Stream Transparency Profiles

in an

Agricultural Landscape,

Eastern Great Plains,

USA

By:

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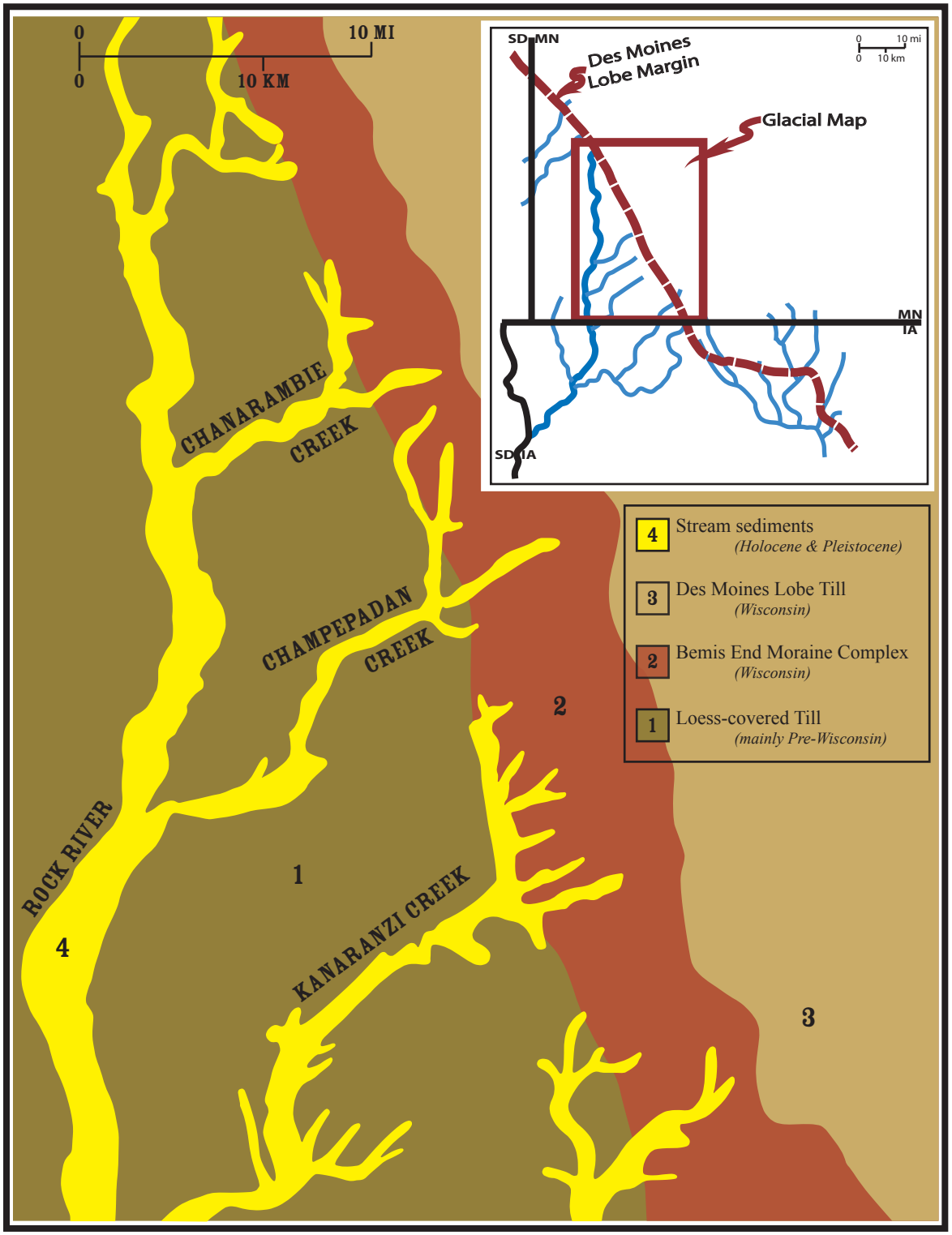
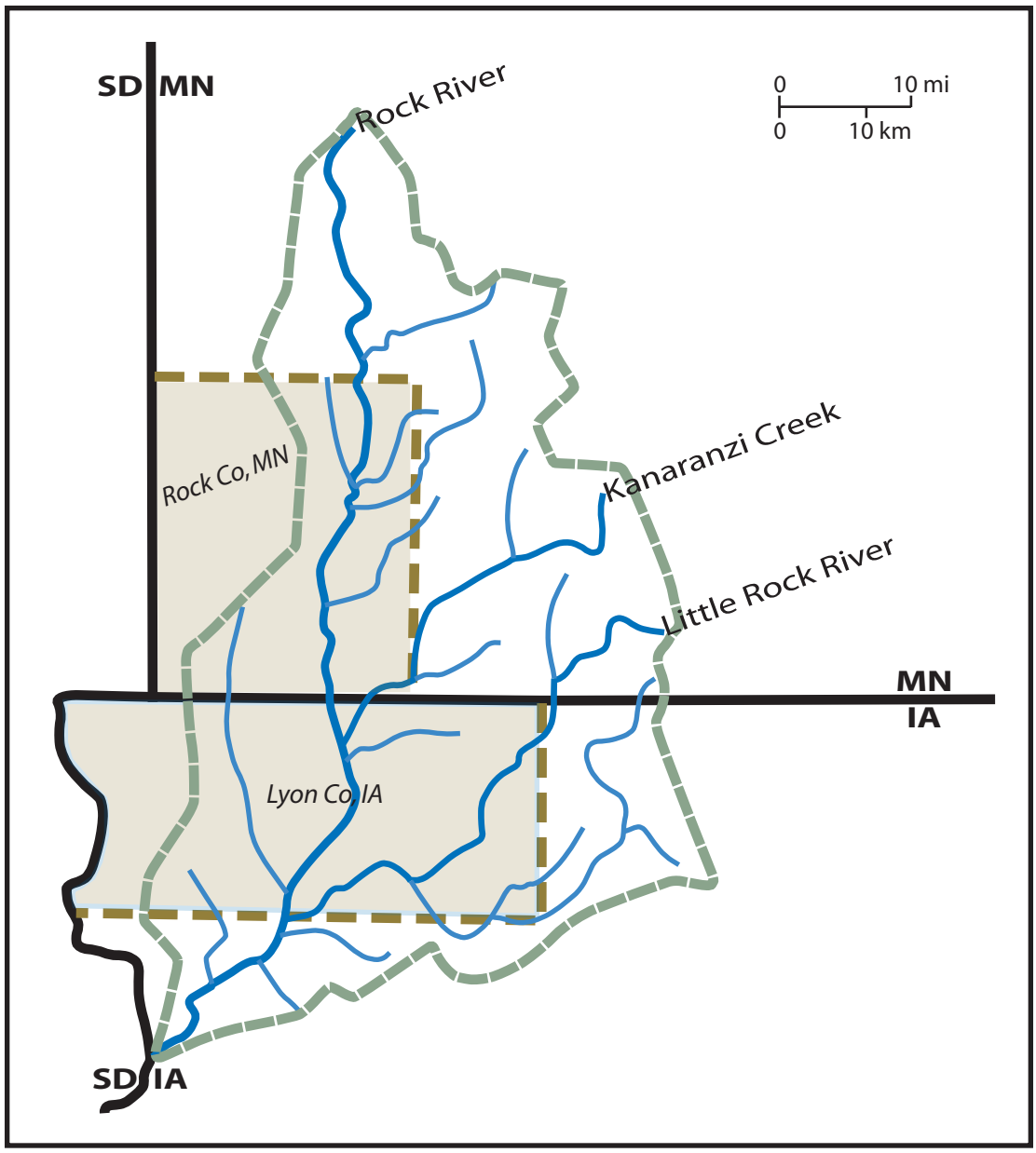
A

LANDSCAPE CONTEXT



Glacial Setting

Streams in the agricultural landscape of southwestern Minnesota and northwestern Iowa generally originate along the margin of the Des Moines Lobe (inset simplified from Eash, 2001). The Rock River and its main tributaries drain a broad loess covered till plain (glacial map generalized from Patterson, 1995) located west and south of the Bemis End Moraine Complex.



Rock River Watershed

The Rock River Watershed is mainly located in Rock County, Minnesota, and Lyon County, Iowa, and in portions of adjacent counties. Transparency profiles have been prepared for the mainstem of the Rock River, for Kanaranzi Creek and the Little Rock River which are the largest tributaries, and for half a dozen minor tributaries.

Agricultural Landscape

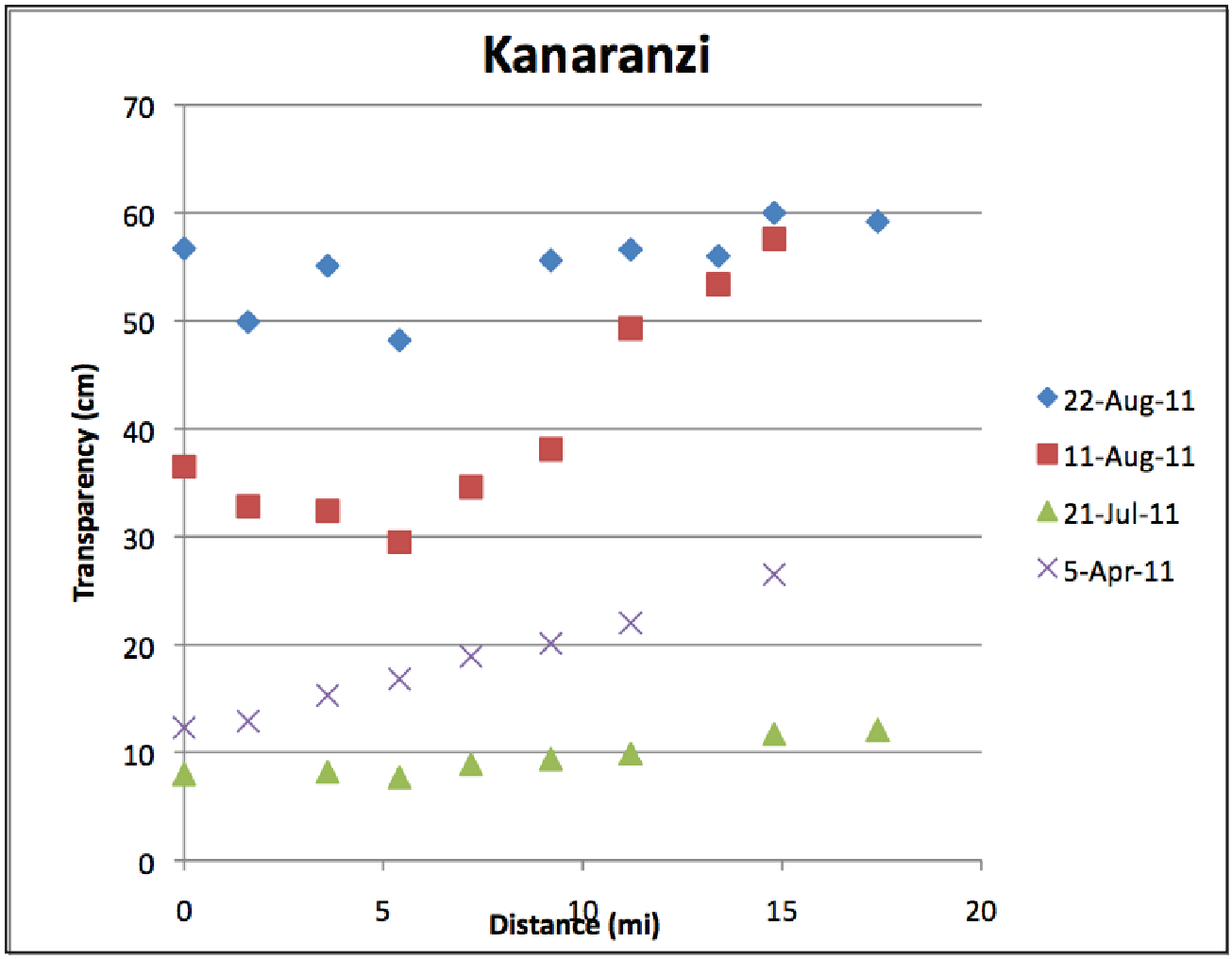
Row crops dominate the landscape in the Rock River Watershed, with cattle grazing concentrated along the riparian corridors. The red stars are locations where transparency measurements were made along Kanaranzi Creek and are generally representative of measurement distributions along other streams.

Appropriate Technology

The sampling program utilizes a simple technology appropriate for this reconnaissance level study. Transparency measurements are made using a small secchi disk at the bottom of a 2 ft (60 cm) tube, a "transparency tube". The field assistants are only occasionally enlisted as equipment bearers. Actual measurements are done by a token, nominally-responsible grandparent who is older than the field vehicle.

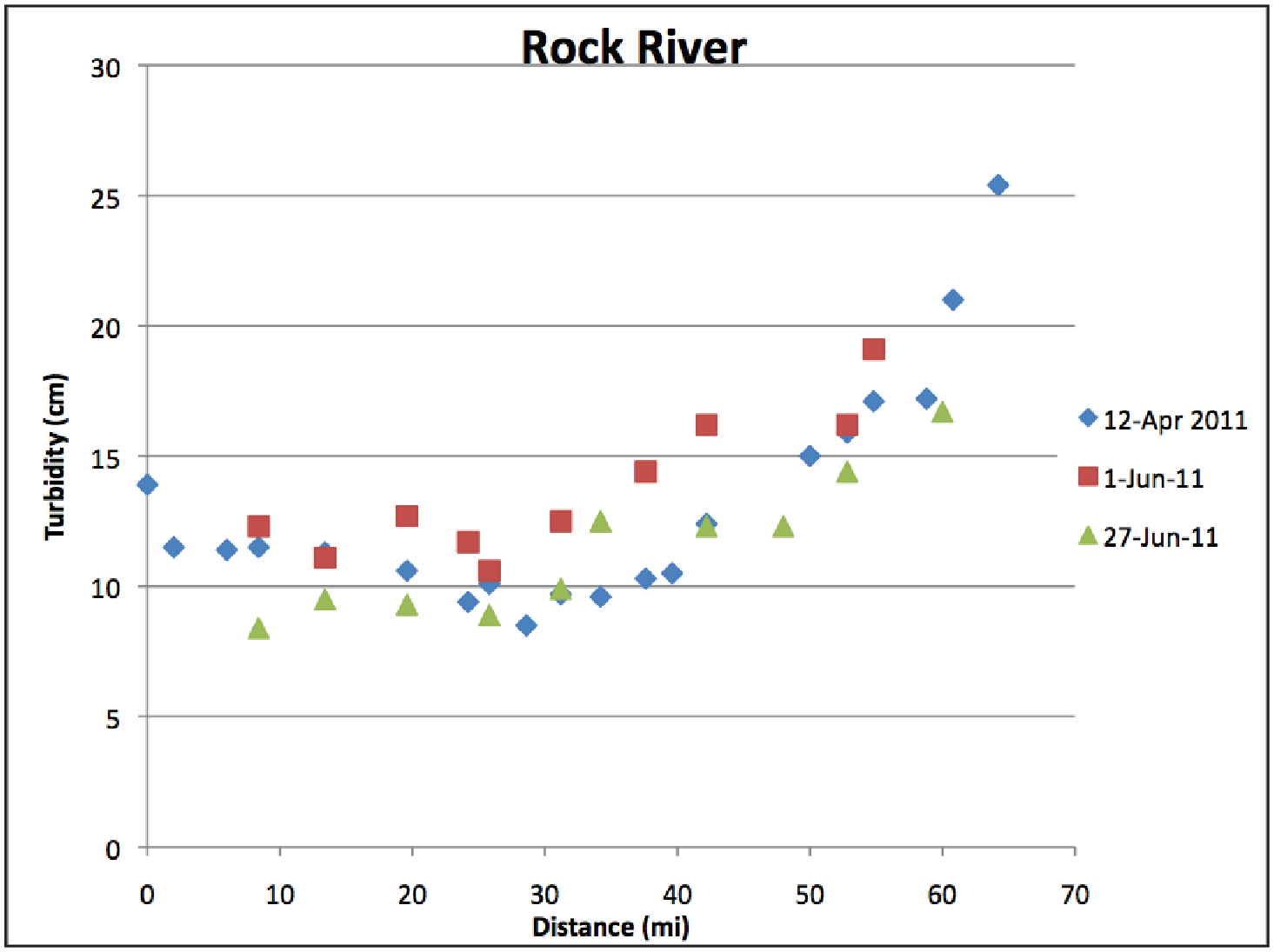
B

Profile Patterns



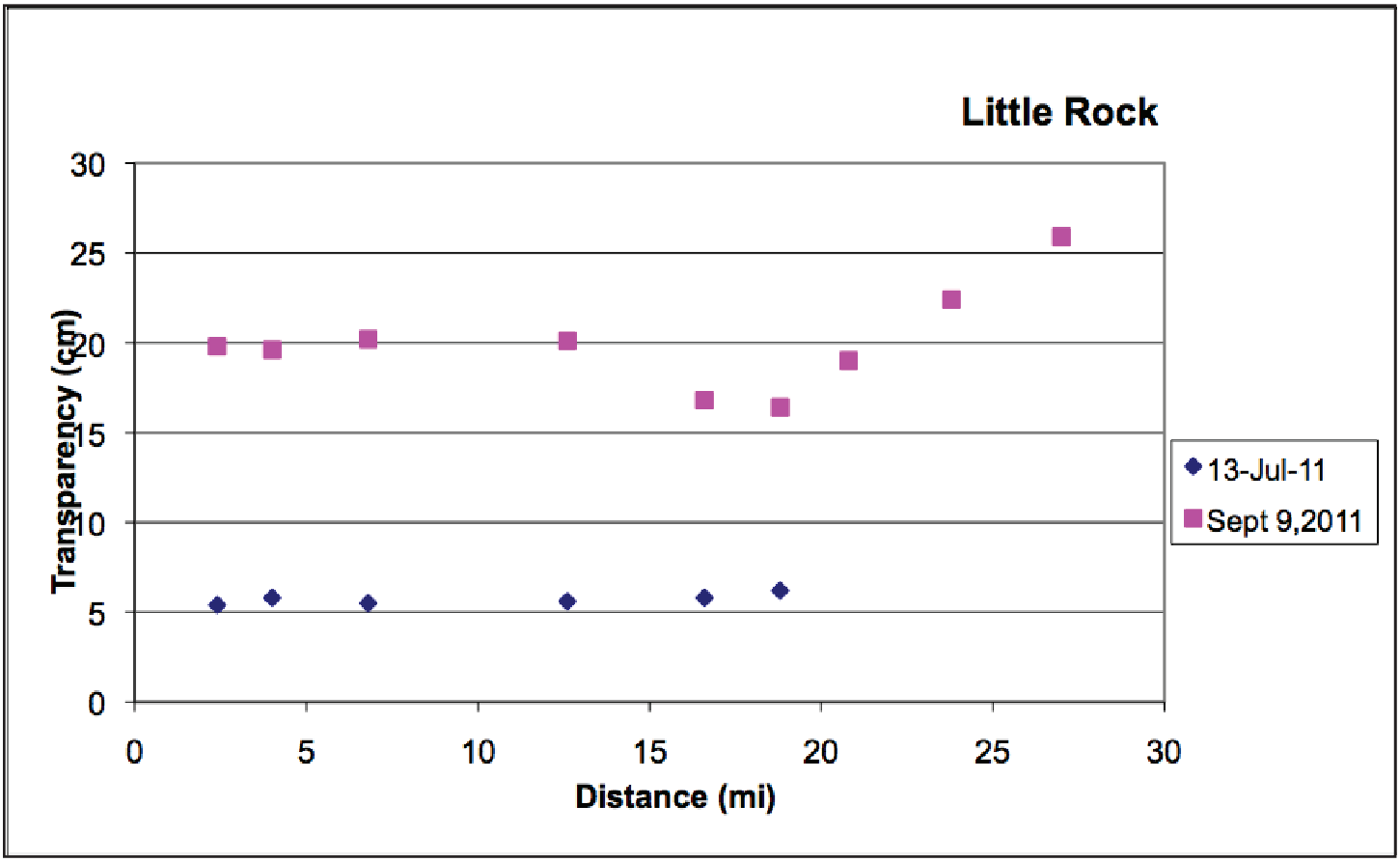
Representative Patterns

A downstream decrease in transparency is the fundamental pattern observed in most stream profiles. The vast majority (viz, 19) of more than two dozen profiles prepared for Kanaranzi Creek over the past five years show this pattern. In addition, these four profiles from 2011 illustrate patterns representative for all five years: relatively flat profiles at low and high transparency values and downstream decreases that are both linear and exponential.



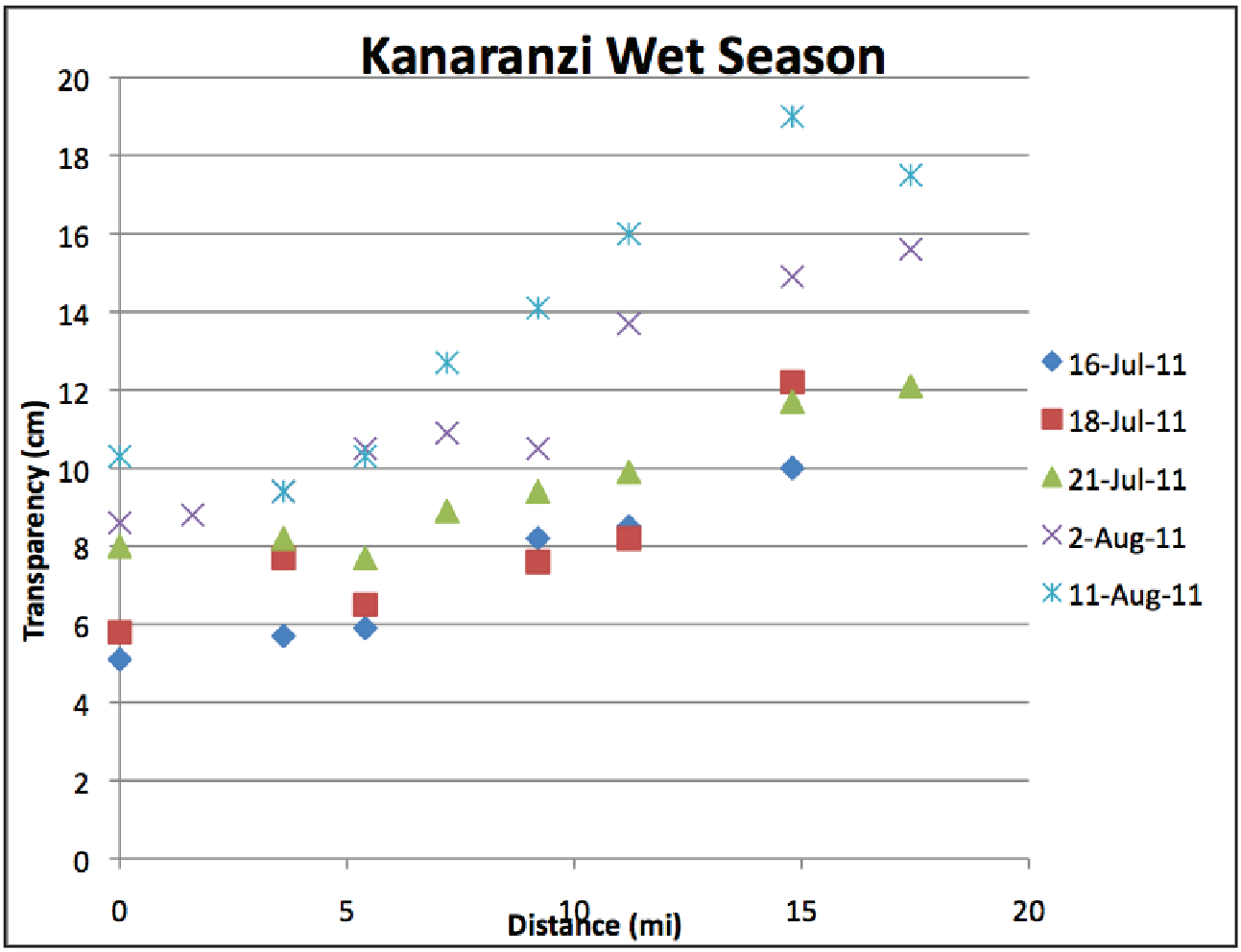
Mainstream Profiles

Downstream decreases in transparency are also characteristic of the mainstem of the Rock River. These three profiles for 2011 show an exponential decrease; three profiles in 2010 are linear. Preliminary partial profiles were also done in 2009 and 2010 along the stream reach between 30 and 50 mi (48 and 81 km). About half of the 13 partial profiles show slight downstream decreases and half were relatively flat. The partial profiles in this reach are consistent with the exponential decreases that characterize the more complete profiles in this illustration.



Other Tributaries

Downstream transparency decreases are also dominant patterns in tributaries other than the Kanaranzi Creek. The July 2011 profile along the Little Rock River is flat at low transparency values which is representative of a mid-summer wet spell. Later in the season, the profile adjusts to a more characteristic downstream decrease. Extended wet spells and short term intense rain events can cause substantial departures from the dominant pattern of downstream decreases.

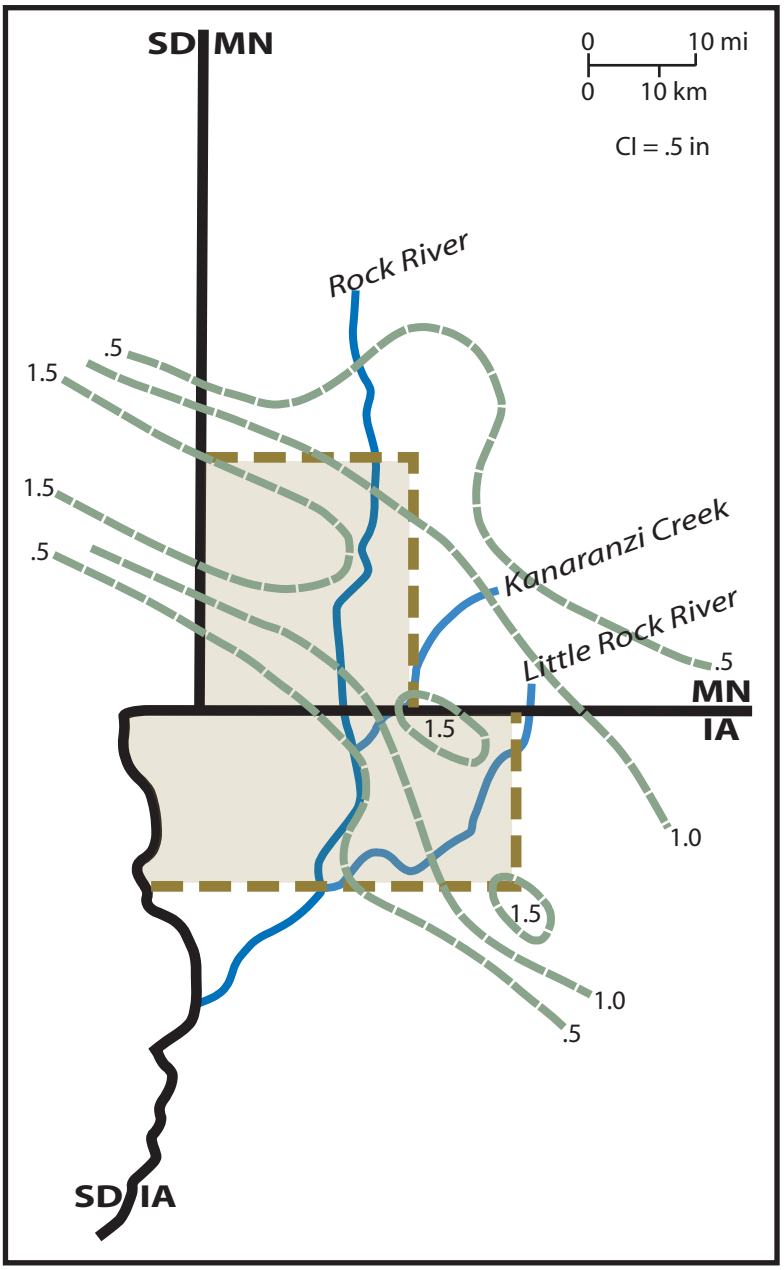


Expanded, Low-value Profiles

Profiles at low transparency values appear to be "flat" when displayed with t-tube measurements ranging up to 60 cm. However, even these "flat" profiles show downstream decreases if the scale of the y-axis is expanded. These five profiles for Kanaranzi Creek all have transparency values under 20 cm, but show the characteristic downstream decrease. All five profiles are from the mid-summer wet spell of 2011.

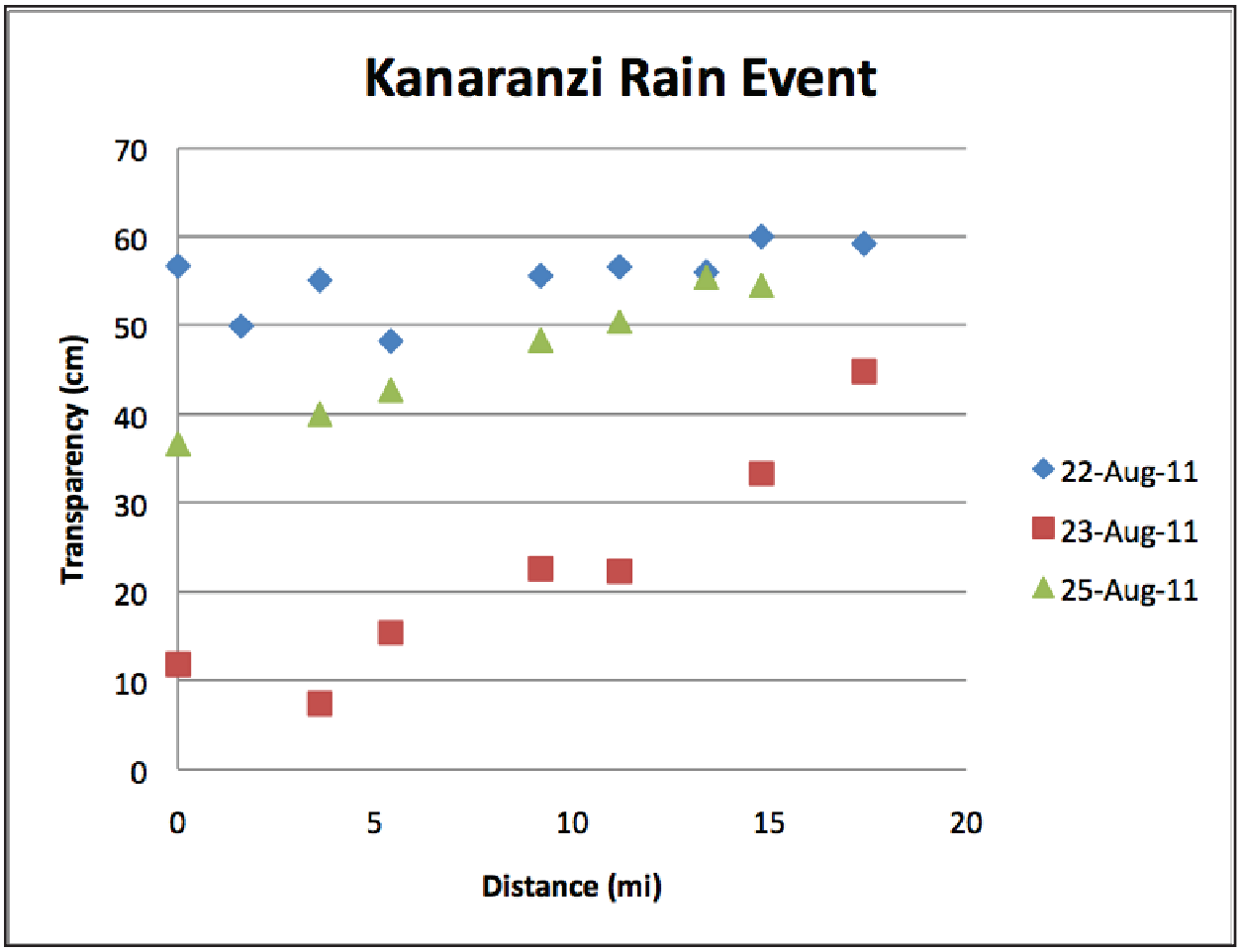
C

Natural Experiment



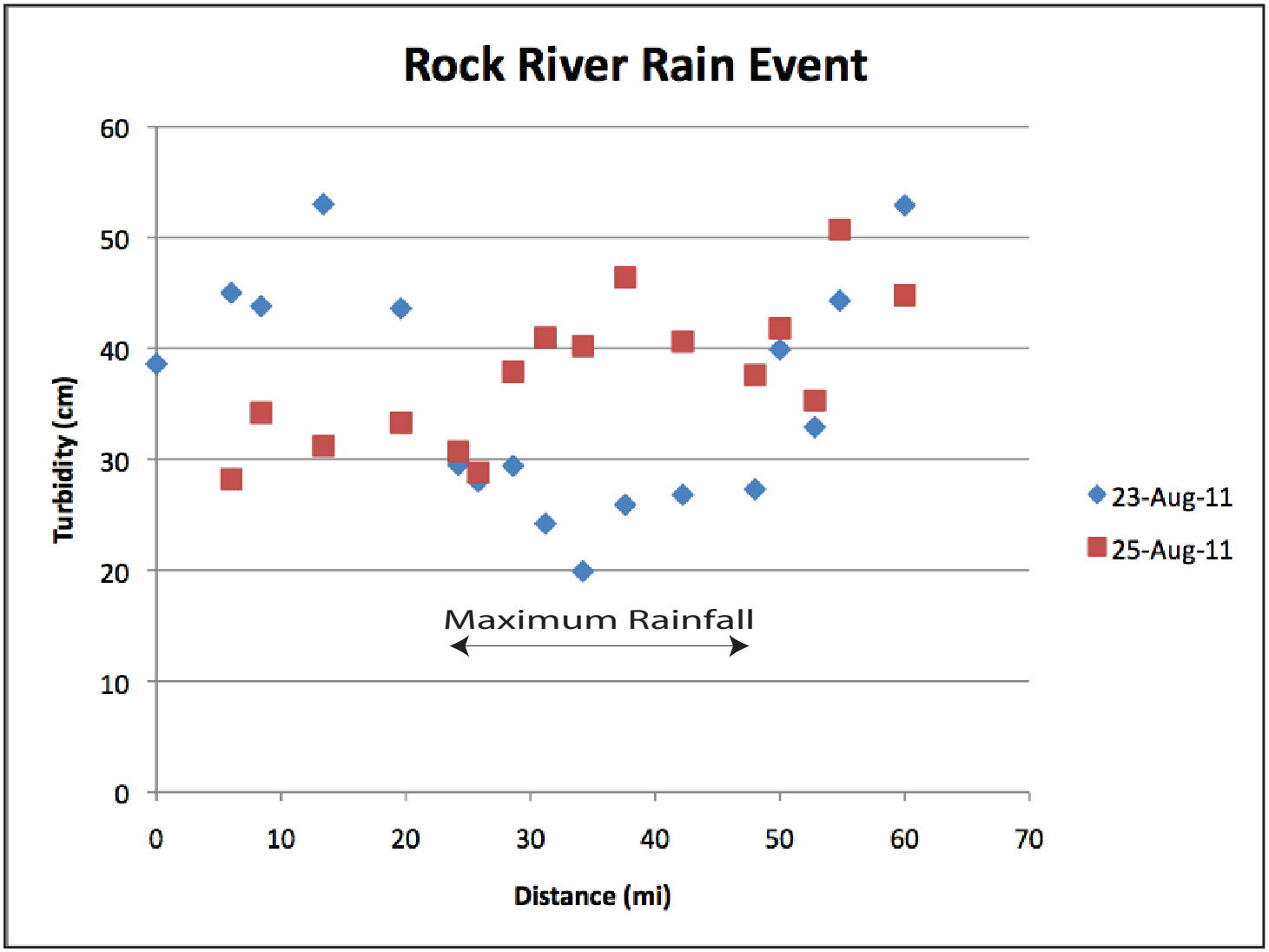
Rain Event

On August 23, 2011, an intense early morning rainstorm cut through the Rock River Watershed to provide a natural experiment monitored by transparency profiles. The area of maximum rainfall was generally located along the lower reaches of Kanaranzi Creek. The overall northwest to southeast maximum rainfall area trended obliquely across the mainstem of the Rock River. Rainfall amounts of less than 1.0 in were confined to the lower reaches of the Little Rock River.



Profile Adjustments

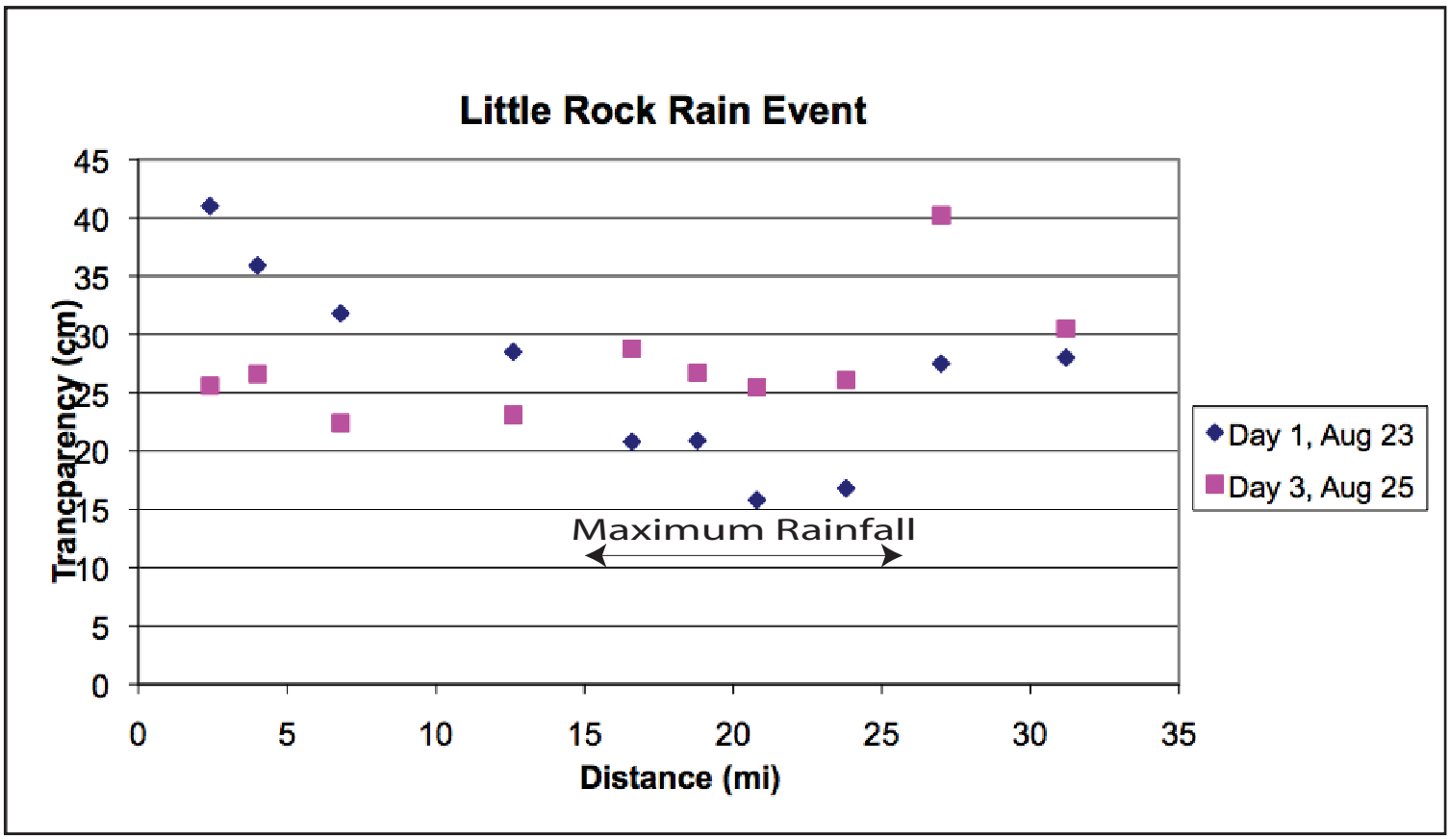
Three transparency profiles along Kanaranzi Creek illustrate adjustments in response to the August 23 rain event. The pre-rain profile done on August 22 is relatively flat at high transparency values. Immediately after the intense storm, transparency values decreased, but they decreased more significantly in the downstream areas of higher rainfall. Two days later, the profile had modified to a more characteristic downstream decrease at higher transparency values.



Profile Departures

The intense rainfall event limited to a specific area, caused a predictable departure from the dominant downstream transparency decrease in the Rock River. Low transparency values between about 25 and 45 mi (40 and 72 km) correspond with the area of maximum rainfall. Downstream from about 15 mi (24 km), rainfall amounts were less than .5 in (1.3 km) and the transparency profile retained the characteristic downstream decrease.

On August 25, two days after the storm, transparencies increased in the area of maximum rainfall and were reduced in downstream reaches as the "slug" of suspended load dissipated downstream.



Profile Modifications

In response to the August 23 rain event, transparency profiles in the Little Rock River show modifications similar to those observed in the mainstem Rock River. Initially transparencies were low in the area of maximum precipitation between 15 and 25 mi (24 and 40 km), while the lower reaches of the stream showed an attendant transparency increase.

On August 25, two days after the storm, transparencies had recovered in the maximum precipitation area and had been reduced in downstream reaches as the load moved downstream.

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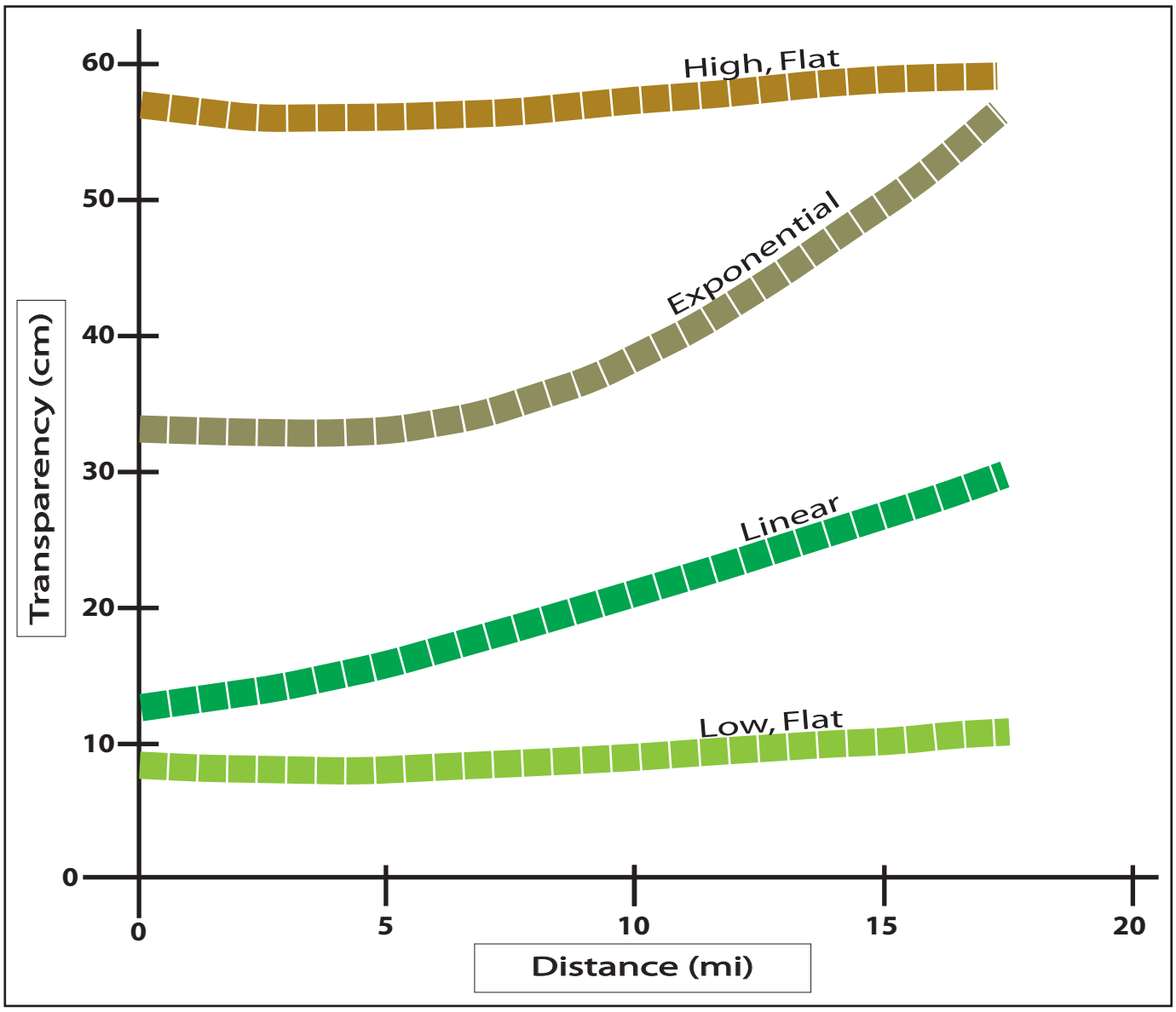
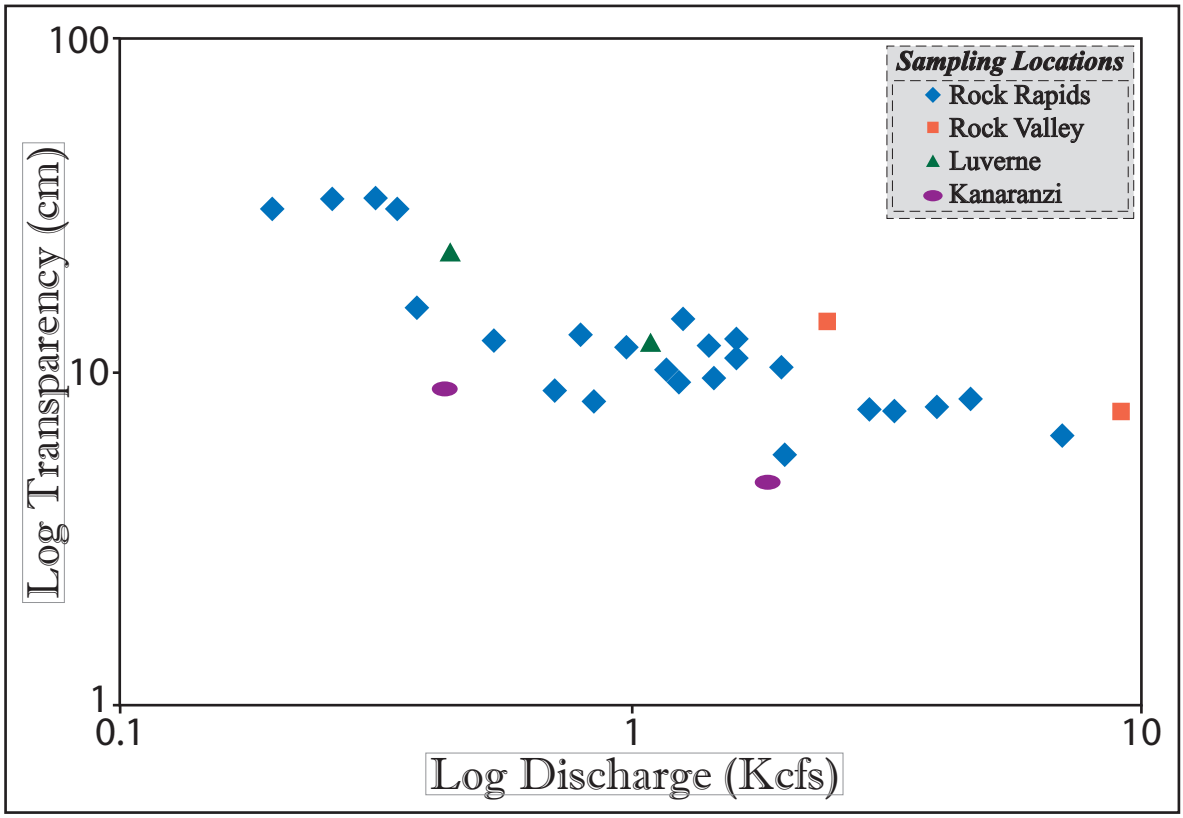
Interpretations and Applications



Families of Curves

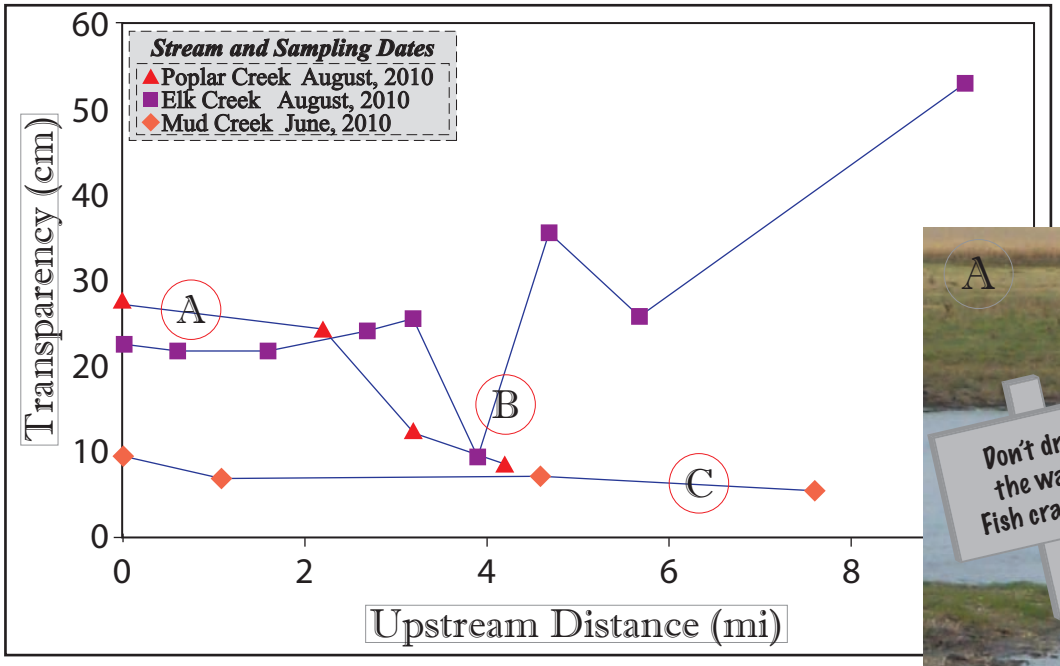
In general, transparency profiles in the Rock River Watershed fall into four separate categories. **1.** Flat curves at low values are associated with spring floods and extended wet spells. **2.** Flat curves at high values usually occur late in the season or during extended dry spells. **3.** Linear downstream decreases are the most common profile. **4.** Exponential downstream decreases seem related to distributions of drainage areas and specific stream reaches.



Discharge Controls

Transparency is inversely proportional to discharge, as demonstrated by this plot of measurements taken in 2010. Rock Rapids, Rock Valley, and Luverne are all USGS gaging stations located on the mainstem of Rock River.

Downstream increases in discharge are likely controls on observed downstream decreases in transparency. Similarly, transparency values also vary in response to discharge changes associated with short term precipitation events and with long term dry or wet spells.



Land Use Impacts

Transparency profiles can be used to assess the impacts of various types of land use. These three examples taken from 2010 data suggest that agricultural practices may have expression in transparency profiles. All three streams are small tributaries of the Rock River. Land use impacts may be less distinctive in the mainstem or larger tributaries where discharge is generally large.

Transparency Profiles can be used to...

- **1. Evaluate** the status of stream impairment. Baseline patterns of downstream transparency decrease should be taken into consideration.

- **2. Distinguish** between the relative contributions of channel bank erosion and overland flow to suspended load sediments.

- **3. Design** in-field experiments that document possible effects of various agricultural practices, such as planting row crops next to a stream channel or allowing livestock direct access to a channel.

- **4. Document** more completely the watershed-scale relationships between discharge and transparency.

Who Cares?

Downstream decreases in transparency are more than simply academic exercises that are interesting. Transparency profiles could conceivably have a wide spectrum of applications, such as those enumerated in this brief, preliminary list.

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