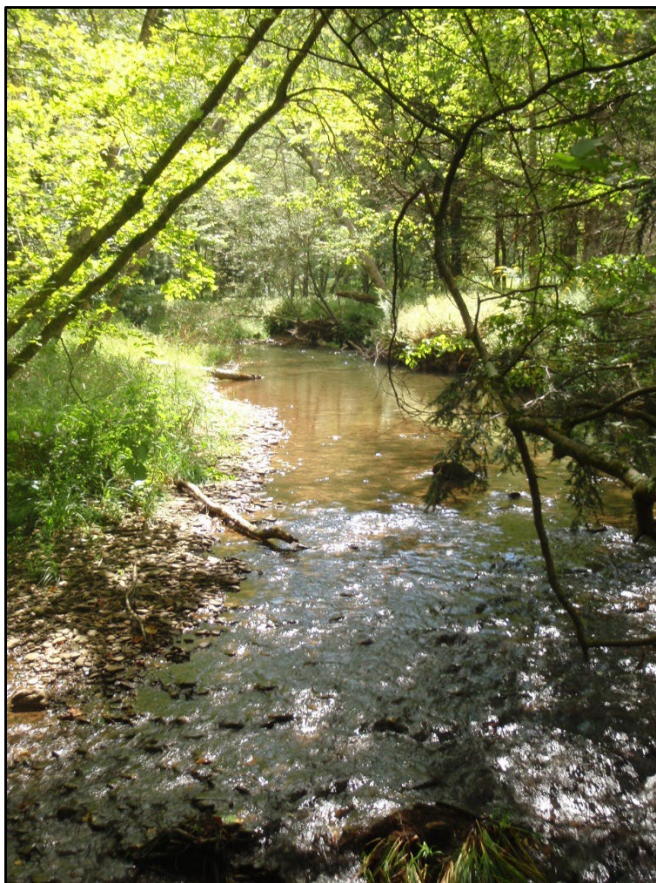


Technical Summary of Biological and Water Quality Data at SRBC Continuous Monitoring Stations within PADCNR State Forest Lands

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OVERVIEW

A series of biological and water chemistry assessments were completed for stream sites that are part of the Susquehanna River Basin Commission's (Commission's) Continuous Instream Monitoring (CIM) program and also located on, or draining predominantly to, Pennsylvania state forest lands managed by the Pennsylvania Department of Conservation and Natural Resources (PADCNR). Macroinvertebrate communities were assessed using the Pennsylvania Department of Environmental Protection (PADEP) Freestone Wadeable Stream Macroinvertebrate Index of Biotic Integrity (IBI) (PADEP, 2013) while fish communities were evaluated using the PADEP Thermal Fish Index (TFI) (Wertz, 2021). Water chemistry was assessed using the Commission's Water Quality Index (WQI) (Berry et al., 2020).

These sites included 15 currently active sites and 6 historic sites that were moved or discontinued for a variety of reasons (Tables 1 and 2). Analysis will only focus on the current sites for this technical summary.

Table 1. Active CIM Sites on PADCNR Land

Waterbody (year installed)	Status	Designation	% Forest	Drainage Area (mi²)
Babb Creek (2024)	Current	CWF	72.5	16.24
Baker Run (2011)	Current	HQ-CWF	94.84	35.21
East Fork First Fork Sinnemahoning (2011)	Current	EV/HQ CWF	94.77	29.99
Grays Run (2011)	Current	HQ-CWF	94.11	19.67
Hicks Run (2011)	Current	EV/HQ CWF	92.61	34.13
Hunts Run (2012)	Current	HQ-CWF	94.01	30.69
Lebo Run (2024)	Current	EV	94.81	10.86
Little Bear Creek (2024)	Current	HQ-CWF	96.41	8.53
Mill Creek (2024)	Current	HQ-CWF	92.75	7.2
Moose Creek (2011)	Current	HQ-CWF	90.15	3.32
Pine Creek Headwaters (2022)	Current	HQ-CWF	84.28	35
Pleasant Stream (2013)	Current	HQ-CWF	88.12	20.45
Sterling Run (2014)	Current	CWF	88.67	24.54
West Branch Pine Creek (2010)	Current	HQ-CWF	92.63	70.24
Young Womans Creek (2012)	Current	EV	95.28	40.95

Table 2. Historic CIM Sites on PADCNR Lands

Waterbody (years active)	Status	Designation	% Forest	Drainage Area (mi²)
Kettle Creek (2012-2019)	Historic	EV	87.48	81.25
Little Pine Creek (2011-2024)	Historic	CWF	82.3	180.3
Marsh Creek (2011-2024)	Historic	CWF	71.88	78.26
Ninemile Run (2011-2022)	Historic	HQ-CWF	88	16.24
Pine Creek (2011-2022)	Historic	HQ-CWF	84.05	389.79
Upper Pine Creek (2011-2022)	Historic	HQ-CWF	81.04	18.72

Water Quality Index Results

Water quality conditions were additionally evaluated using the Susquehanna River Basin Water Quality Index (WQI), which summarizes multiple water quality parameters into a composite score ranging from 0 to 100, with higher scores representing better overall water quality conditions. There are three categories within the WQI that represent the most common water quality sources of impairment in the basin: metals (representative of abandoned mine drainage), nutrients (representative of agriculture), and development.

Across the monitored state forest stream sites, WQI values were generally high, with most sites consistently scoring within the upper portion of the index scale. These results indicate that the assessed watersheds maintain good to excellent overall water quality conditions.

Site-specific comparisons showed that many streams maintained median WQI values in the 80–95 range, supporting the conclusion that these predominantly forested watersheds continue to provide high-quality aquatic habitat conditions (Figure 1). Moose Creek is heavily impacted by road salt runoff from Interstate 80, and chloride seems to persist throughout the year, which is primarily what brings the WQI score down.

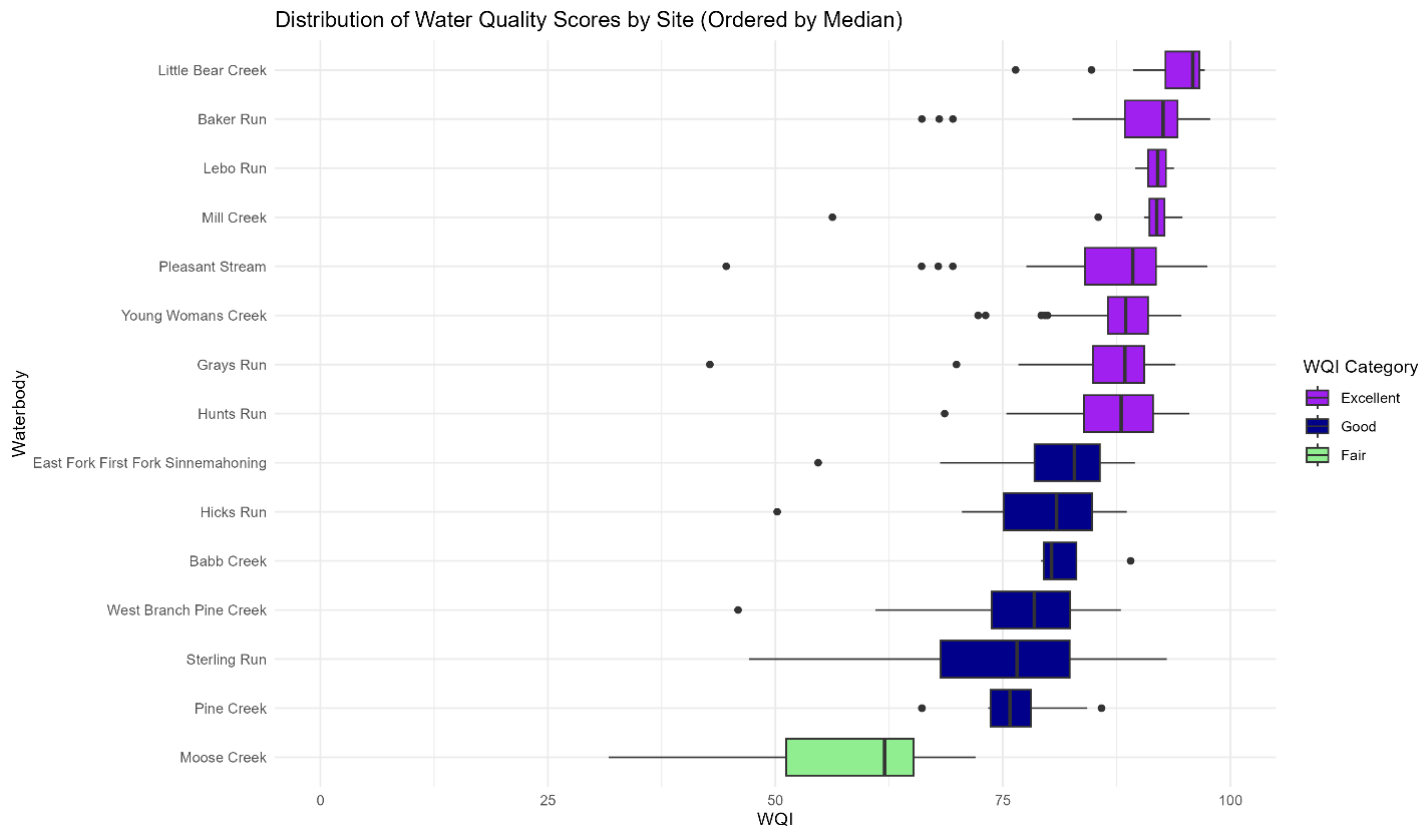


Figure 1. Water Quality Index Score at PADCNR Sites Ordered by Median Value

Seasonal Water Quality Patterns

Seasonal WQI boxplots indicated generally high water quality across all seasons and sites. Most streams maintained WQI values within favorable ranges throughout the year, although some sites exhibited increased variability during summer conditions (Figure 2).

Several streams demonstrated slightly reduced WQI values during summer sampling periods, potentially reflecting seasonal thermal stress, lower baseflows, or episodic water quality fluctuations. However, the overall seasonal patterns suggest that water quality remains consistently strong across the monitored PADCNR watersheds.

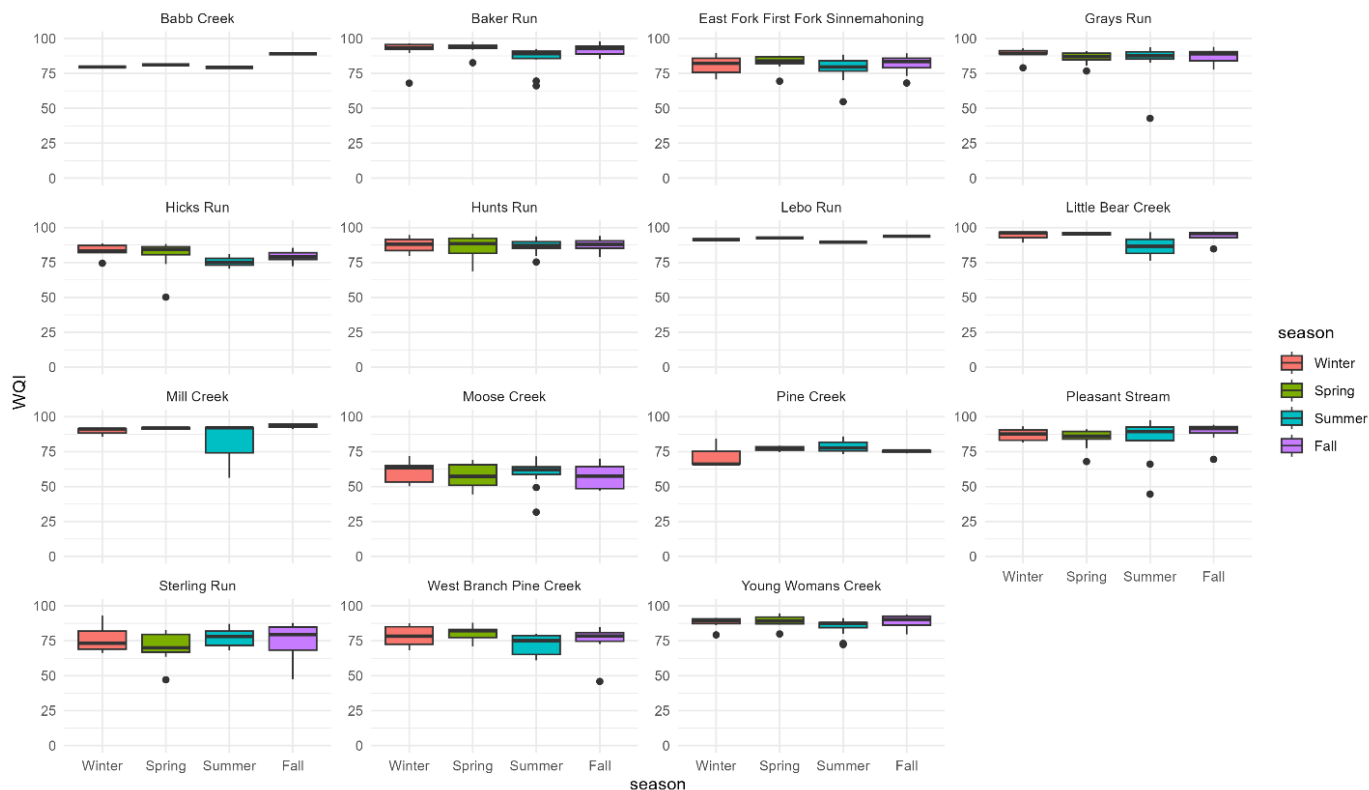


Figure 2. Seasonal WQI Scores Across All Current PADCNR Sites

Macroinvertebrate IBI Conditions

Macroinvertebrates were collected routinely at each sampling station, more frequently in the years directly after installation of the monitoring equipment, and less frequently once 10 years of annual data were achieved. Index of Biological Integrity (IBI) can score from 0-100, with a score above 53 as a representative threshold for attaining an aquatic life use. Generally, sites scoring over 78 can be considered good quality. Very few samples were below this threshold, and none were below 53.

The macroinvertebrate IBI results demonstrate that most assessed sites consistently score well above impairment thresholds, indicating strong benthic community integrity across the monitored watersheds.

Figures summarizing IBI distributions by site show that nearly all current monitoring locations exhibit median IBI scores in the upper 70s to low 90s range. Several sites, including Young Womans Creek, West Branch Pine Creek, Baker Run, and Grays Run, exhibited particularly strong biological performance with consistently elevated IBI values. In contrast, a small number of sites displayed greater variability or somewhat lower median scores, though still generally within non-impaired ranges (Figure 3).

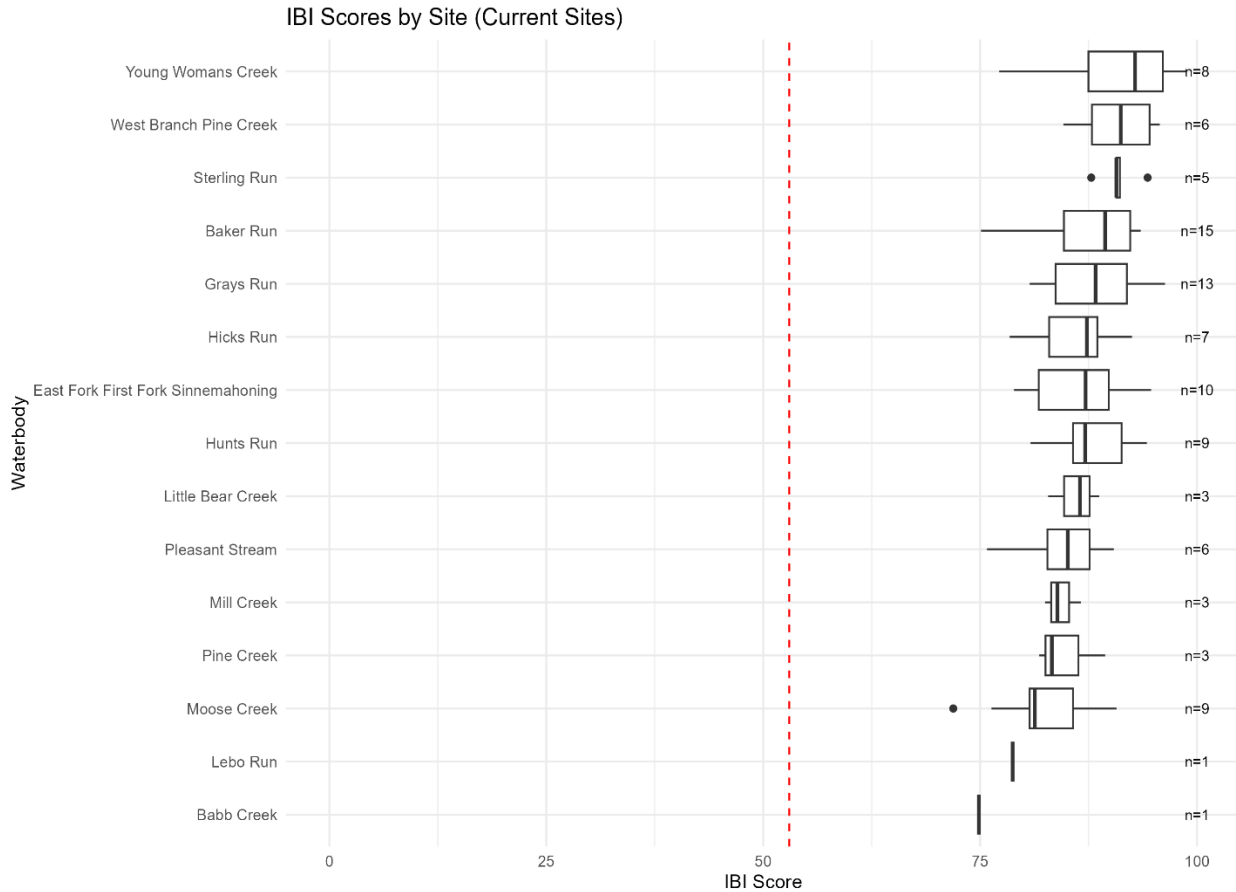


Figure 3. Box Plot of IBI Scores for PADCNR Sites (shown from lowest to highest median score and including total number of samples collected)

The site-level IBI boxplots also suggest relatively stable biological condition over time, with limited evidence of chronic degradation trends. Variability observed at some locations may reflect seasonal influences, hydrologic variability, or localized disturbances rather than persistent problems.

A comparison of IBI scores across stream designation categories indicates that streams classified as Exceptional Value (EV) and High-Quality Cold Water Fisheries (HQ-CWF) generally supported the highest biological condition scores. However, high IBI performance was observed across multiple designation classes, reinforcing the overall high-quality nature of these predominantly forested systems.

Thermal Fish Index (TFI) Patterns

TFI scores fish communities based on a thermal tolerance value which are also typically representative of other stressors besides temperature. Each site is scored on a 2-10 scale based on its fish community composition, with the coldest streams scoring closest to 2 and the warmest

streams at a 10. Results similarly indicate generally favorable thermal conditions across the monitored stream network. Most sites exhibited TFI scores characteristic of coldwater or coolwater thermal assemblages (Figure 4).

Site-specific TFI boxplots indicated that Grays Run and East Fork First Fork Sinnemahoning generally supported lower TFI scores, suggesting colder thermal regimes and fish assemblages more strongly associated with coldwater conditions. In contrast, Baker Run and several larger systems exhibited somewhat higher TFI values, indicating relatively warmer thermal assemblages, though still generally within ranges consistent with high-quality forested stream systems.

Several smaller tributary systems like Moose Creek (comprised of only brook trout) and Lebo Run (which has brook and brown trout, sculpins, and blacknose dace) have TFI scores near 2.

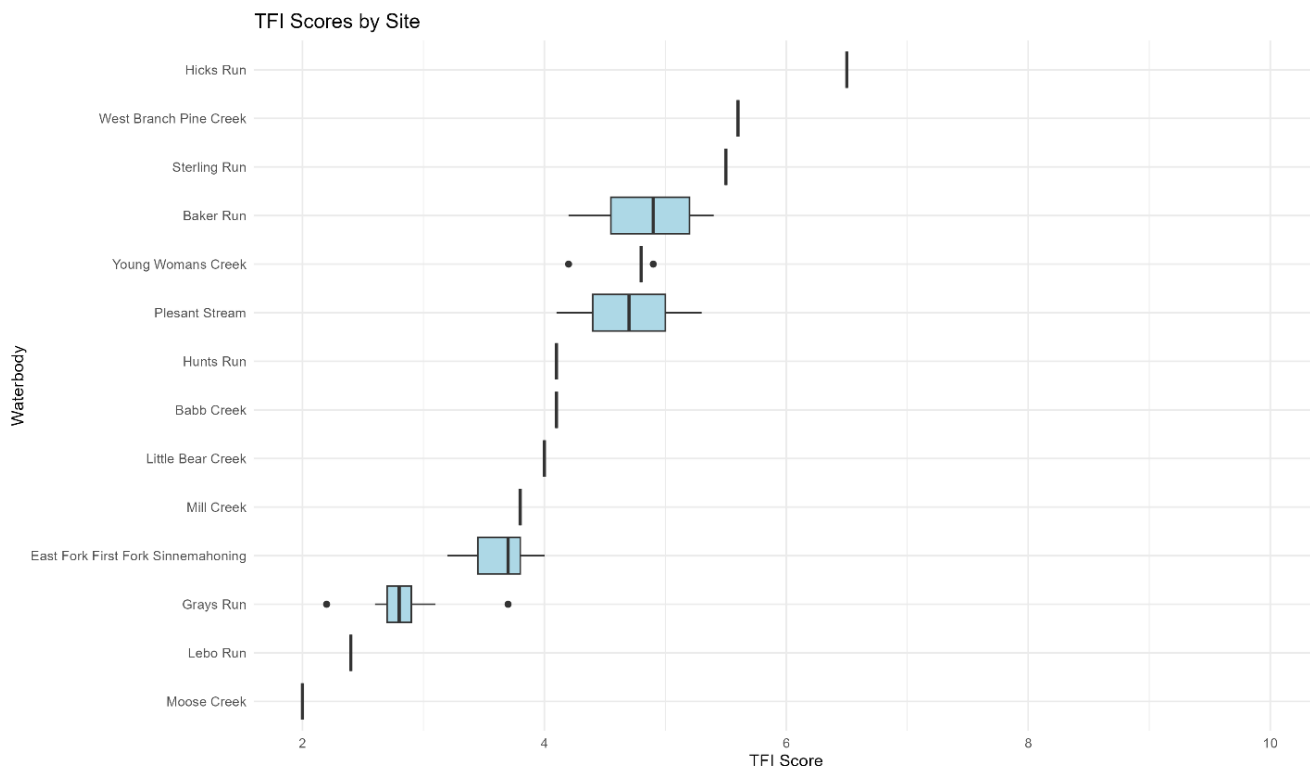


Figure 4. *Box Plot of TFI Scores at All PADCNR Sites (scale is 2-10, with 2 being all cold water communities and 10 being the warmest fish assemblages)*

Thermal Fish Index (TFI) Patterns

Temporal trend analyses for sites with four or more sampling events showed relatively stable thermal conditions over time. Baker Run displayed a slight upward trend in TFI scores during the monitoring period, potentially indicating modest warming or shifts toward relatively warmer fish assemblages. Young Womans Creek remained comparatively stable with a slight shift

in more cold water fish in later years, while Grays Run and East Fork First Fork Sinnemahoning exhibited limited interannual variability (Figure 5).

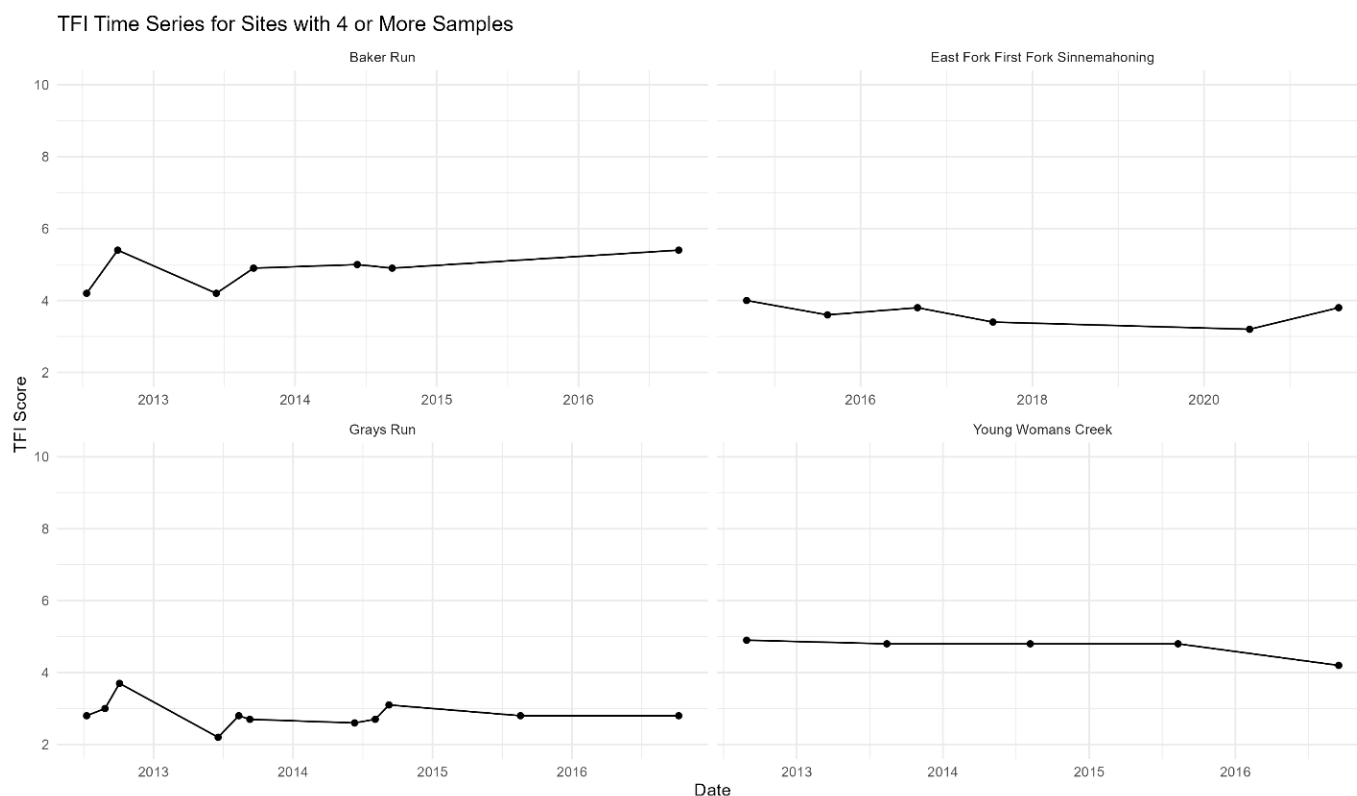


Figure 5. Time Series of TFI Scores at Sites with Four or More Fish Samples

Relationships between TFI and other watershed metrics should therefore be interpreted accordingly. Positive relationships between TFI and drainage area or IBI may partially reflect the tendency for larger stream systems to naturally support somewhat warmer, yet still healthy, fish assemblages relative to smaller high-elevation headwater streams. Despite variability among sites, the TFI results collectively suggest the majority of monitored state forest watersheds continue to maintain thermally suitable habitat conditions for coldwater and transitional coolwater aquatic communities.

Impact of Forest Cover on Stream Health

A positive relationship was observed between percent forest cover and mean IBI score. Watersheds with greater forest cover generally supported higher macroinvertebrate integrity scores, reinforcing the importance of intact forested landscapes in maintaining stream biological condition (Figure 6). Although some scatter was present in the relationship, the overall trend suggests that increasing watershed forest cover is associated with improved aquatic biological health.

A similar positive trend was observed between watershed forest cover and mean WQI scores. Streams draining highly forested watersheds generally exhibited higher WQI scores, indicating consistently good overall water quality conditions in more intact forested systems.

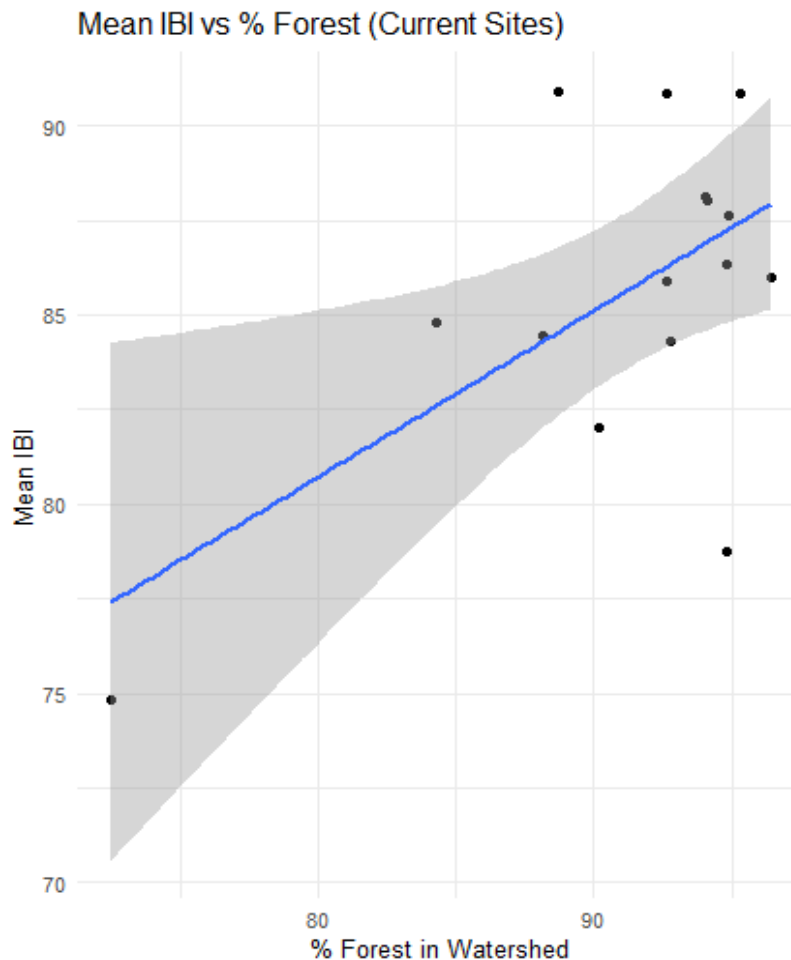


Figure 6. Mean IBI Score and % Forested Land Use in the Upstream Drainage Area

IBI AND TFI RELATIONSHIPS

Relationship Between IBI and TFI

Relationships between mean macroinvertebrate IBI and mean Thermal Fish Index (TFI) scores demonstrated a moderate positive association across monitored sites. However, because lower TFI scores represent colder-water fish assemblages and higher scores indicate warmer assemblages, this relationship should not be interpreted as evidence that warmer conditions necessarily improve stream quality.

Instead, the observed pattern likely reflects natural longitudinal differences among stream systems. Smaller headwater streams often supported colder thermal assemblages characterized by lower TFI scores, while somewhat larger downstream systems exhibited slightly warmer fish assemblages and, in many cases, similarly strong or higher macroinvertebrate IBI scores.

Importantly, high macroinvertebrate integrity was observed across a broad range of TFI values, indicating that both colder headwater systems and moderately warmer downstream forested streams supported healthy aquatic communities. The positive relationship between IBI and TFI may therefore reflect natural stream size, drainage area, habitat complexity, and fish assemblage transitions rather than thermal degradation. This interpretation is further supported by the generally high watershed forest cover and consistently favorable WQI scores observed across sites.

Overall, the results suggest that the monitored PADCNr watersheds support biologically healthy stream systems across a range of naturally occurring thermal conditions, from cold headwater environments to somewhat warmer downstream reaches.

CONCLUSIONS

Taken together with the macroinvertebrate IBI and Thermal Fish Index results, the WQI findings provide additional evidence that Pennsylvania state forest watersheds managed by PADCNr support high-quality aquatic ecosystems with strong biological, thermal, and chemical integrity.

Key findings include:

- Most stream sites exhibit consistently high macroinvertebrate IBI scores.
- Thermal Fish Index scores indicate generally stable and suitable coldwater thermal conditions.
- Watersheds with greater forest cover tend to support higher biological integrity and water quality.
- Smaller streams predictably have more coldwater taxa.
- Temporal analyses show relatively stable conditions at long-term monitoring sites with limited evidence of widespread degradation.

Overall, the results reinforce the importance of large, intact forested watersheds managed by PADCNr in sustaining high-quality aquatic ecosystems within Pennsylvania's freestone stream systems.

REFERENCES

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