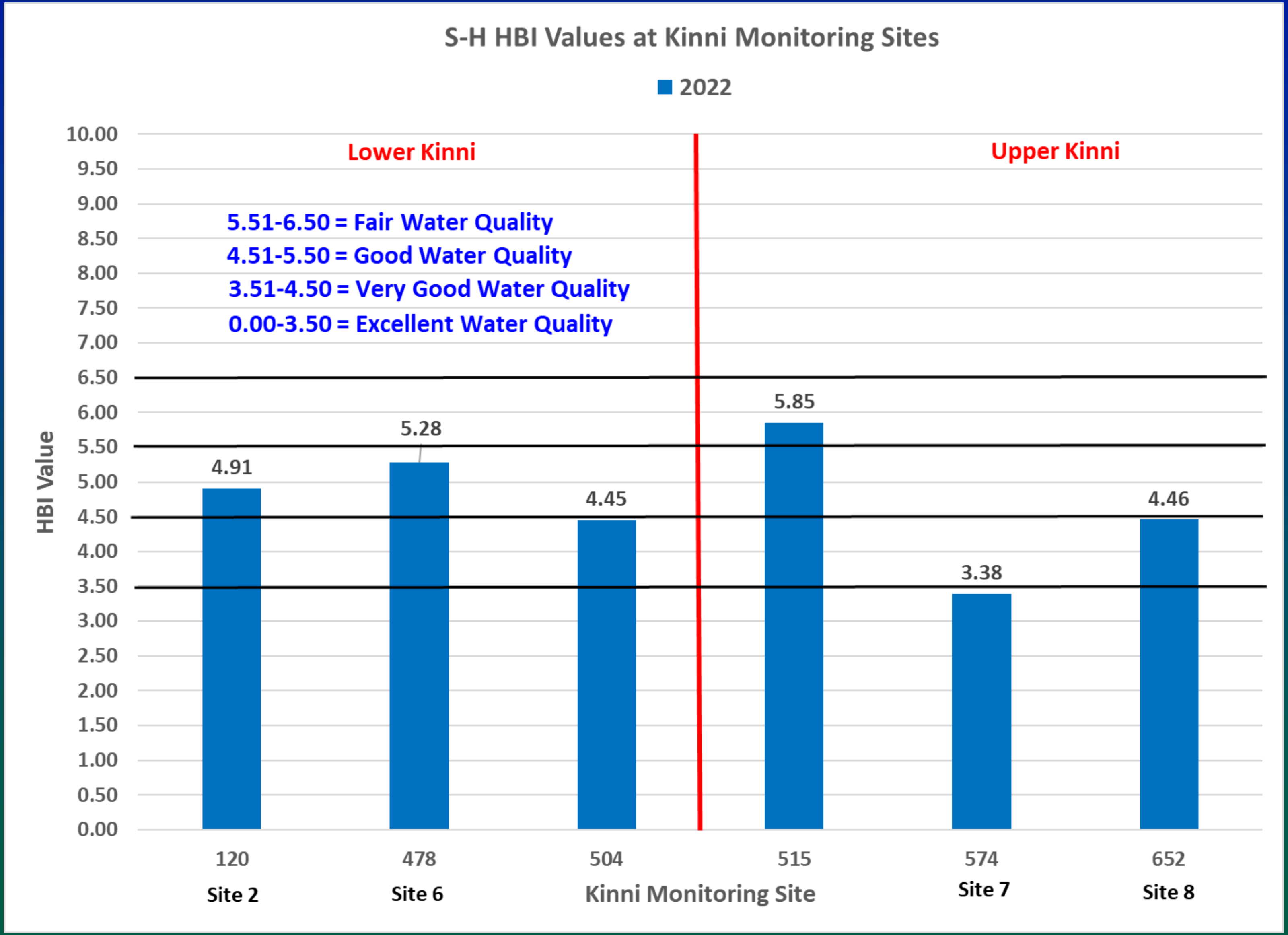
In 2022, species richness values were consistent across the Upper and Lower Kinni monitoring sites, excepting the new Lake Louise channel.



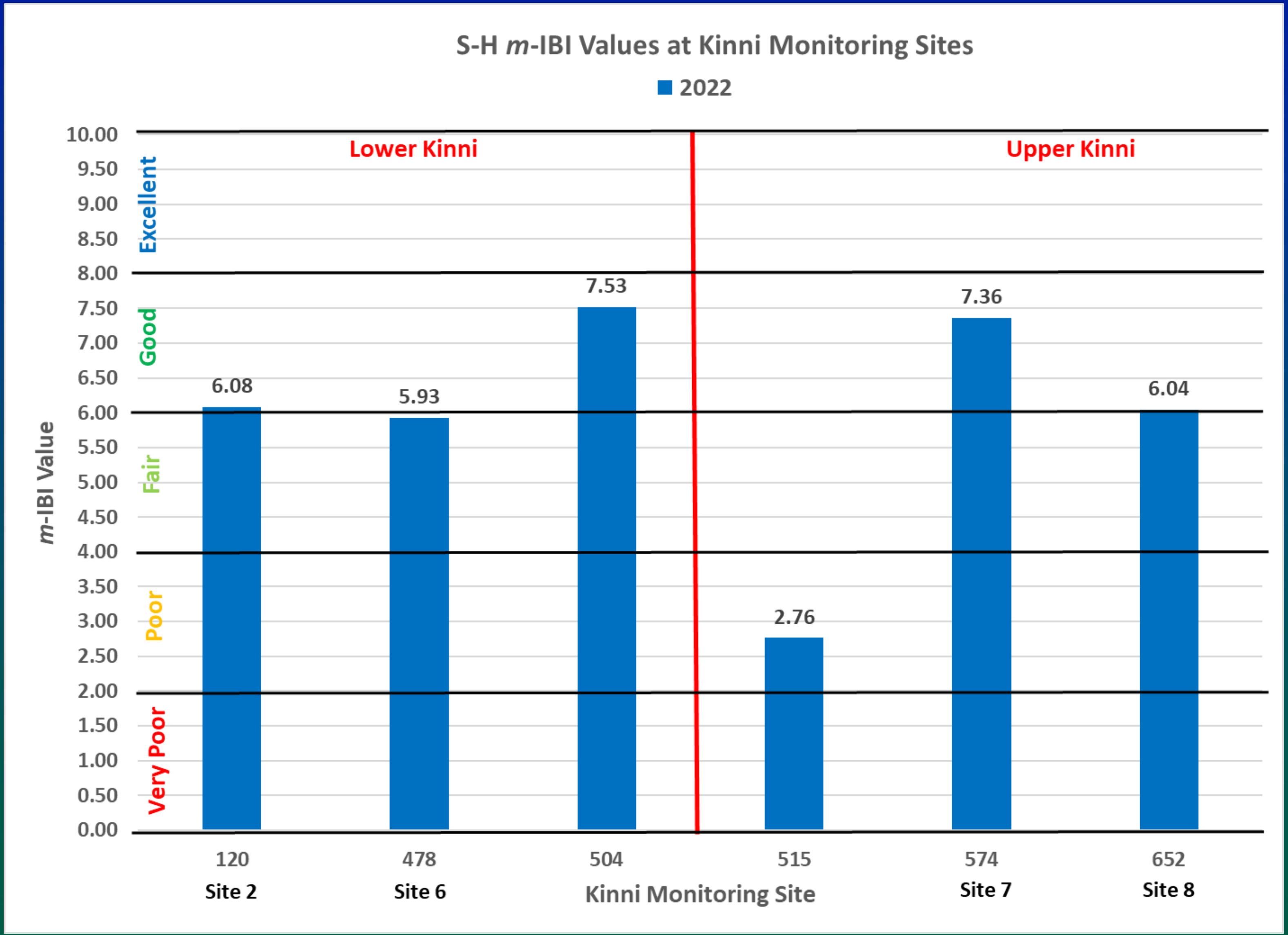
Number of EPT species is useful for comparing monitoring sites. Values are generally consistent across five of the Upper and Lower Kinni sites.



The HBI metric evaluates water quality, based on the degree of organic pollution and decreased O_2 levels. Five Kinni sites are Excellent, Very Good, and Good. The site in the new Lake Louise channel is Fair.



The *m*-IBI metric integrates the effects of multiple (9) key stressors on macroinvertebrates. In 2022, *m*-IBI values indicated good conditions in the Upper Kinni and fair-good conditions in the Lower Kinni..



Condition of Kinni River Macroinvertebrate Community in Lake Louise (Site 515)

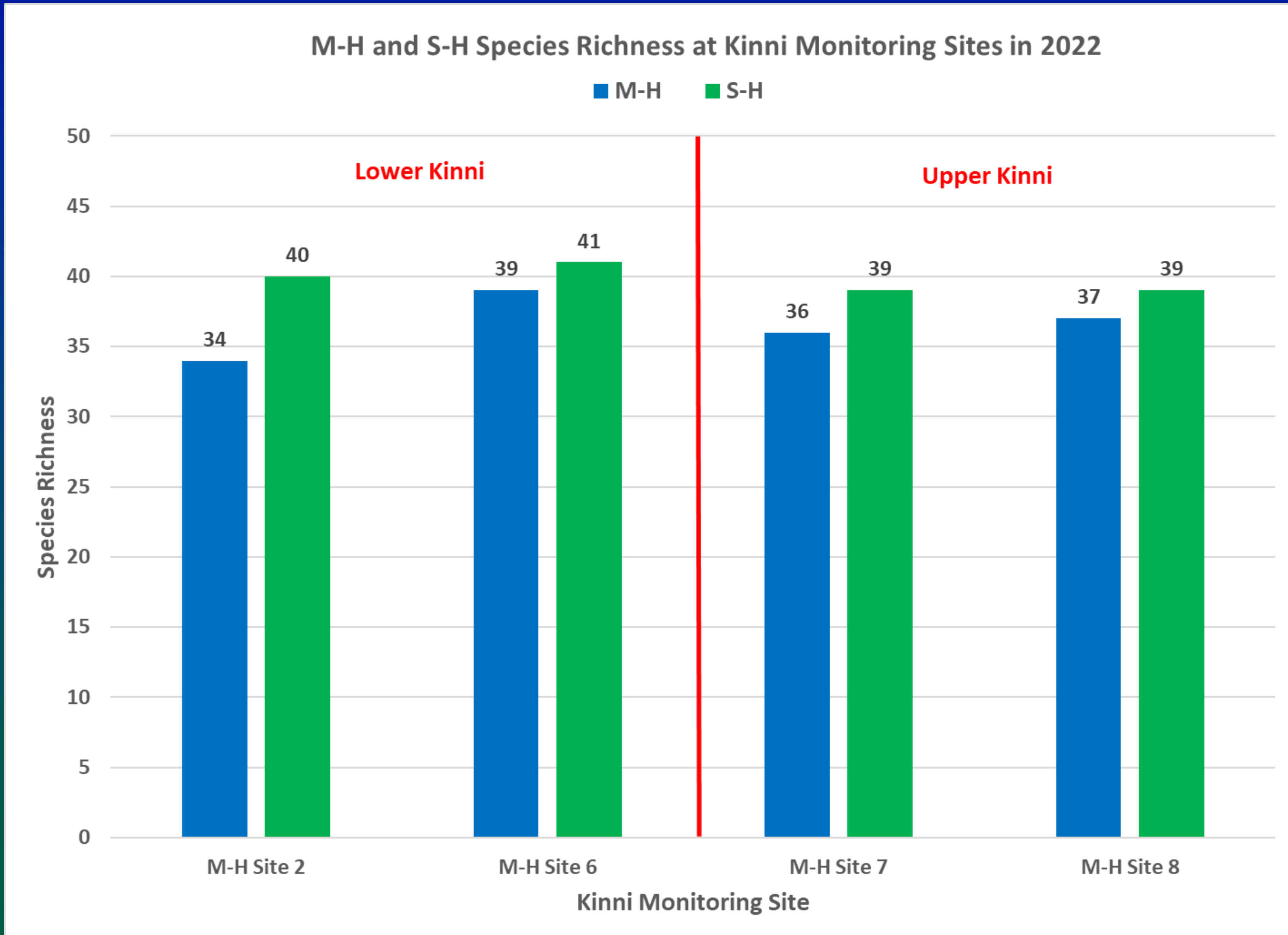
- Based on multiple metrics (species richness, # EPT species, HBI, *m*-IBI), the macroinvertebrate community in the "new" Kinni River within Lake Louise is degraded.

- Contributing factors include channel instability, fine sediment presence, and Lake George water quality problems.

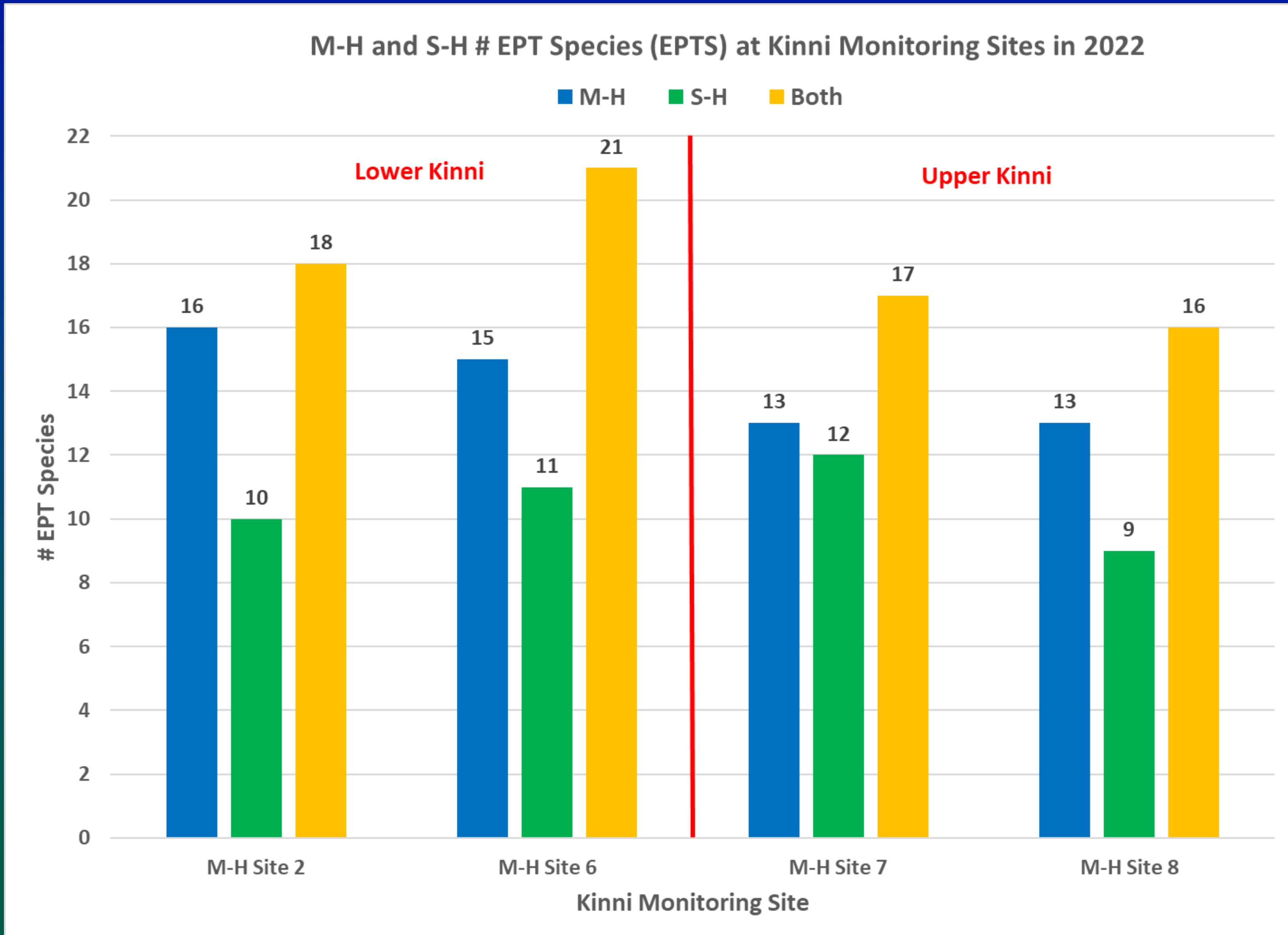
- The new Kinni will greatly benefit from river restoration after dam removal, serving as a future example of river recovery.

Site 515 in Lake Louise

Species richness values are consistently high when M-H and S-H protocols are combined for sites sampled in the Upper and Lower Kinni.

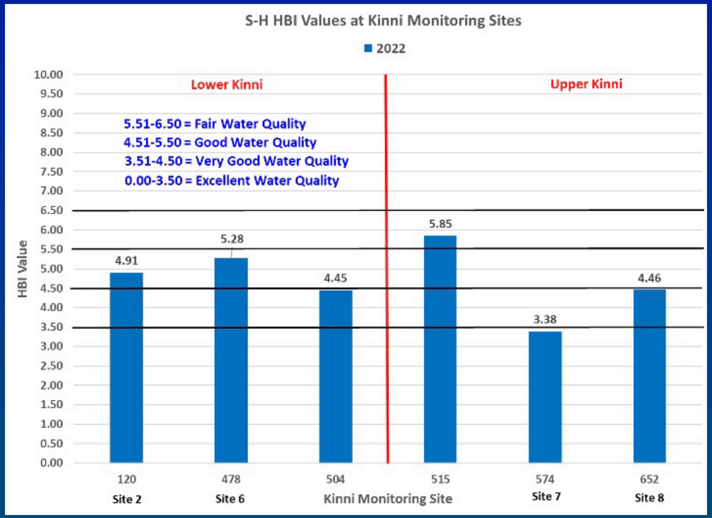


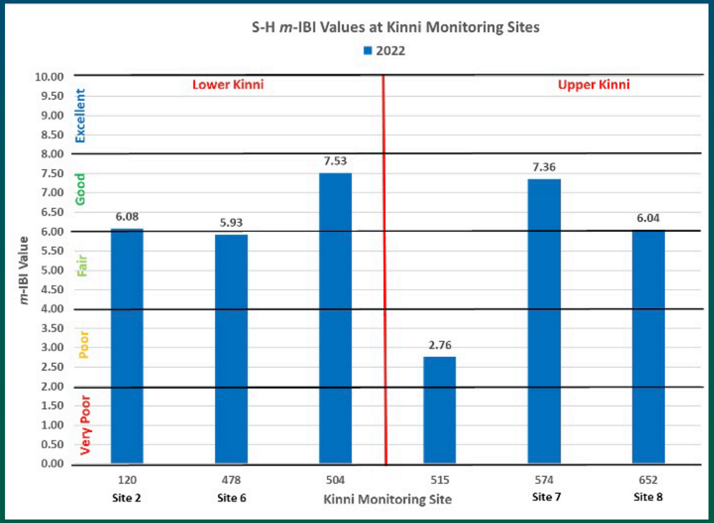
EPT species numbers are strong for both the Upper and Lower Kinni, especially when M-H and S-H protocols are employed together



Determining Health of the Kinnickinnic River Using Macroinvertebrate Monitoring, 2022, Pt I

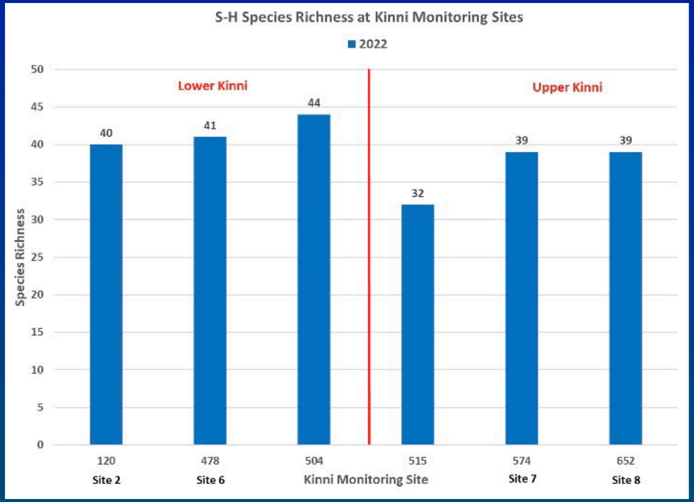
- Index calculations:
  - HBI values for five Upper and Lower Kinni sites qualify as Excellent, Very Good, and Good. The site in the new Lake Louise channel is Fair.
  - *m*-IBI values for four Upper and Lower Kinni sites are Good. One Lower Kinni site (6) is Fair, and the site in the new Lake Louise channel is Poor.

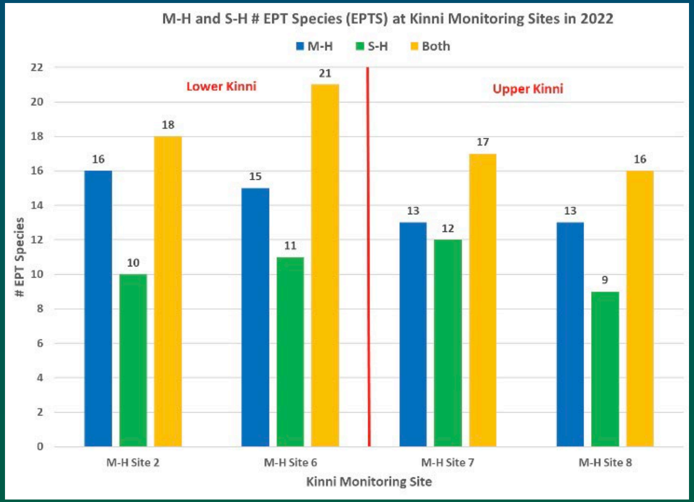




Determining Health of the Kinnickinnic River Using Macroinvertebrate Monitoring, 2022, Pt II

- Community descriptors:
  - Species richness values are high and consistent at Upper and Lower Kinni sites, except in the new Lake Louise channel.
  - EPT species numbers are strong at Upper and Lower Kinni sites, especially when Multi-Habitat and Single-Habitat protocols are employed together.





Determining Health of the Kinnickinnic River Using Macroinvertebrate Monitoring, 2022, Pt III

- Number of macroinvertebrate species documented in the Kinnickinnic River (2002 and 2022, M-H+S-H) = 80+

- Species abundance analyses indicate a relatively even abundance pattern, with few numerically dominant species.

- Number of orders per site averaged 8 in 2002 and 7 in 2022. All sampled sites support orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), Coleoptera (beetles), Diptera (flies, midges), and Amphipoda (scuds). Less consistently present are Odonata (damselflies) and Isopoda (aquatic sowbugs).

- Number of families per site averaged 16 families in 2002 and 14 families in 2022 (2002 & 2022 not statistically different) (all M-H data)

Determining Health of the Kinnickinnic River Using Macroinvertebrate Monitoring, 2022, Pt III *(continued)*

- River samples analyzed as of 2022 show, with few exceptions, consistently high macroinvertebrate richness values. Richness is the foundation of community diversity and complexity.

- Kinnickinnic caddisfly species richness is 26, approaching the caddisfly richness number (average 30 species) that Houghton and DeWalt (2023) reported for "Least disturbed streams . . ." in the northcentral US.

- Re-collection data show consistency of EPT (mayflies, stoneflies, caddisflies) fauna from 2002 to 2022.

- HBI values acquired at 6 sites in 2022 indicate that Kinnickinnic River water quality is Excellent (1), Very Good (2), Good (2), and Fair (1).

- *m*-IBI values acquired at 6 sites in 2022 indicate that Kinnickinnic River health is Good (4), Fair (1) and Poor (1).

Macroinvertebrate Monitoring in 2024-2025

WDNR Site

2024:

Site 3

Site 5

Site 9

Site 11

2025:

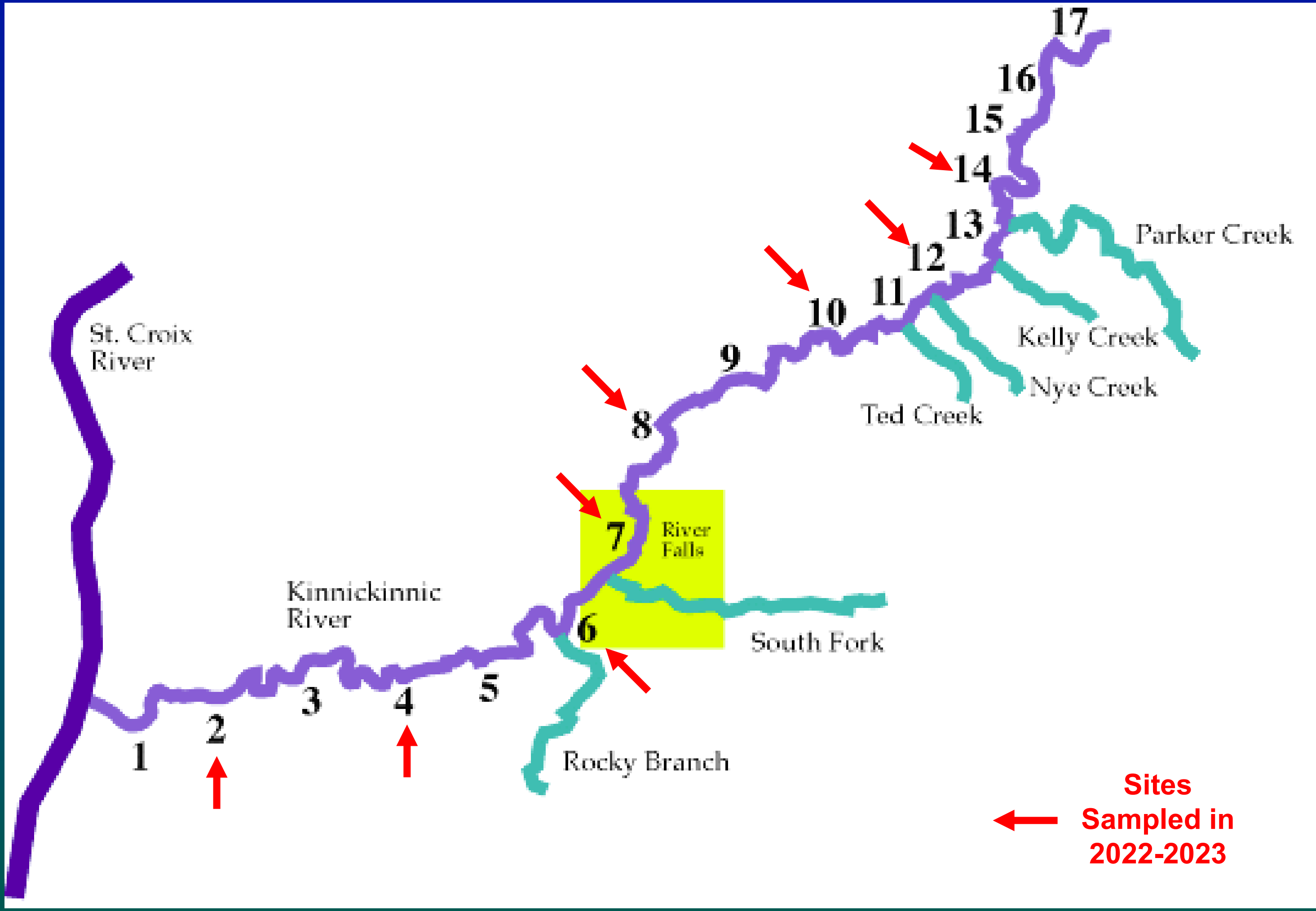
Site 1

Site 13

Site 15

Site 16

Site 17



Both M-H and S-H samples will be collected at all sites

The 2002 M-H samples collected at all of these sites by Garry will also be analyzed

Acknowledgments

Funding:
- Kiap-TU-Wish
- Kinnickinnic Corridor Collaborative (KinniCC)

Volunteers:
- KinniCC Stream Team (Reid Dawald, Amber Rappl, Tovah Flygare)
- Sean Morrison (Inter-Fluve)
- Dr. John Wheeler and Dr. Charlie Rader (UW-River Falls)
- John Kaplan (Kiap-TU-Wish)

Sample Analysis:
- Jeffrey Dimick and Staff (Aquatic Biomonitoring Laboratory at UW-Stevens Point)

Kent Johnson (L) and Reid Dawald (R) at S-H Site 515 in the former Lake Louise (2022 photo by John Wheeler)

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April 2, 2024

Presentation Breakdown

Kent: Slides 1, 6, 7, 8, 9, 12, 13, 14, 15, 16, 25, 26, 27, 28, 29, 32, 34, 36, 37, 38

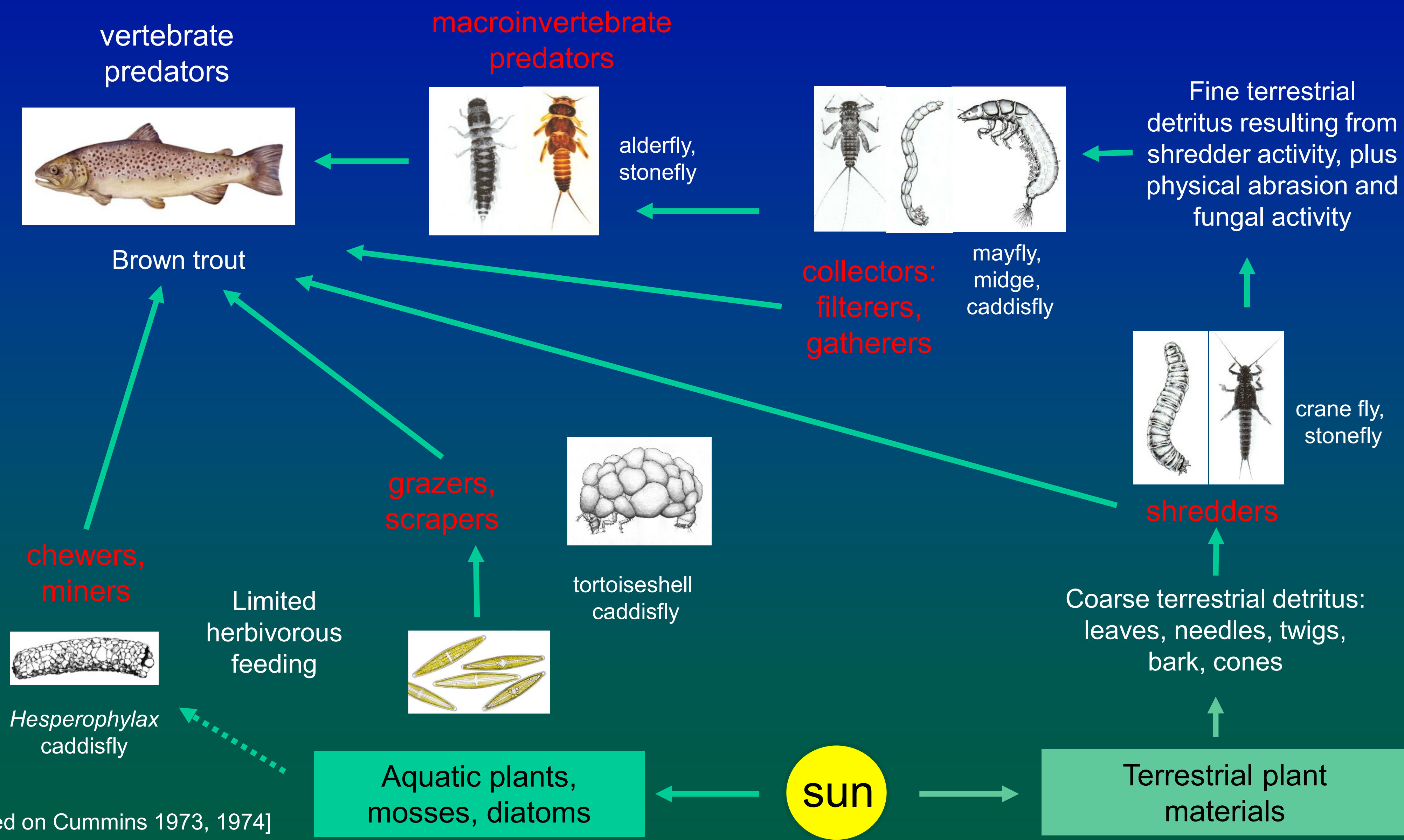
Clarke: Slides 2, 3, 4, 5, 10, 11, 17, 18, 19, 20, 21, 22, 23, 24, 30, 31, 33, 35

Reserve slides follow. Save for reference.

Edited from v4_32, _33 – save for possible use

- The Kinni data set will improve in strength, and temporal/spatial patterns may become more apparent with additional samples at sites throughout the river.
- How do the 2002 results compare to the 2022 results?
- Overall statement about Kinni health (limited data so far)?
- Distribution of Functional Feeding Groups . . . save for written report

Macroinvertebrates play vital roles in transferring energy and nutrients through the stream ecosystem



[based on Cummins 1973, 1974]

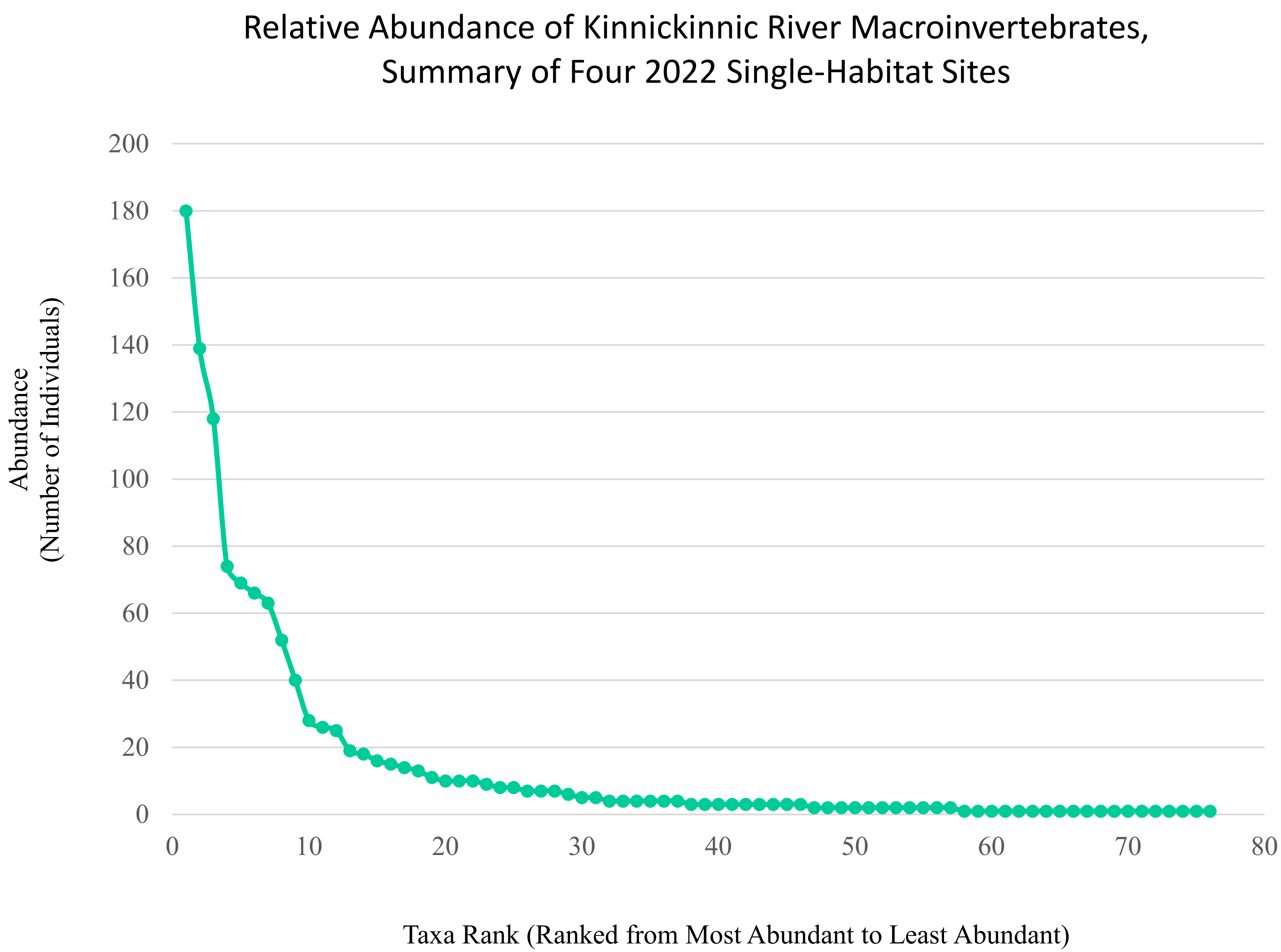
International Scientists Formulate a Roadmap for Insect Conservation and Recovery

- Immediate action
  - Increase landscape heterogeneity in agriculture
  - Reduce light, water, and noise pollution
  - Phase out pesticide use and replace with ecological measures
  - Reduce imports of ecologically harmful products
  - Avoid and mitigate alien species introductions
  - Conservation of threatened species
  - Enhance restoration and conservation programs
  - Education for awareness, citizen science, and capacity building

- Mid-term action
  - New research
  - Existing data

- Long-term action
  - Partnerships
  - Global monitoring programs

Source: Harvey et al. 2020 *Nature Ecology & Evolution*


Relative Abundance of Kinnickinnic River Macroinvertebrates,
Summary of Four 2022 Single-Habitat Sites
200
180
160
140
120
100
80
60
40
20
0
Abundance
(Number of Individuals)
0
10
20
30
40
50
60
70
80
Taxa Rank (Ranked from Most Abundant to Least Abundant)

Much larger declines (52% of butterflies, 99% of monarchs, 70% of flying insect biomass) have been reported in distinct populations (referenced in Forister et al. 2019).

- 52% of butterfly species have declined in abundance at monitored sites
    - UK
    - 10-year trends
    - Fox *et al*. 2015 *The State of the UK's Butterflies 2015*

- 99% of monarchs - declined
    - Pacific Coast overwintering population
    - comparing to 1980's
    - Pelton *et al*. 2019 *Frontiers in Ecology and Evolution* https://doi.org/10.3389/fevo.2019.00258

- 70% of flying insect biomass in protected areas- decreased
    - Germany
    - decline over 27 years
    - Hallman *et al*. 2017 *PLoS One, 12,* e0185809