Wells Creek Watershed Report: 1993

by

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Introduction:

Wells Creek is a degraded stream in Southeastern Minnesota on which the trout fishery can be greatly improved if efforts at watershed management are successful. Degradation of the stream occurred in the latter half of the 1800's when farming and logging by European settlers caused accumulation of heavy alluvial deposits in most area valleys. Prior to white settlement many streams in the area had environments favorable to native brook trout. Grazing and deforestation of hillsides reduced survival of these fish by degradation of water quality and habitat. Recent efforts to establish brown and rainbow trout fisheries have been unsuccessful due to marginal stream conditions.

Sampling was conducted in 1993 to obtain baseline information on stream physical parameters, water quality and biological charactersitics to help evaluate the impacts of a watershed management project. The report also contains two appendicies: (1) a stocking history; and (2) information on use of a stream temperature model.

The Study Area

Wells Creek, tributary to the Mississippi River, is located in Goodhue County, Minnesota. From its source northwest of Bellchester the stream flows east to its confluence with the Mississippi River just south of Frontenac. The landscape containing Wells Creek consists of a valley floodplain with steep side slopes and gently rolling uplands. Table 1 provides information on the stream and its watershed.

Methods

Sampling locations are described in Table 2. Temperature was taken in May and July at Station 1, and at Stations 2 and 3 in August. Discharge was measured with a Gurley Current Meter in May, July and December at Station 1 and in July at Station 3.

Benthic invertebrates were sampled with a Surber sampler at four sites (Table 3) on July 16. Sites were determined by stratified random selection as follows: (1) A baseline was chosen (for example: "400 feet above Goodhue County bridge No. 8506"); (2) Transects were located by measuring a specific distance (1-10 feet) upstream from the baseline; this number was obtained from a random number table; (3) Sample sites on the transect were selected by measuring stream width (feet) and obtaining a number from a random number table.

A Peterson estimate of brown trout abundance was done on October 20 and 27 at stations 4A and 4C with a Wisconsin-style stream electrofishing unit.

Results

Water temperature ranged from 53 to 65 degrees between May and August. (Table 3). Temperature was lower at Station 2 than Station 3. Spring locations and influence on temperature was not studied.

Flow was high in area streams in summer 1993 due to above average precipitation; Wells Creek was no exception. Discharge was higher in July and December than in May (Table 4).

Trichoptera larvae and ephemeroptera nymphs were the most abundant invertebrates sampled (Table 5). Trichopterans and amphipods were found at all four sites; ephemeroptera nymphs and coleoptera larvae were sampled at 3 sites each. Plecoptera nymphs were sampled at two sites and tipulidae larvae, hemiptera adults, zygoptera naiads and small molluscs were sampled at one site each.

Adult and fingerling brown trout were sampled in station 4C; only adults were sampled in station 4A. The minimum estimate of adult abundance (all adults sampled in all runs, both stations) was 22 and 42 per mile for Stations 4A and 4C, respectively. Adult biomass was estimated as 49.3 and 14.6 lb./A. in Stations 4A and 4C, respectively. Abundance of fingerlings was estimated at 144 per mile.

Discussion

Temperature at Station 1 was low in May and showed little increase by July; this was due to the cool summer and sustained high flow. In August the ditched area (Station 3) was warmer than the shaded area (Station 2). Discharge was higher in summer than in spring due to early summer rainfall. Discharge remained high into December, likely due to the saturated landscape.

Invertebrate numbers were higher in the middle reaches (Stations 2 and 3, sand/gravel substrate) where effects of elevated temperature due to lack of shade may enhance stream productivity. Overall invertebrate numbers were low, likely due to a high proportion of fine substrates in sampled areas. Trout numbers and biomass were low; fingerlings were present only in the upper, cooler reach.

Table 1: Watershed Description; Wells Creek

Stream Name: Wells Creek Alternate Name(s): none

Tributary Number: M-43

Counties: Goodhue, Wabasha

Major Watershed Name: Mississippi River (Red Wing - Lake Pepin)

Watershed Unit: 38

Sequence of Waterways to Basin: Tributary to Mississippi River

Maps Used: USGS Quadrangles(Minn.): Red Wing, Bay City, Lake City, Lake City N.W., Goodhue East

Length of Stream: 18.8 miles

Average Width -- Upper Station 20 ft. Lower Station 33 ft.

Mouth Location T. 112N R. 13W S. 12

Flow at Mouth 65 cfs, Date 7-16-93

Elevation at Mouth 670 ft.

Headwater Elevation 930

Head Location (seepage area) T. 111 N R. 14 W S. 7 (S.E. 1/4)

Flow at Gaging Station -- Minimum N/A cfs, Average N/A cfs

Location of Gaging Station: No U.S.G.S. Gaging Stations are present; however, Lake City Division of Waters personnel have established a permanent gaging site at the Territorial Road bridge.

Gradient 14.4 ft./mile

Sinuosity 1.5

Drainage Area 52,000 acres

Land Ownership in Drainage Area: Private: farms, small rural residences, business holdings; County: roadways, maintenance sites Municipal: towns, villages State: Forest Lands, roadways

Table 2: Location of Sampling Stations; Wells Creek

Temperature:

Station 1: Coordinates: T.112, R.13W., S.22

Feature(s): Territorial Road bridge

Distance from mouth: 3.1 miles

Station 2: Coordinates: T.112, R.13W., S.20

Feature(s): State Forest Land parcel, (west fenceline)

Distance from mouth: 6.8 miles

Station 3: Coordinates: T.112N., R.14W., S.34

Feature(s): ditched area N. of C. H. 2

Distance from mouth: 13.0

Discharge : Stations 1 and 2 above

Benthic Invertebrates:

Site 1: Coordinates: T.112N., R.13W., S.22

Feature(s): Riffle 400 feet above Territorial Road bridge

Miles above mouth: 3.2

Site 2: Coordinates: T.112N., R.13W., S.20

Feature(s): Riffle 400 feet above bridge N.E. corner Balow property

Miles above mouth: 4.9

Site 3: Coordinates: T.112N., R.14W., S.25

Feature(s): Riffle 200 feet above county bridge

Miles from mouth: 10.3

Site 4: Coordinates: T.111N., R.14W.S.4

Feature(s): Riffle 200 feet above ford on Wojcik farm

Miles above mouth: 14.1

Table 2 (Continued):

Fish:

Station 4A:

Coordinates: T.111N., R.14W., S.4

Feature(s): 880 foot pool/riffle area in center of S. 4; starts at highline along County Road 3

Miles above mouth: 14.0

Station 4C:

Coordinates: T.111N., R.14W., S.8

Feature(s): Proceeds 975 feet upstream from top of first riffle above bridge on county road in N.W. corner of S. 8 on Heise property.

Miles above mouth: 17.6

Table 3: Temperature			
Date	Station	Air Temp. (F)	Water Temp.(F)
5-24	1	56.0	53.0
7-16	1	78.0	59.0
8-26	2	81.0	55.0
8-26	3	82.0	65.0

Table 4: Discharge (CMS)		
Date	Discharge	
	Station 1	Station 3
5-24	30.0	---
7-16	32.0	22.0
12-16*	36.4	---

* Data obtained from Scott Johnson, Assistant Area Hydrologist, Lake City, MN, 1993.

Table 5: Benthic Invertebrates (number per square meter)					
Taxon	Site 1	Site 2	Site 3	Site 4	Total
Trichoptera	43.2	54.0	129.6	54.0	280.8
Chironomidae	0	0	21.6	10.8	21.6
Coleoptera	0	10.8	21.6	10.8	43.2
Tipulidae	0	0	10.8	0	10.8
Amphipoda	21.6	10.8	10.8	10.8	54.0
Ephemeroptera	32.4	118.8	21.6	0	172.8
Hemiptera	0	10.8	0	0	10.8
Plecoptera	21.6	21.6	0	0	43.2
Zygoptera	0	0	0	10.8	10.8
Mollusca	0	0	0	32.4	32.4
Total	118.8	226.8	216.0	118.8	680.4

Appendix 1: Stocking Record				
Date	Species	Size	Number	Pounds
1960	Brown Trout	Yearling	1646	384
1961	Brown	Yrl.	1242	323
1961	Rainbow	Yrl.	258	55
1962	Rainbow	Yrl.	400	80
1962	Brown	Yrl.	793	166
1963	Brown	Yrl.	795	157
1963	Rainbow	Yrl.	296	57
1964	Brown	Yrl.	1100	210
1965	Brown	Yrl.	598	133
1965	Brown	Yrl.	500	100
1966	Brown	Yrl.	502	93
1966	Rainbow	Yrl.	384	80
1966	Brown	Yrl.	189	45
1967	Brown	Yrl.	480	100
1967	Rainbow	Yrl.	504	97
1967	Brown	Yrl.	274	98
1968	Brown	Yrl.	600	150
1968	Brown	Yrl.	400	100
1968	Brown	Yrl.	102	34
4-1969	Brown	Yrl.	696	174
5-1969	Brown	Yrl.	406	116
4-1970	Brown	Yrl.	702	180
6-1970	Brown	Yrl.	353	114
4-1971	Brown	Yrl.	500	100

Stocking Record (Continued)				
4-1972	Brown	Yrl.	501	109
4-1973	Brown	Yrl.	503	117
4-1974	Brown	Yrl.	1075	250
6-1975	Brown	Yrl.	798	228
4-18-88	RBT(RDB)*	Yrl.	10,002	333.4
11-18-88	RBT(RDB)*	Yrl.	9358@8.4	1114
05-01-90	BNT	Flg.	11002	23.8
05-31-90	BNT(PLR)	Flg.	19929	135.5@147
05-29-92	BNT(PLRxW)	Flg.	11000	71.0@155
06-08-93	BNT(PLR)ad^	Flg.	11000	59.6@184.6

* Temperature-tolerant strain.

^ Adipose clip for stocking evaluation

Appendix 2:

Predictive Modelling of Wells Creek Temperature Profiles

1. Four Scenarios

An attempt will be made over the next year or two to fit Wells Creek stream geometry, hydrological and meteorological information into the USFWS Instream Temperature Model outlined in Instream Flow Information Paper No.16 by Theurer, Voos and Miller(see refs.). The model will be used to explain temperature responses of Wells Creek to changes in riparian and channel conditions. Modelling of four scenarios will be attempted, they include:

Scenario I: The present condition. The stream is in a degraded state with high exposed banks and stretches of the stream are wide and straight with little depth. Mid-summer temperatures are too high for maintenance of a trout population.

Scenario II: Riparian conditions are: (1). entire corridor retired (climax vegetation allowed back) and, (2). channel sinuosity of 2.5. Conditions will be modelled in a portion of the watershed which has been minimally affected by farming or development for many years. The "relict" area used will be State Forest Land in section 20.

Scenario III: The assumption is that restoration of riparian vegetation to the "relict" condition (Scenario II) occurs from the headwaters of the stream down to the upstream end of reach II (Fisheries Survey, 1986) and channel sinuosity is 2.5.

Scenario IV: The assumption is reestablishment of climax vegetation from the headwaters to the upstream end of Reach I (Fisheries Survey, 1986); channel sinuosity is 2.5.

2. Seasonal Time Window

Sampling will be conducted June through August to best represent periods when temperature limits trout survival.

3. Stochastic Modelling

To reach the conditions for scenarios I, II, III or IV a minimal period of 50 years is needed. To "push" the stream to an earlier attainment of desired conditions some bank plantings of trees or restoration of overhanging grasses would be required. First-level attempts at application of the model will be with stochastic data (with the exception of data for Scenario I). These data will be generated for scenarios(II,III and IV).

1). Purpose of the model: "to predict the average daily temperature and diurnal fluctuations in water temperatures throughout a stream system network based on either historical or synthetic hydrological, meteorological, and stream geometry conditions" (Theurer, Voos and Miller, 1994).

2. Data requirements and availability:

* Meteorological data: from published climatological records.
* Solar radiation: function of the latitude of the stream.
* Shading: from local topographic conditions and riparian vegetation.
* Hydrological data: discharge or flow data from throughout the stream and initial water temperatures at the beginning points.
* Stream geometry information: usually collected as part of the necessary hydrological study (see following table).

Tables of Data Needed for Application of Model

1). Table of Stream Geometry Data :(Sources: field observations, USGS maps)

Items for table headings:

Stream name

Node type*

Distance

Drainage Area(ha)

Latitude(in radians)

Elevation(M)

Manning"s "n" value

Average Stream width

Shade(dec.)

Remarks*

*Node Type refers to a change point which will impact stream temperature downstream; examples are: spring, tributary, water appropriation. Nodes are collectively called a "stream network". Temperature response will be calculated at each node.

2). Table of Shade Parameters (sources: same as for table 1)

* Distance(from downstream-most node)
* Stream azimuth
* Topographic altitude(radians): average angle of local topography above the horizon within an internodal reach; used to calculate local sunrise and sunset times; these in turn can be used to ascertain topographic shading.
* Parameters of topographic shading
  - @ Crown measurement(m)
  - @ Height(m): height of vegetation
  - @ Offset(m): distance from the water's edge
  - @ Density(dec.)
  - @ These measurements, along with latitude and average stream width will be used to calculate shade provided by riparian vegetation.

A shade parameter table will be constructed for each scenario.

3). Table of hydrological data:

Hydrology of Wells creek is fairly unknown. There is no USGS gaging station on the stream and flows from past surveys are lacking. Flow inputs and starting temperatures are not known; these data will be synthesized (constructed from climatological and meterological data). Points of zero discharge will be starting points (example: tributary headwaters). Incoming flow will be assumed to be lateral into the tributary. Flow is from springs, seeps, surface-flow feeder streams, rainfall and snowmelt. Entrance temperature is ambient (except spring water which will be assumed to be at 46 degrees F.). Local annual mean air temperature will be taken from climatological documents (NOAA). An overview of the geology and hydrology of the Wells Creek watershed is given in Johnson(1993).

Determination of Synthetic discharges

Flow from subdrainage areas and mean annual discharge at the mouth will be used to synthesize discharges at nodal points. A proportion will be set up as follows to synthesize flows for the various tributary inflow nodes:

$$\frac{\text{X discharge of tributary}}{\text{trib. drainage area}} = \frac{\text{Mean annual discharge at mouth of Wells Creek}}{\text{Entire drainage area of Wells Creek}}$$

Discharges of known springs will be taken from the last fisheries survey or from current measurements. Discharge measurements will be made annually starting in 1994; these readings will be used to set up a power curve to validate synthyesized discharges (Theurer et. al., 1984, p. I-25). These discharges will be used in the temperature model.

Meterological Data

Meteorological data (air temperature, relative humidity, wind speed, and possible sunshine) will be obtained from the nearest climatological data station (NOAA, U. of Minn. Hydrology Lab).

Generation of Longitudinal Temperature Profiles

Longitudinal temperature profiles are "plots of water temperature versus distance from mouth for a given set of meteorological, hydrological and stream geometry conditions" (Theurer, Voos and Miller,1984). A set of longitudinal profiles for Wells Creek will be generated for the years 1975, 1976, 1986, 1987 and 1993; this will give representation to both high and low flow periods. July and August will be studied; these months represent the period of upper temperature limits for trout.

Correlation of Trout Populations With Habitat

Brown trout will be sampled for population abundance and structure; abundance of juvenile fish will be correlated to critical rearing habitat (riffles, nursery areas, pools) following procedures outlined in Theurer, Voos and Miller, 1984. This effort will be to estimate, through predictive modelling of stream temperature, benefit to the trout population from aforementioned scenarios of riparian and watershed restoration.

References:

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