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HISTORY SURVEY
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Assessing Vulnerability of Coolwater Habitats in Illinois Wadeable Streams: Final Summary Report (T-83-R-1)

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Final Summary Report

Project Title:
Assessing Vulnerability of Coolwater Habitats in Illinois Wadeable Streams.

Project Number: T-83-R-001

Contractor information:

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Goals/ Objectives: (**1)** Identify coolwater habitats and associated fish species on Illinois' wadeable streams; (**2)** Characterize thermal and flow regimes under current conditions and scenarios describing landcover and climate change; (**3)** Assess vulnerability (sensitivity and exposure) of thermal and flow regimes to landcover and climate changes for coolwater reaches; (**4)** Examine potential changes in fish species distributions and connectivity of their associated habitats; (**5)** provide annual and final reports that include an assessment of vulnerability to alterations in landcover and climate projected to occur in Illinois.

Project Title: Assessing Vulnerability of Coolwater Habitats in Illinois Wadeable Streams.

Narrative:

Coolwater stream habitats are uncommon in Illinois and they support rare ecological assemblages and several species of conservation concern. These streams maintain relatively narrow thermal habitats for a broad array of fish and invertebrate species such that even small changes in temperature can shift thermal regimes to the point where these species are impacted. Coolwater habitats were identified using observed temperatures meeting a previously derived temperature thresholds (mean daily July temperature < 22 °C [coolwater] - 24 °C [transitional]) and known locations of fish species associated with stream reaches that maintain these conditions in Illinois (Brook Stickleback, Longnose Dace, Mottled Sculpin). To assess the vulnerability of these coolwater habitats we monitored stream temperature at 31 sites in northern Illinois as well as additional 28 sites in other parts of the state. Future work with these data will include improving statewide stream temperature and fish distribution models. These models will be used to further assess the vulnerability (exposure and sensitivity) of coolwater habitats to changes in landcover and climate by examining a range of potential conditions. Initial efforts during this project focused on exposure of coolwater reaches to potential climate and landcover change. Future analysis will examine how the thermal character of coolwater reaches is influenced by geologic, climatic and landcover conditions. We plan to continue to examine potential changes in fish species distributions and the functional isolation of coolwater habitats associated with landcover and climate change scenarios.

We worked with IDNR staff to maintain an integrated geodatabase containing stream reach attributes and biological collections information. Summaries of landuse/landcover, surficial geology, and other GIS derived attributes for upgraded linework are available for use statewide. Ongoing efforts to consolidate and improve GIS data with IDNR staff necessitated that we allocated a significant portion of our available staff resources to these efforts rather than other parts of this project. This resulted in some objectives of the project to be less comprehensively addressed than we originally planned.

Job 1: Identify coolwater habitats (reaches) on wadeable streams in Illinois and their associated fish species in greatest need of conservation.

We compiled existing water temperature records from over 300 sites statewide and classified each record based on the mean daily temperature (MDJT) from the month of July (Figure 1). Sites with MDJT below 22 °C were considered coolwater and were further characterized in subsequent Jobs (Hinz et al. 2011). Some characterization of stream reaches with transitional water temperatures (MDJT 22-24 °C) was also conducted. Georeferenced locations of key coolwater fish species identified in our previous project (Hinz et al. 2011) were also reviewed statewide based on available information (Metzke et al. 2012).

Based on these reviews we selected stream reaches with known locations of four fish species (Brook Stickleback, Longnose Dace, Mottled Sculpin, American Brook Lamprey) associated with coolwater temperatures in Illinois streams (Hinz et al. 2011) to be the focus of collecting additional information and to constrain the vulnerability analysis (Figure 2). The majority of these sites were visited during the project and additional field based data were collected (see Job 2).

This job was completed by identifying coolwater habitats using existing resources as well as additional surveys undertaken during this project. Although existing water temperature records from hundreds of deployments were reviewed, and new data were collected, only a small fraction of Illinois' stream reaches have been assessed using field data. Given the rarity and disconnected nature of coolwater stream reaches in Illinois it is likely that additional reaches, particularly in headwater areas, have not been identified at this time.

Job 2: Characterize thermal and flow regimes of identified coolwater reaches under current conditions and several scenarios describing changes to landcover and climate.

This job was partially completed during the project period. Reaches were characterized using previously developed models and through field surveys. GIS data were initially summarized and attributed to stream reaches at 1:100,000 scale for scenario development. Preliminary characterization scenarios were limited to looking at fixed changes in temperature rather than using watershed specific downscaled climate data during the project period.

One problem with using the 1:100,000 scale GIS data summaries is that many coolwater stream reaches are not included due to their small size. This can lead to an underestimation of the magnitude of climate or landuse induced alterations in statewide stream resources. GIS data were attributed using an updated 1:24,000 stream linework and associated watersheds but new models have yet to be applied statewide. Preliminary revised models were developed for flow exceedance frequencies and summer water temperatures that incorporated new data collected during the project period.

We reviewed available climate downscaling data associated with an ongoing Upper Midwest Great Lakes – Landscape Conservation Cooperative project (Jason Robinson, INHS). Some of these data summaries were integrated into our GIS system and attributed to our focal stream reaches. These data will be used to further assess vulnerability of coolwater stream reaches as we improve our thermal, discharge, and fish distribution models as time allows after the project period.

Instream monitors were deployed at characterization sites to record water temperature at either one hour or 15 minute intervals. Water temperature loggers were deployed at over 70 sites during the course of the project. Temperature records were summarized for each

deployment and location (Figures 3 & 4). We have compiled water temperature data from 387 sites including records from this and other projects (e.g., T-2-R-1, T-13-R-1, Kaskaskia River Assessment Project). Monitoring sites spanned a wide range of thermal conditions but most sites have maintained temperatures in the coldwater to coolwater range during the project period (Figure 5). We continue to collect water temperature data in wadeable stream reaches in across the State of Illinois.

Water level loggers were deployed in Wade Creek at Nachusa Grasslands and data collected, retrieved and summarized. Discharge measurements at logger locations have been made periodically to assist with the development of a rating curve. We continue to collect water level data from Wade Creek.

We conducted a survey on Wade Creek to document the presence of fish species within a known coolwater reach. American Brook Lamprey (Illinois Threatened Species), Brook Stickleback (Illinois coolwater obligate species, Hinz et al. 2011), Blacknose Dace (Illinois coolwater associate species, Hinz et al. 2011), Common Shiner, Creek Chub, Johnny Darter, Green Sunfish, Central Mudminnow, White Sucker, Fathead Minnow, and Central Stoneroller were all observed during this survey.

A test of the existing water temperature model (Hinz et al. 2011) was undertaken using the updated linework within the Rock River EDU (Figure 6). Some stream segments appear to be cooler using the updated linework than they were using the earlier version (Figure 7). Further characterization (i.e., modeling) of the thermal regime and flow regime of stream reaches requires the completion of upgrades to stream linework and associated summaries for the remainder of the state. We expect to continue with these efforts as time allows including revising the new water temperature model and applying it to all EDUs statewide.

Job 3: Assess the vulnerability (exposure and sensitivity) of coolwater reaches to potential landcover and climate changes based on alterations of thermal and flow regimes.

Preliminary analysis conducted focused on climate exposure with only limited work on sensitivity. For many reaches with summer temperatures near the boundary between the transitional and warm water classes exposure to climate stressors are high (Figure 8). There is little information available on annual variability of water temperatures in Illinois streams. The small number of stream reaches that have been monitored for multiple years suggest that annual variability is great enough to shift conditions between thermal regime characterization classes (Figure 9). Stream reaches with mean temperatures within the transition between cold/coolwater and warmwater and high interannual variability may be particularly vulnerable to climatic changes. We continue to collect water temperature information from selected reaches to better characterize interannual variation. Coolwater reaches also appear to be sensitive to expected shifts in the timing and magnitude of storm flows as modeled flows are responsive to changes in the distribution of precipitation during the summer period that was modeled.

Further assessment of the vulnerability of stream reaches, particularly sensitivity, requires the completion of upgrades to stream linework and associated summaries. This work was delayed primarily due to constraints of staff availability for completion of updates to the geodatabases. We plan to continue this work in the future as stream temperature and discharge models are updated and improved.

Job 4: Examine potential changes in fish species distributions and connectivity of habitats associated with landcover and climate change scenarios.

This job was partially completed during the project period. Focal fish species were selected based on their Illinois distributions being limited to cooler water reaches. Their distributions were mapped statewide using existing and new data developed during this project. These species appear to occupy primarily locations that are already spatially isolated from each other and will likely become increasing isolated if projected changes in air temperature and precipitation are realized.

Species Distribution Models (SDMs) for 97 fish species, that have been observed at > 10 reaches statewide, were developed for wadeable streams in Illinois (Cao et al. 2016). Unfortunately, the fish species identified as coolwater indicators in Job 1 were not able to be reliably modeled due to the small number of observed locations within Illinois. However, we applied Random Forest models statewide to wadeable stream reaches (defined here as less than or equal to 18 meters wetted width at the time of sampling) for 50 of the 97 fish species. Three climate variables at the total-watershed level were found to be the most important predictors for fish species abundance (growing degree days, July minimum temperature, annual precipitation) for 43 of these species. All 50 species ranked landuse in the top 10 predictors showing its broad importance in Illinois streams. Forested and agricultural lands in the total watershed were found to be the most important. Only five species ranked urban landuse in the top 10 predictors (Cao et al. 2016).

We expect to continue field survey efforts in areas that were identified as potential coolwater reaches to support future SDMs for coolwater species.

Job 5: Prepare reports and manuscripts.

This report and two annual reports were prepared. All water temperature data, summaries, fish distribution maps have been made available to the Division of Natural Heritage, Office of Resource Conservation, Illinois Department of Natural Resources. A Technical Report that further describes the results of this work is being prepared. Work associated with this project was also presented at the Annual Meeting of the Society for Freshwater Science in 2015.

References

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Hinz Jr., L. C., B. A. Metzke, and J. M. Vandermyde. 2015. Assessing Vulnerability of Coolwater Habitats in Illinois Wadeable Streams: Annual Report 2015. Prepared for Illinois Department of Natural Resources, State Wildlife Grant Program. Illinois Natural History Survey Technical Report 2015(46).

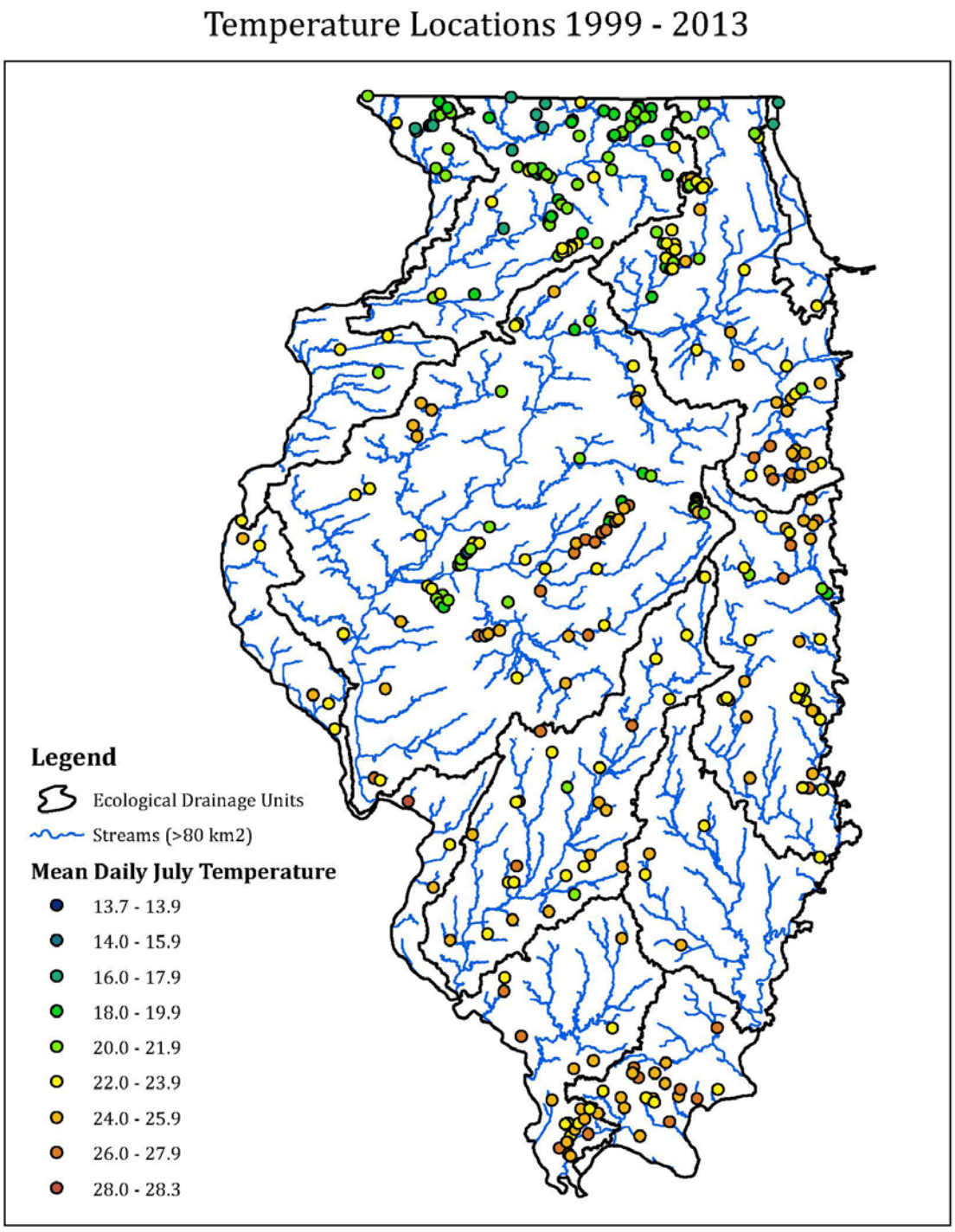

Figure 1. Sites selected to characterize for vulnerability to climate and landuse change based on previously collected water temperature data.

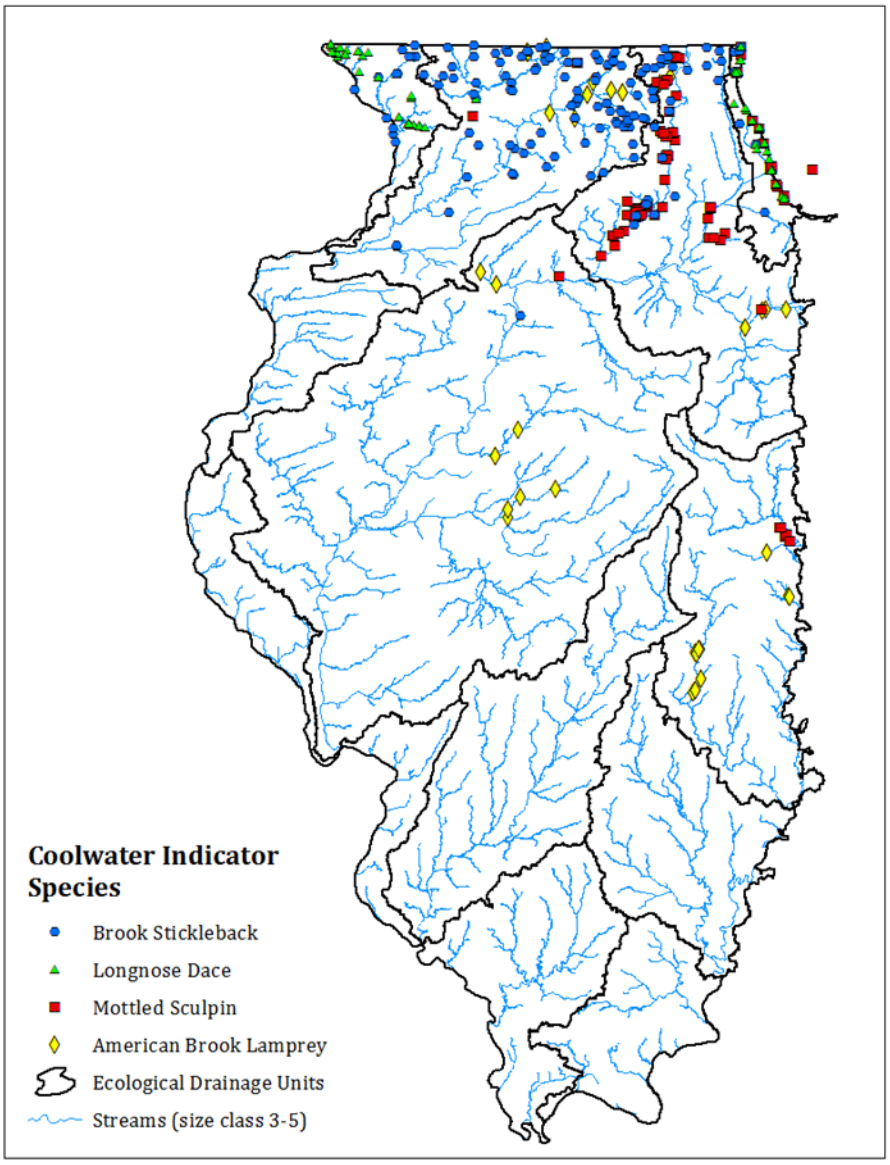

Figure 2. Locations of fish species associated with Coolwaters in Illinois used to assist with characterization site identification.

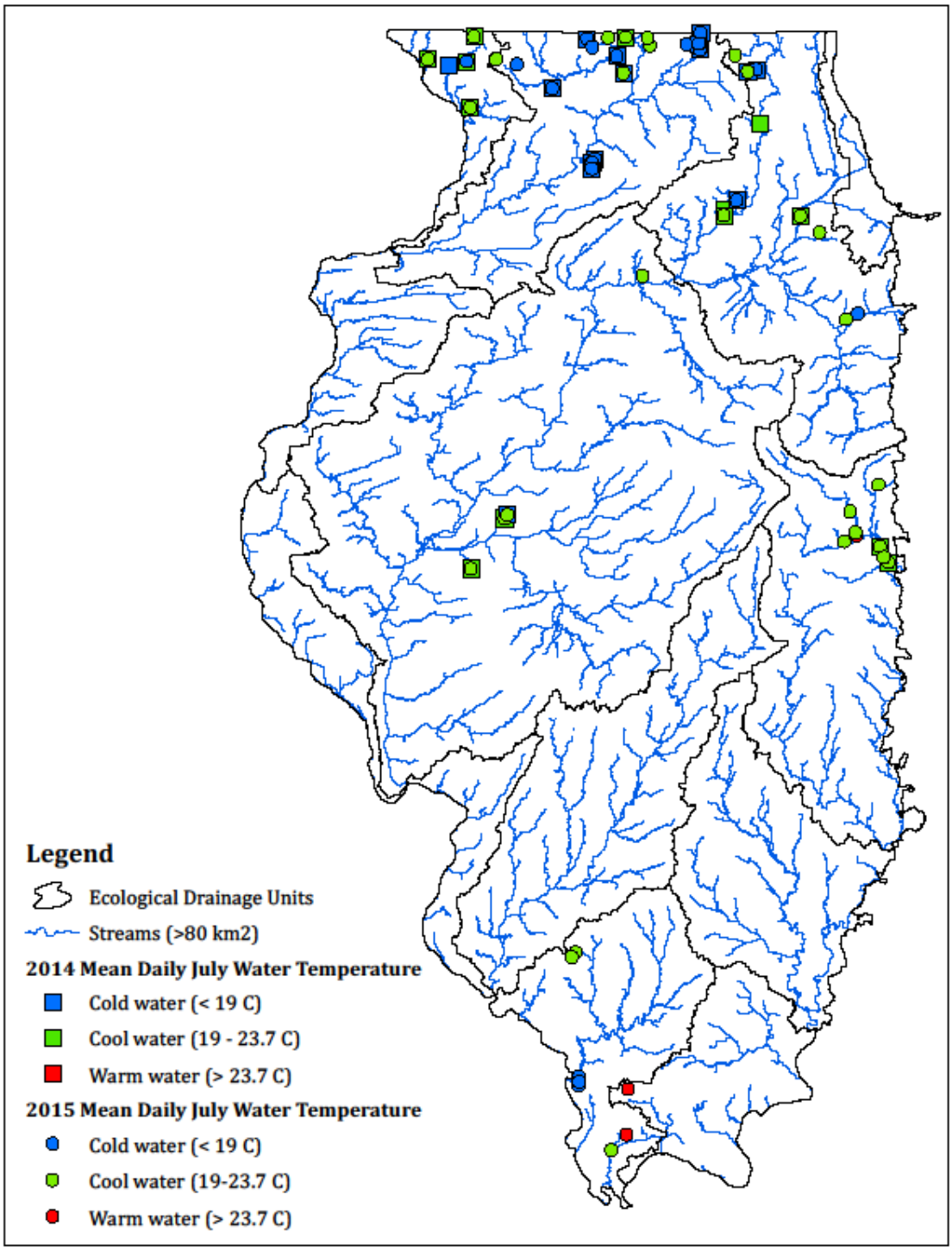

Figure 3: Water temperatures observed in characterization reaches during 2014 and 2015.

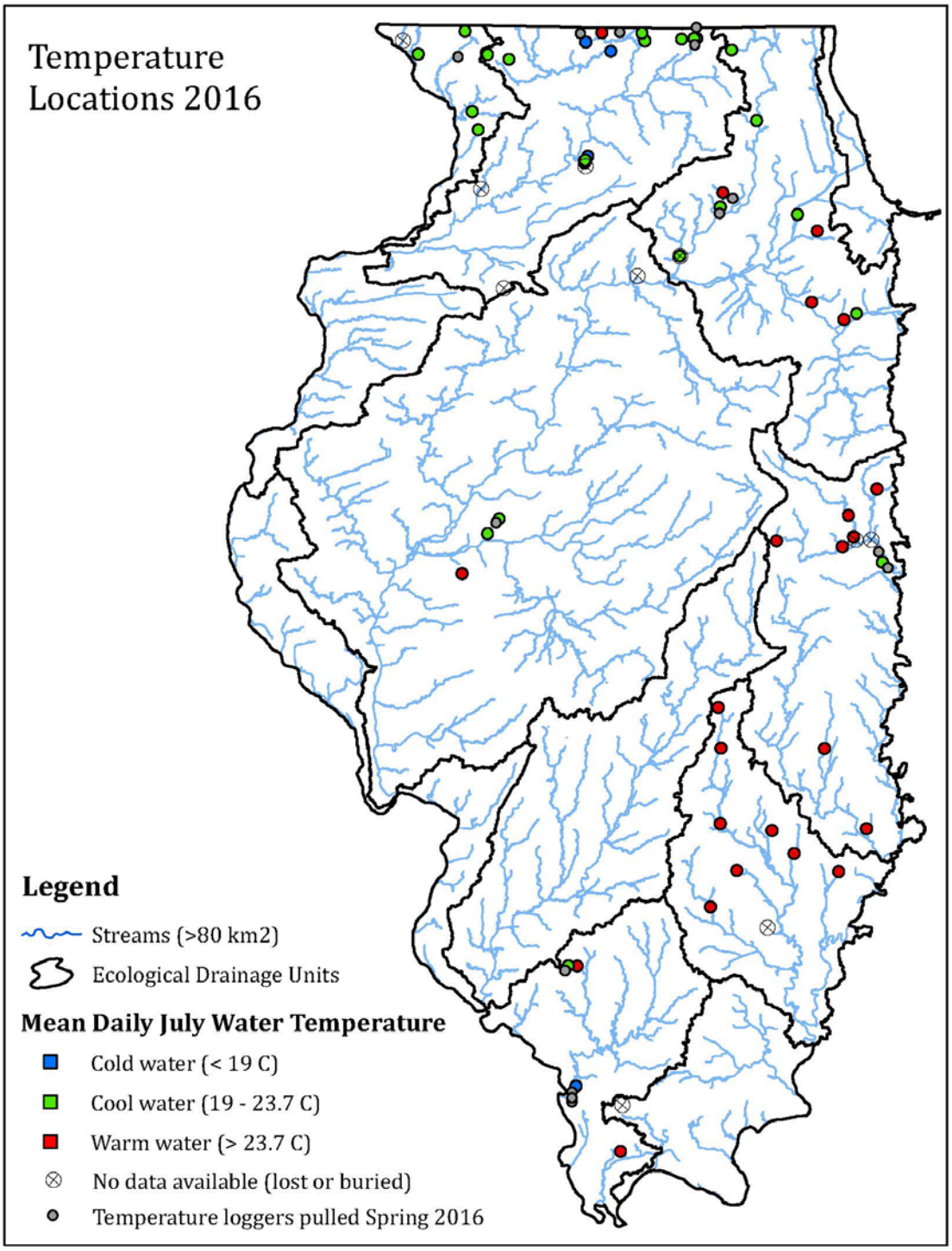

Figure 4: Water temperatures observed in characterization reaches during 2016.

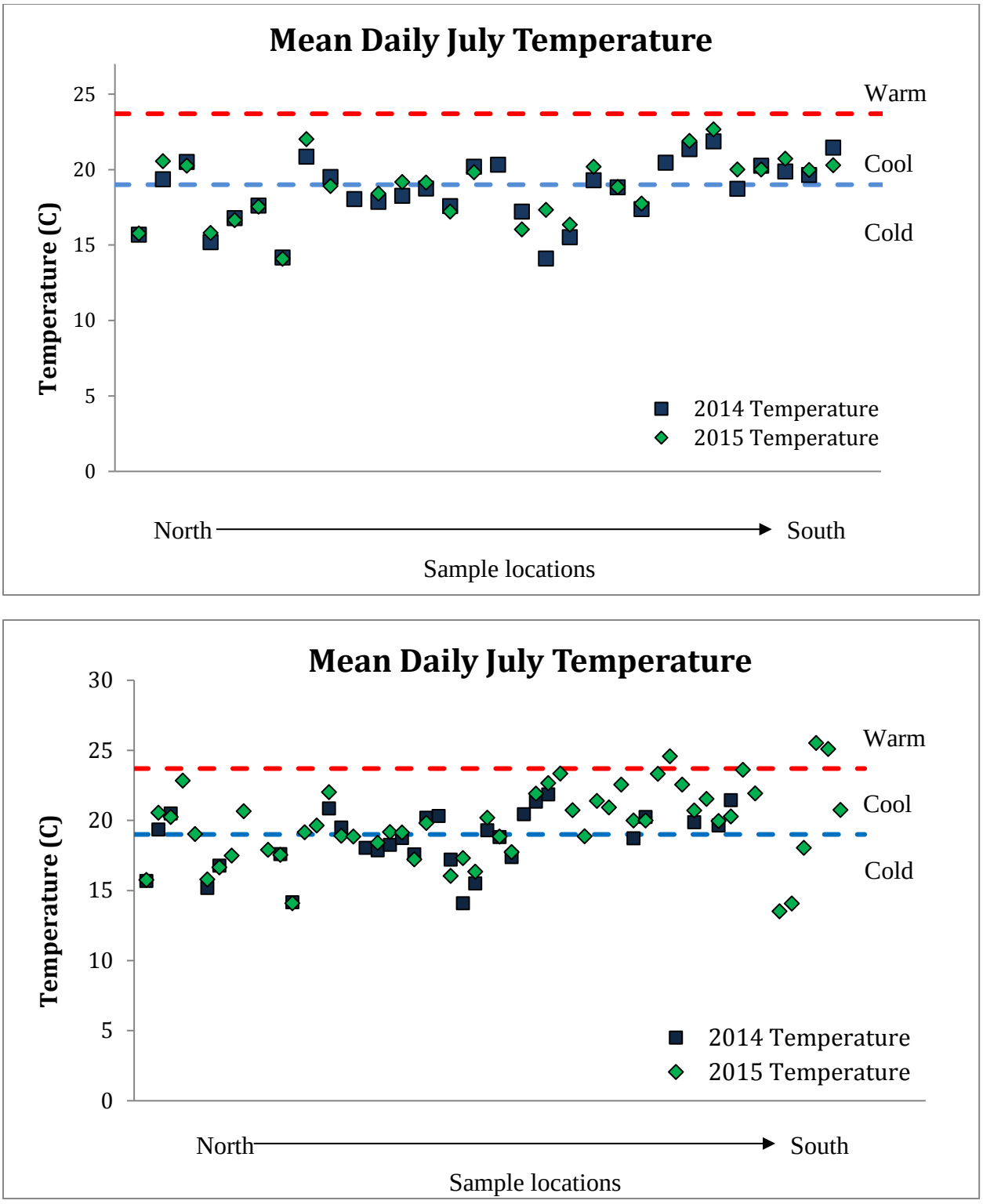

Figure 5. Observed temperatures at monitoring sites during the 2014 -2015. Top: Only sites that were sampled both years are displayed. Bottom: All sites. Temp categories are from Hinz et al. 2011.

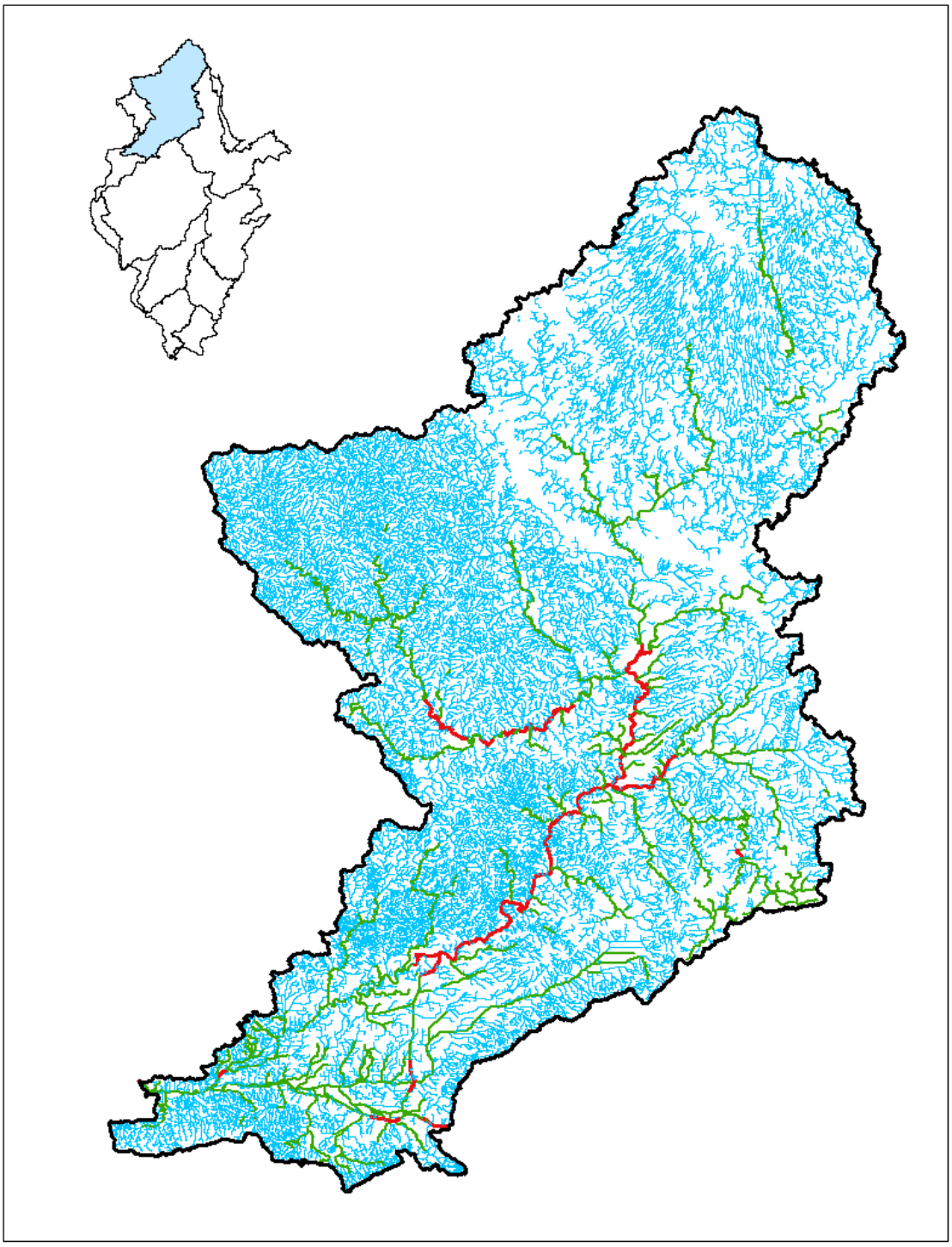

Figure 6. Modeled thermal classes based on the existing water temperature model applied to the updated 1:24,000 linework and summaries for the Rock River.

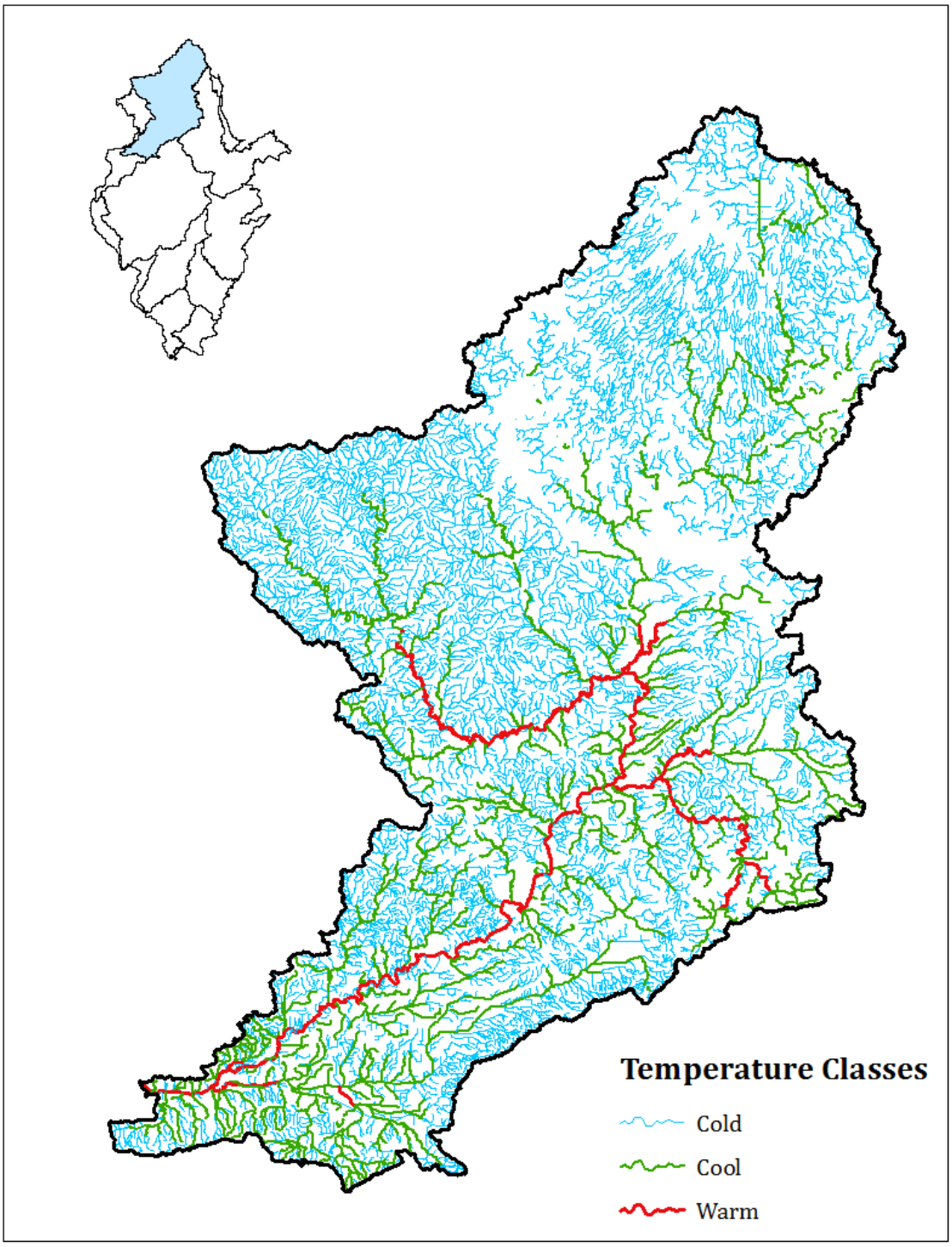

Figure 7. Modeled thermal classes based on the existing water temperature model applied to the 1:100k linework that was used to develop the temperature model.

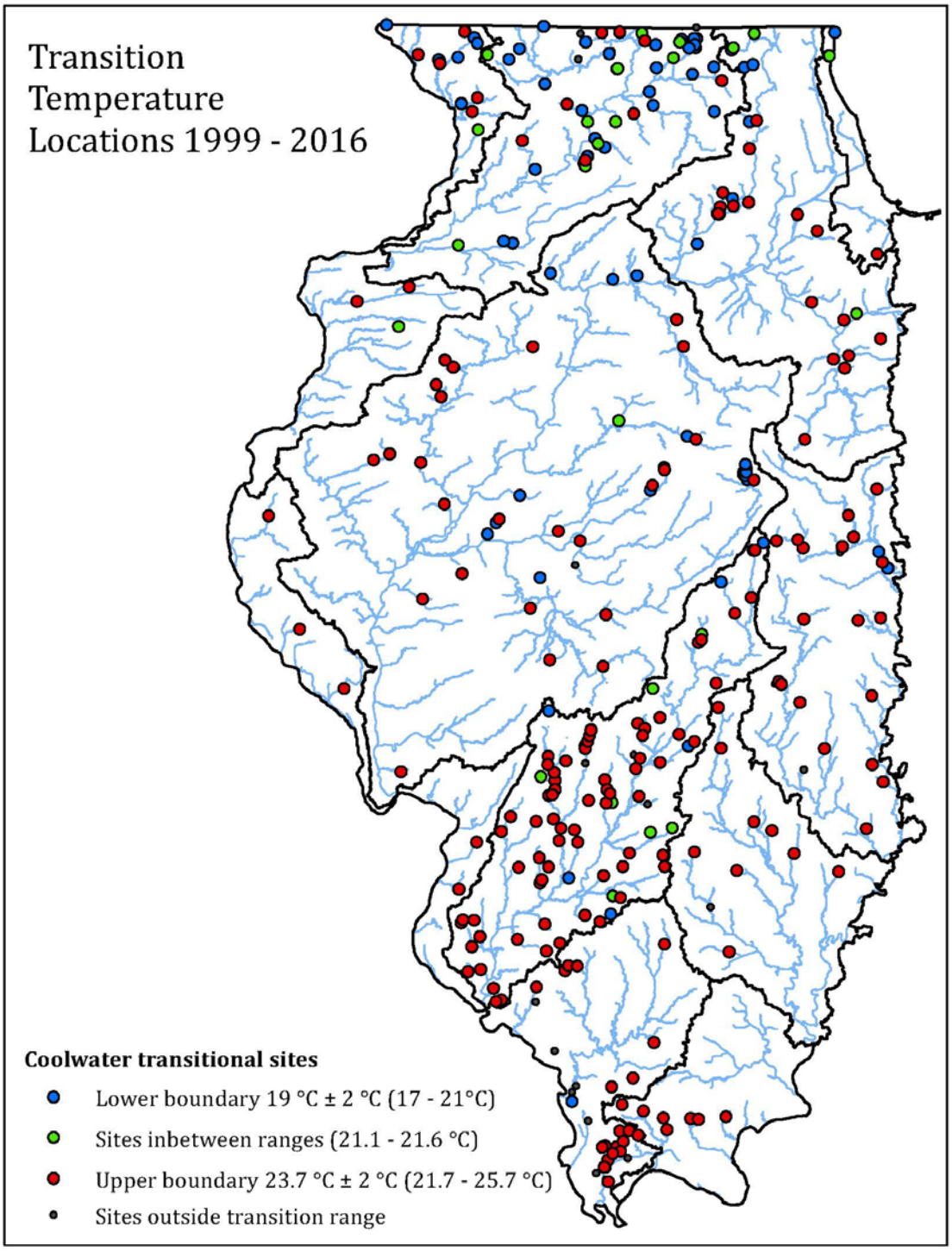

Figure 8. Observed summer temperatures in Wadeable streams in Illinois. Transitional sites with temperatures near the boundary of warm waters (red circles) are considered highly vulnerable based on potential exposure to increased temperatures assocaited with expected changes in climatic conditions.

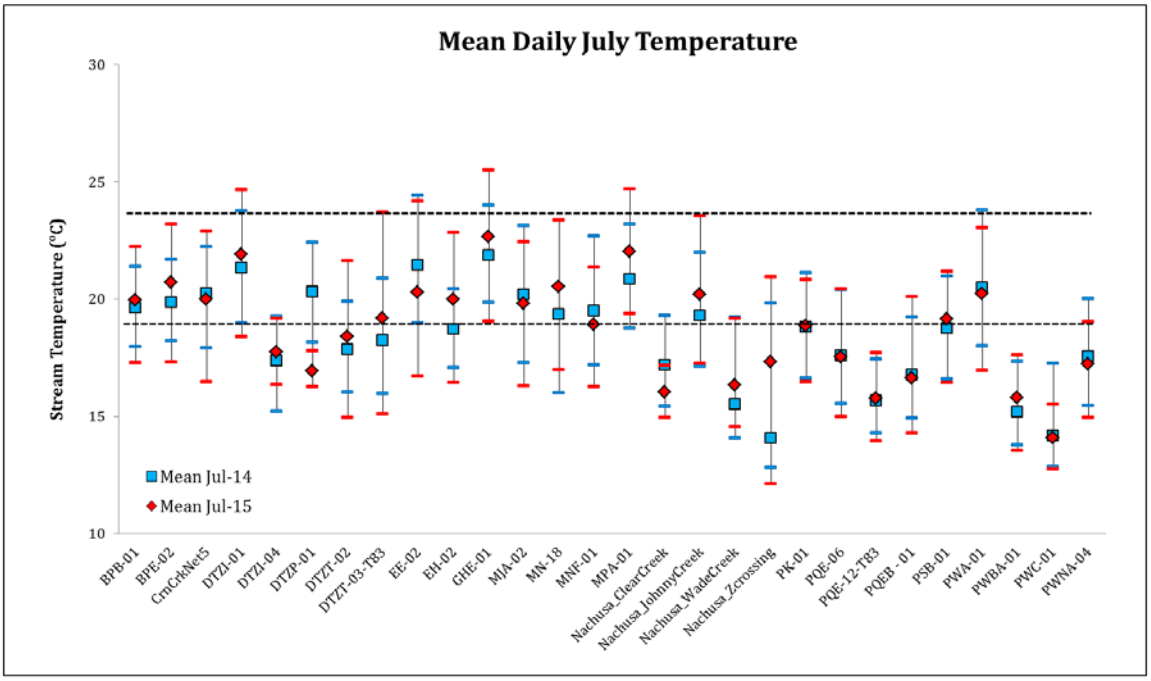

Figure 9. Variability in stream temperatures between years 2014 and 2015. Note that at some locations mean stream temperatures oscillate between thermal classes (indicated by dashed horizontal lines) and that these are not consistent between years throughout the State of Illinois. Sites that exhibit these broad ranges of conditions that have mean temperatures in the transition zones between coldwater and warmwater thermal regimes may have fauna that are extremely vulnerable to exposure to increased temperatures associated with potential climate change.