**Analysis by: Andy Nuhfer, Hunt Creek Fisheries Research Station.**

## Background:

*Study reach*

The reach of Canada Creek addressed in this analysis flows north through the Canada Creek Ranch located in the northwestern corner of Montmorency County. This stream is quite unique among trout streams in the northern lower peninsula of Michigan because its salmonid population consists almost entirely of brook trout even though summer water temperatures in portions of the stream are very high. Anecdotal accounts suggest that brown trout occasionally stray into the stream reach within the ranch boundaries, but no measurable population exists there and they have never been encountered during electrofishing surveys. Summer water temperatures in the upstream portion of this reach are too high to support good numbers of trout but as the stream flows north significant cooling occurs through accrual of groundwater and cold water inflow from Montague Creek. For example, on 8/25/05 discharge at the Geodetic Trail sediment trap (a warm site) was 22.16 $ft^3/s$ compared to 31.04 $ft^3/s$ at Wilson Bridge (a cool site). Thus, discharge increased by 8.88 $ft^3/s$ (40% increase) over about a 4.7-mile-long reach.

*Management actions*

Past management has included occasional stocking of brook trout prior to 1962, and extensive construction of stream improvement structures between 1956 and 1960. The numbers and types of instream structures built are shown in the table below.

**In-stream Structures from 1956 to 1960**

| Type | Number | year | Number |
|---|---|---|---|
| Channel seal | 1 | 1956 | 82 |
| Sheet-piling wing deflector | 1 | 1957 | 48 |
| Inverted sheet-piling wing deflector | 11 | 1958 | 60 |
| Inverted digger log | 1 | 1959 | 99 |
| Diverter | 1 | 1960 | 10 |
| Fry cover | 2 | | |
| Boom cover | 105 | **Total** | **299** |
| Log jam | 73 | | |
| Hand excavated pools along outside bends | 18 | | |
| Log sod cover | 34 | | |
| Tree top(s) | 51 | | |
| Stump cover | 1 | | |
| **Total** | **299** | | |

In 1959 and 1960 removal and exclusion of non-trout fish species was attempted in 1 mile of the reach to test the feasibility of “rough fish” removals as a method to improve the quality of the brook trout population and the angler fishery (Whalls 1970). This experiment was largely unsuccessful. Beginning in 1996 sediment traps were excavated at four sites within the ranch in hopes of achieving the improvements in stream morphology and trout abundance observed in Michigan streams such as Hunt Creek and Poplar Creek (Alexander and Hansen 1983, 1986). Repairs to old log jam structures and cable-anchoring of trimmed trees to increase LWD began around 2002 and continue to the present time (2005). A chronology of recent habitat improvement work done in Canada Creek within the ranch is summarized in the table below. All four sediment traps are scheduled to be excavated again in 2006 and there are plans to continue adding LWD.

| Treatment | Period (years dug for traps) | Location | |
|---|---|---|---|
| | | Latitude | Longitude |
| Geodetic Trail sediment basin | 1996, 2000 | N45.12745 | W84.20918 |
| Clark’s Trail sediment basin | 1997, 2000, 2003 | N45.15819 | W84.212246 |
| Karbon’s (aka, Bickley’s) sand trap | 1996, 2000, 2003 | N45.16935 | W84.22104 |
| Doty Trail sediment basin | 1997, 2000, 2003 | N45.17268 | W84.22070 |
| Repair old structures & add LWD | 2002-2004 | 1.4 mile reach from Doty Trail to Wadsworth Br. | |
| Additional LWD, cabling of trimmed trees, cutting channels through log jams and placing cut material along banks. | 2005 | From south boundary of the ranch to Karon’s trap area.<br>From Doty Trail south to Clark’s trap area. | |

*Fish and habitat data collections*

The first recent fish collections occurred in 1999. The primary purpose of that collection was to obtain a measure of fish abundance and species composition at a site located downstream of all sand traps. A secondary objective was to train seasonal workers in identification of non-trout species sometimes encountered while sampling trout streams. In 2000, we learned that there were plans to repair old (circa 1950s) stream improvement structures and add LWD so we established a study reach downstream of the Doty Trail sediment basin and made plans to make population estimates of brook trout and determine relative abundance of non-trout species for two years before and two years after LWD additions were made. In 2005, we made relative abundance estimates at three stations distributed such that we captured information on fish and habitat across a range of summer temperature regimes. The matrix below shows the distribution of fish and habitat sampling over space and time.

| | | | Brook trout | | Non-trout | |
|---|---|---|---|---|---|---|
| Site | Date | Reach length (ft) | Catch/effort & length frequency | Population Estimate by inch | Catch/effort & length frequency | Habitat Data |
| Wilson Bridge | 7/28/99 | 600 | X | | X | Qualitative observations |
| Doty Trail | 7/21/00 | 400 | | X | X | Qualitative observations |
| | 7/25/01 | 400 | | X | X | Qualitative observations |
| No sampling in 2002 because this was the first year of LWD treatment | | | | | | |
| Doty Trail | 8/23/03 | 400 | | X | X | Qualitative observations |
| | 8/20/04 | 1,000 | | X | X | Status & Trends fixed site protocols |
| Geodetic Trail trap | 8/25/05 | 500 | X | | X | Status & Trends random site protocols |
| Downstream of Montague Creek | 8/25/05 | 500 | X | | X | Status & Trends random site protocols |
| Downstream of Wilson Bridge | 8/25/05 | 500 | X | | X | Status & Trends random site protocols |

*Fish abundance vs. LWD additions*

Additions of LWD and repairs to old stream improvement structures in the stream reach between Doty Trail and Wadsworth Bridge were associated (temporally) with declines in abundance of brook trout (see figure 1 at end of analysis). There is no obvious or logical causal link between the decline in brook trout abundance and LWD additions. The temporal changes in abundance may be related to other environmental factors (see figure 2 at end of analysis showing temporal changes in abundance in Hunt Creek where no habitat work was done). A recent analysis of population trend data in Michigan trout streams showed that reproduction and year class strength had very strong influence in subsequent abundance of older trout (Zorn and Nuhfer, *in press*).

Note that abundance of yearling-and-older (YAO) brook trout in Canada Creek (Figure 1) is higher than in the Hunt Creek reach that is open to angling (Figure 2). Abundance of young-of-year (YOY) and YAO in Canada Creek near Doty Trail in 2004 was similar to abundance of brook trout found in a survey of the Black River in 2005 (Main River Bridge at Blue Lakes Rd). In the 2005 Black River survey there were 262 YOY and 135 YAO brook trout per acre.

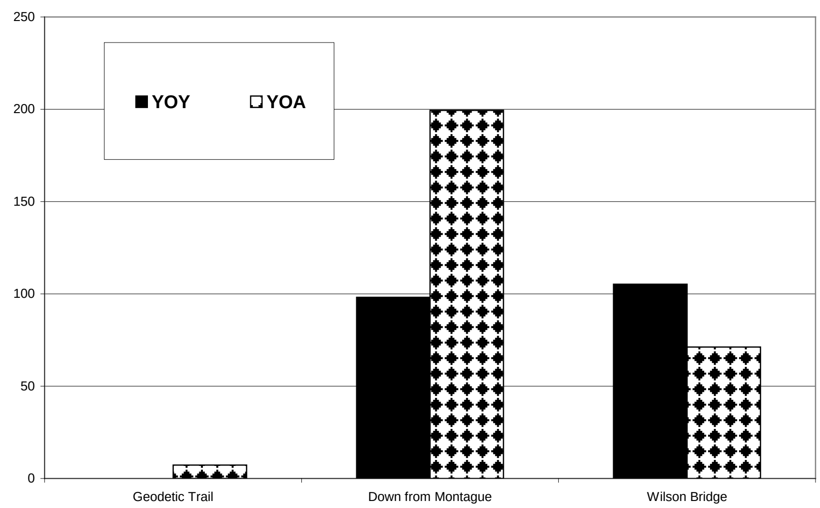
Abundance of YOY brook trout in Canada Creek near Doty Trail compares favorably with other Michigan streams supporting brook trout. Figure 3 shows relative abundance of YOY brook trout compared to the average abundance of YOY at fixed sites sampled during 2002-2004 for Michigan's Statewide Status and Trends Program (SSTP). Abundance of YAO brook trout also compared favorably with SSTP sites, particularly during 2000 and 2001 (Figure 4). Numbers of legal sized (greater than or equal to 8 inches long) brook trout in Canada Creek near the Doty Trail site ranged from 251 in 2000 down to 42 in 2004 (Figure 5).

Amounts of LWD may not be limiting abundance of YAO and legal sized brook trout at the present time since the stream clearly supported far higher densities of larger brook trout around 2000. However, during years and periods when reproductive success is higher needs for LWD and other cover are expected to be higher, and potentially limiting.

*Brook trout abundance versus summer water temperature*

Stations where fish were sampled in 2005 ranged from very warm (Geodetic Trail area) to thermally suitable, i.e. immediately downstream of Montague Creek and at Wilson Bridge. In 2004, mean July water temperatures at Geodetic Trail and Wilson Bridge were 68.6 and 63.0 $^{0}$F respectively. July temperatures near Montague Creek in 2005 were about 1 $^{0}$F warmer than at Wilson Bridge (Table 3).

**Number of young of year (YOY) and yearling and older (YAO) brook trout caught per acre (CPE/Acre) during one-pass electrofishing at three sites on Canada Creek on 8/25/05.**




*LWD Habitat survey summary*

In Canada Creek, LWD was most abundant at the 500-foot Wilson Bridge reach surveyed in 2005 and the least LWD was found at Geodetic Trail (see table below). The quantity of LWD at sites on the Au Sable and Pere Marquette rivers are shown for comparison purposes. There have been extensive additions of LWD in the form of log jams, lunker structures, and other complex structure at the Au Sable and Pere Marquette river sites. Both sites typically support more than 100 pounds per acre of trout, although it must be noted that brown trout are the dominant species. In general, there is more log jam type cover at these sites as compared to Canada Creek. The effectiveness of habitat improvement efforts in Canada Creek might be enhanced if individual structures were larger and more complex. Many of the single logs (with limbs removed) cabled to the banks of Canada Creek do not create much habitat complexity or refuge from water current, although they do provide overhead cover. I believe the structures would be more effective if only a few limbs were trimmed from the cabled logs and if more logs were bundled together in a more complex fashion, i.e. not all oriented parallel to the current.

| **Site and year of survey** | **Square feet of LWD per acre[1]** |
|---|---|
| Doty Trail 2004 (1000 foot station) | 3,509 |
| Downstream of Geodetic Trail 2005 (500 foot station) | 1,781 |
| Downstream of Montague Creek 2005 (500 ft. station) | 3,117 |
| Downstream of Wilson Bridge 2005 (500 foot station) | 3,997 |
| Au Sable River at Stephan Bridge 2002 | 3,816 |
| Pere Marquette River up from mouth of Baldwin River | 3,865 |

[1]Data represents the sum of both complex structure (log jams etc.) and individual logs, both natural logs and logs cabled to the bed or bank were included.

*Temperature analysis*

High summer water temperatures clearly limit the potential for abundant brook trout populations in the upper reaches of Canada Creek. The average daily maximum temperatures during July almost always exceed 68 $^0$F upstream of Clark Rock (Table 1). Whalls (1970) observed that brook trout sought refuge in spring upwelling areas when temperatures rose to 68 $^0$F or higher and similar observations have been reported by Ken Byrne and others who fish Canada Creek. Whalls speculated that predation mortality was high during these hot water periods because trout schooling in areas of spring upwelling without cover quickly returned to the exposed areas when he chased them away. Temperatures over 68 $^0$F occur virtually every day during July at Geodetic Trail and Gravel Bottom (Table 2).

Brook trout abundance is almost never higher than 10 pounds per acre in Lower Peninsula trout streams where average July temperatures are higher than 66 $^0$F. This mean July temperature was exceeded at Geodetic Trail and Gravel Bottom in most years (Table 3). In warm summers such as 2002, it was also exceeded at some downstream stations. The highest daily maximum temperatures observed in Canada Creek reach or exceed 80 $^0$F in upstream reaches during hot periods (Table 4). These temperatures are lethal to brook trout if exposure times are extended.

The maximum-weekly-mean temperature tolerance for salmonid species shown in the table below is based on data from Eaton et al. (1995). Brook trout are rarely found at sites where mean temperature (average of weekly maximum and minimum) during any week exceeds about 72 $^0$F. In Michigan, trout streams water temperatures are usually highest during July.

Mean temperatures during the hottest week of the year should not exceed these values.

| | Temperature | | |
|---|---|---|---|
| Species | Centigrade | Fahrenheit | Sample size |
| Brook trout | 22.3 | 72.1 | 180 |
| Brown trout | 24.1 | 75.4 | 53 |
| Chinook salmon | 24.0 | 75.2 | 282 |
| Coho salmon | 23.4 | 74.1 | 193 |
| Rainbow trout | 24.0 | 75.2 | 442 |

A summary of the hottest weekly mean temperatures in Canada Creek during the summers of 2002 through 2004 are shown below. The fact that brook trout persist and thrive at some sites in Canada Creek during hot summers such as 2002 when the mean temperature during the hottest week reached or exceeded 72 $^0$F presumably occurs because sufficient cold water seepage areas are available for refuge.

**Hottest weekly mean** water temperatures ($^0$F), in Canada Creek at seven sites. Sites are arranged with the most upstream site at the top and the downstream site at the bottom.

| | Year | | | |
|---|---|---|---|---|
| Site | 2002 | 2003 | 2004 | 2005 |
| Geodetic Trail | 77.1 | 73.0 | 70.9 | --- |
| Gravel Bottom | 74.7 | 69.9 | 68.5 | 72.5 |
| Clark Rock | 73.0 | 67.9 | 66.0 | --- |
| Above Montague | --- | --- | --- | 70.2 |
| Below Montague | --- | --- | --- | 70.2 |
| Wilson Bridge | 71.9 | 66.6 | 64.9 | 69.2 |
| Wadsworth Bridge | 72.1 | --- | 65.1 | 69.4 |

Table 1 – **Average of daily maximum** water temperatures ($^0$F), in Canada Creek at seven sites by month. Temperatures were collected using electronic data loggers manufactured by Onset Corporation and

deployed by Ken Byrne. Sites are arranged with the most upstream site at the top and the downstream site at the bottom. Months without complete data are omitted from the table.

| Year/Month | May | June | July | August | September |
|---|---|---|---|---|---|
| **Geodetic Trail** | | | | | |
| 2001 | --- | --- | --- | 73.6 | 63.5 |
| 2002 | 56.5 | 70.5 | 78.4 | 72.7 | --- |
| 2003 | 61.0 | 70.6 | 73.8 | 74.4 | 64.2 |
| 2004 | 59.7 | 70.6 | 73.2 | 69.4 | --- |
| **Gravel Bottom** | | | | | |
| 2001 | --- | --- | --- | 71.1 | 62.0 |
| 2002 | 55.8 | 69.2 | 75.6 | 70.2 | --- |
| 2003 | 58.0 | 67.0 | 70.2 | 71.2 | 61.1 |
| 2004 | 59.0 | 68.8 | 70.9 | 67.3 | --- |
| 2005 | 57.6 | 73.0 | 71.9 | 69.3 | 64.6 |
| **Clark Rock** | | | | | |
| 2001 | --- | --- | --- | 68.2 | 60.1 |
| 2002 | 55.4 | 67.9 | 73.6 | 68.0 | --- |
| 2003 | 58.3 | 66.0 | 67.9 | 68.5 | 59.5 |
| 2004 | 57.9 | 67.0 | 68.2 | 64.4 | --- |
| **Upstream of Montague Creek** | | | | | |
| 2005 | 56.3 | 70.2 | 69.7 | 67.0 | 62.8 |
| **Downstream of Montague Creek** | | | | | |
| 2005 | 56.4 | 70.3 | 69.8 | 67.2 | 62.9 |
| **Wilson Bridge** | | | | | |
| 2001 | . | 67.3 | 67.5 | 66.9 | 58.9 |
| 2002 | 54.8 | 66.9 | 71.9 | 66.5 | --- |
| 2003 | 57.4 | 64.5 | 66.5 | 67.0 | 58.6 |
| 2004 | 57.1 | 65.7 | 66.5 | 63.2 | --- |
| 2005 | 55.6 | 68.9 | 68.7 | 66.3 | 62.0 |
| **Wadsworth Bridge** | | | | | |
| 2001 | --- | --- | --- | 67.6 | 59.1 |
| 2002 | 54.7 | 66.8 | 72.0 | 66.9 | --- |
| 2003 | --- | --- | --- | --- | --- |
| 2004 | 56.9 | 65.3 | 66.4 | 63.4 | --- |
| 2005 | 55.4 | 69.0 | 69.1 | 66.7 | 62.7 |

Table 2 – Number of days during summer that mean and maximum water temperatures in Canada Creek exceed 68 $^0$F. Temperatures collected using electronic data loggers manufactured by Onset Corporation and deployed by Ken Byrne. Sites are arranged with the most upstream site at the top and the downstream site at the bottom. Months without complete data are omitted from the table.

| | No. of days mean daily temperature is ≥ 68 $^0$F | | | No. of days maximum daily temperature is ≥ 68 $^0$F | | |
|---|---|---|---|---|---|---|
| | **Geodetic Trail** | | | **Geodetic Trail** | | |
| | June | July | August | June | July | August |
| 2001 | Missing data | Missing data | 15 | Missing data | Missing data | 27 |
| 2002 | 13 | 31 | 18 | 18 | 31 | 28 |
| 2003 | 8 | 23 | 24 | 20 | 29 | 29 |
| 2004 | 6 | 19 | 5 | 25 | 27 | 19 |
| | **Gravel Bottom** | | | **Gravel Bottom** | | |
| 2001 | Missing data | Missing data | 9 | Missing data | Missing data | 25 |
| 2002 | 13 | 29 | 8 | 18 | 31 | 26 |
| 2003 | 3 | 2 | 16 | 15 | 26 | 26 |
| 2004 | 2 | 6 | 3 | 19 | 25 | 14 |
| 2005 | 16 | 16 | 9 | 26 | 30 | 21 |
| | **Clark Rock** | | | **Clark Rock** | | |
| 2001 | Missing data | Missing data | 8 | Missing data | Missing data | 12 |
| 2002 | 9 | 19 | 0 | 15 | 30 | 16 |
| 2003 | 2 | 0 | 7 | 12 | 19 | 20 |
| 2004 | 1 | 3 | 0 | 10 | 19 | 5 |
| | **Upstream of Montague Cr.** | | | **Upstream of Montague Cr.** | | |
| 2005 | 12 | 7 | 3 | 22 | 22 | 12 |
| | **Downstream of Montague Cr** | | | **Downstream of Montague Cr** | | |
| 2005 | 12 | 7 | 4 | 22 | 22 | 12 |
| | **Wilson Bridge** | | | **Wilson Bridge** | | |
| 2001 | 7 | 3 | 6 | 15 | 13 | 10 |
| 2002 | 6 | 12 | 0 | 14 | 29 | 11 |
| 2003 | 1 | 0 | 2 | 9 | 8 | 15 |
| 2004 | 1 | 0 | 0 | 6 | 12 | 2 |
| 2005 | 8 | 4 | 2 | 18 | 17 | 9 |
| | **Wadsworth Bridge** | | | **Wadsworth Bridge** | | |
| 2001 | Missing data | Missing data | 6 | Missing data | Missing data | 10 |
| 2002 | 6 | 14 | 0 | 14 | 30 | 12 |
| 2003 | Missing data | | | Missing data | | |
| 2004 | 1 | 0 | 0 | 5 | 12 | 3 |
| 2005 | 8 | 4 | 2 | 18 | 19 | 11 |

Table 3 – **Average daily water temperatures** ($^0$F), in Canada Creek at seven sites by month. Temperatures collected using electronic data loggers manufactured by Onset Corporation and deployed by Ken Byrne. Sites are arranged with the most upstream site at the top and the downstream site at the bottom. Months without complete data are omitted from the table.

| Year/Month | May | June | July | August | September |
|---|---|---|---|---|---|
| | | | **Geodetic Trail** | | |
| 2001 | --- | --- | --- | 69.2 | 60.4 |
| 2002 | 52.4 | 66.6 | 73.7 | 68.5 | --- |
| 2003 | 56.1 | 65.3 | 68.8 | 70.1 | 60.7 |
| 2004 | 55.6 | 65.4 | 68.6 | 65.3 | --- |
| | | | **Gravel Bottom** | | |
| 2001 | --- | --- | --- | 66.1 | 58.7 |
| 2002 | 51.8 | 65.4 | 71.0 | 65.7 | --- |
| 2003 | 54.2 | 62.4 | 65.6 | 67.2 | 58.6 |
| 2004 | 55.0 | 64.0 | 66.3 | 63.1 | --- |
| 2005 | 53.6 | 68.6 | 68.5 | 66.7 | 6.24 |
| | | | **Clark Rock** | | |
| 2001 | --- | --- | --- | 64.2 | 57.3 |
| 2002 | 51.6 | 64.2 | 69.1 | 63.9 | --- |
| 2003 | 54.2 | 61.5 | 64.0 | 65.2 | 57.0 |
| 2004 | 54.4 | 62.5 | 64.0 | 61.0 | --- |
| | | | **Upstream of Montague Creek** | | |
| 2005 | 52.7 | 66.4 | 65.8 | 64.4 | 60.3 |
| | | | **Downstream of Montague Creek** | | |
| 2005 | 52.8 | 66.5 | 65.9 | 64.6 | 60.4 |
| | | | **Wilson Bridge** | | |
| 2001 | --- | 63.2 | 63.4 | 63.4 | 56.5 |
| 2002 | 51.2 | 63.5 | 67.9 | 62.9 | --- |
| 2003 | 53.6 | 60.5 | 62.9 | 64.0 | 56.2 |
| 2004 | 53.9 | 61.7 | 63.0 | 60.1 | --- |
| 2005 | 52.5 | 65.5 | 64.8 | 63.6 | 59.6 |
| | | | **Wadsworth Bridge** | | |
| 2001 | --- | --- | --- | 63.7 | 56.6 |
| 2002 | 51.4 | 63.5 | 68.2 | 63.2 | --- |
| 2003 | --- | --- | --- | --- | --- |
| 2004 | 53.8 | 61.7 | 63.1 | 60.2 | --- |
| 2005 | 52.5 | 65.6 | 65.1 | 63.7 | 59.7 |

Table 4 – **Highest daily maximum** water temperatures ($^{0}$F), in Canada Creek at seven sites by month. Temperatures collected using electronic data loggers manufactured by Onset Corporation and deployed by Ken Byrne. Sites are arranged with the most upstream site at the top and the downstream site at the bottom. Months without complete data are omitted from the table.

| | May | June | July | August | September |
|---|---|---|---|---|---|
| **Geodetic Trail** | | | | | |
| 2001 | --- | --- | --- | 83.2 | 73.4 |
| 2002 | 69.2 | 80.6 | 85.9 | 77.4 | --- |
| 2003 | 68.3 | 83.5 | 79.6 | 79.6 | 71.3 |
| 2004 | 68.3 | 78.1 | 78.7 | 76.8 | --- |
| **Gravel Bottom** | | | | | |
| 2001 | --- | --- | --- | 80.5 | 71.5 |
| 2002 | 68.9 | 78.6 | 82.8 | 75.2 | --- |
| 2003 | 64.8 | 78.9 | 75.8 | 76.4 | 68.0 |
| 2004 | 66.9 | 76.5 | 76.5 | 74.0 | --- |
| 2005 | 68.9 | 79.6 | 77.7 | 75.5 | 70.4 |
| **Clark Rock** | | | | | |
| 2001 | --- | --- | --- | 76.9 | 69.5 |
| 2002 | 67.8 | 76.5 | 80.9 | 72.2 | --- |
| 2003 | 64.9 | 76.9 | 72.8 | 73.4 | 65.4 |
| 2004 | 65.5 | 74.7 | 72.9 | 70.5 | --- |
| **Upstream of Montague Creek** | | | | | |
| 2005 | 66.0 | 76.5 | 76.2 | 74.0 | 68.6 |
| **Downstream of Montague Creek** | | | | | |
| 2005 | 66.3 | 76.9 | 76.2 | 74.4 | 68.9 |
| **Wilson Bridge** | | | | | |
| 2001 | --- | 76.2 | 74.4 | 75.9 | 69.0 |
| 2002 | 67.5 | 75.3 | 79.7 | 70.7 | --- |
| 2003 | 63.7 | 75.0 | 71.0 | 72.5 | 64.3 |
| 2004 | 64.6 | 73.2 | 71.1 | 69.0 | --- |
| 2005 | 64.6 | 75.7 | 74.7 | 72.6 | 68.4 |
| **Wadsworth Bridge** | | | | | |
| 2001 | --- | --- | --- | 77.1 | 69.8 |
| 2002 | 67.2 | 75.3 | 79.3 | 71.6 | --- |
| 2003 | --- | --- | --- | --- | --- |
| 2004 | 64.3 | 72.8 | 71.0 | 69.5 | --- |
| 2005 | 64.6 | 75.9 | 75.3 | 73.8 | 69.3 |

### *Summary and recommendations*

Sediment Basins: No data on brook trout abundance in cooler reaches (i.e. downstream from approximately Clark Rock) are available for the period before sediment basins were constructed. Thus, biological data can not be used to evaluate their effectiveness. Anecdotal information indicates that maintenance of sediment basins has resulted in exposure of coarse substrates suitable for spawning.

If stream morphology data such as randomly located zigzag pebble counts or systematic (fixed transect based) pebble counts were collected now and 5 years from now, the data could provide a quantitative basis for judging whether sediment traps are having a significant effect on the prevalence of coarse substrates. It would also be useful to establish and collect data at a series of fixed channel cross sections that are tied to elevation benchmarks so that channel down cutting (or aggradations) could be estimated, but these methods require surveying skills and a substantial amount of time..

LWD Enhancement: The low level evaluation of effects of structure repairs and LWD additions conducted downstream of Doty Trail did not detect beneficial effects on the brook trout population. In fact, brook trout abundance was higher during the pretreatment period. These data are too sparse to make a judgment about the effectiveness of the habitat work at this time. Factors such as system-wide variation in recruitment over time or differences in immigration into the sampling reach between years may have produced the anomalous results. For example, some of the highest temperatures of the year in 2001 occurred immediately prior to the date when the population was estimated so relatively more trout may have immigrated into the sampling station from warmer stream reaches upstream than during cooler years such as 2003 and 2004 (see Table 4). An alternate explanation may be that the amount of LWD added to date is insufficient to produce measurable effects. Presently, approximately 8% of surface area below Doty Trail contains LWD. We have no measure of how much LWD was present before additions to this reach occurred during or after 2002 so perhaps the amounts added were too small to have any measurable effect on trout abundance.

Construction of more complex structures and log jams, as opposed to neatly trimmed logs, may produce greater benefits to the trout population. Addition of cover in areas of concentrated spring seepage may also increase the effective of habitat enhancement efforts. Whalls (1970) hypothesis that schools of fish in exposed areas would suffer higher predation rates is reasonable. Areas of concentrated spring seepage could probably be located via systematic reconnaissance with a thermometer or observations of concentrated fish during hot periods.

Continued collection of water temperature would allow monitoring of changes in thermal conditions that might occur in the future due to beaver dam construction or other factors. The high temperatures in the upper reaches such as near Geodetic Trail and Gravel bottom are well documented so at least one thermometer deployed at the upstream sites could be moved to another stream reach where no temperature data has been collected to date.

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Figure 1.

**Number of young of year (YOY) and yearling and older (YOA) brook trout per acre in a 700 meter reach of Hunt Creek downstream of the Hunt Creek Fisheries Research Area. No habitat manipulation has occurred here during this time period.**

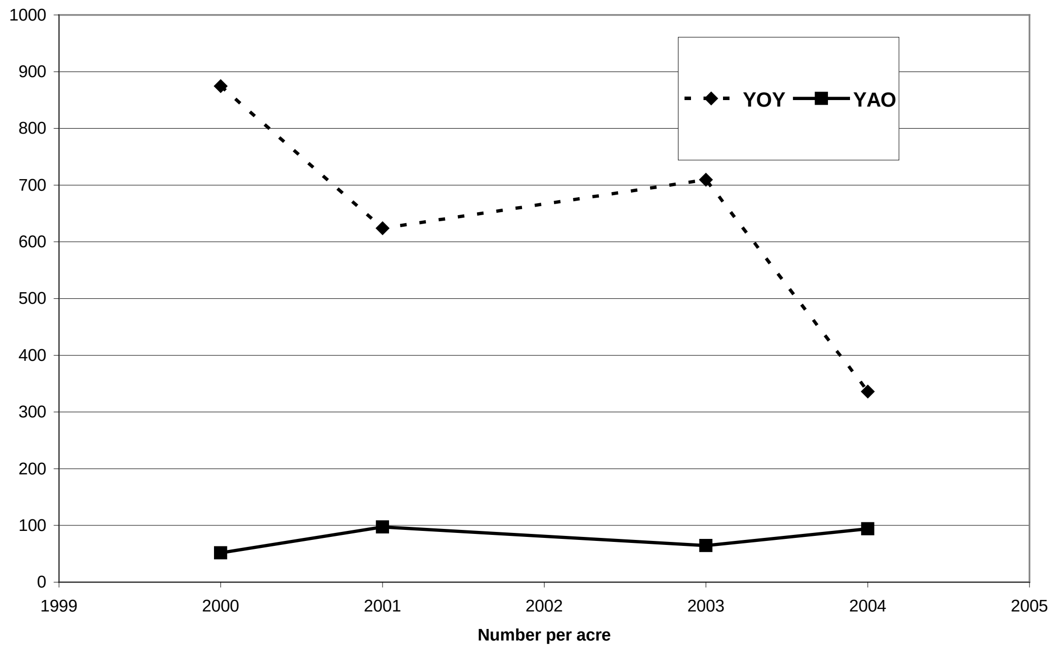


Figure 2. **Number of young of year (YOY) and yearling and older (YOA) brook trout per acre downstream of the Doty Trail sand trap on Canada Creek. LWD additions commenced in this reach in 2002.**

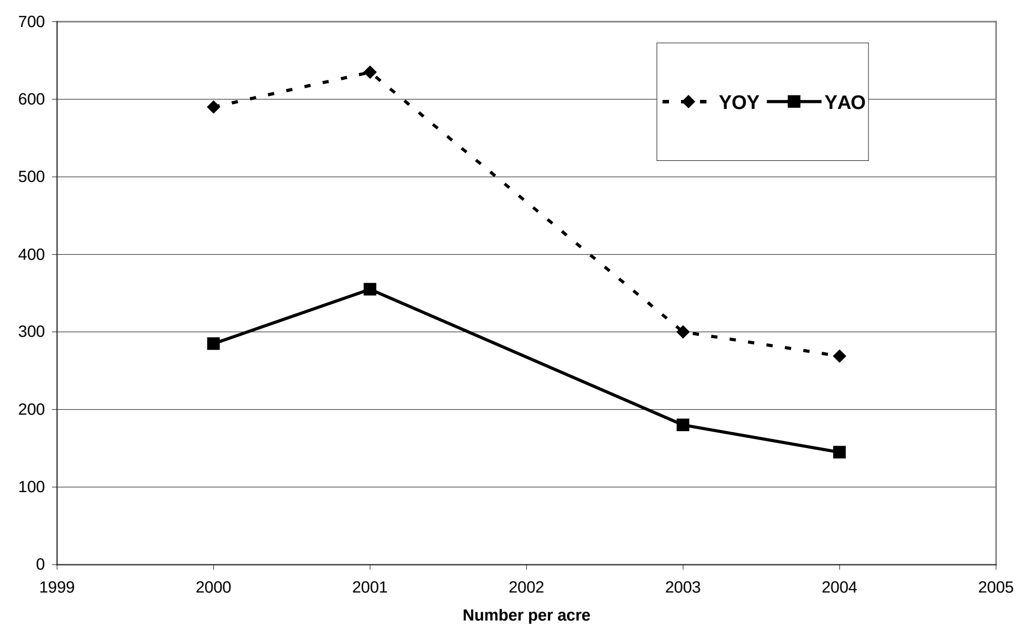

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**Figure 3 - Brook trout young-of-year density at status and trends sites during 2002-2004 compared to densities in Canada Creek near Doty trail**

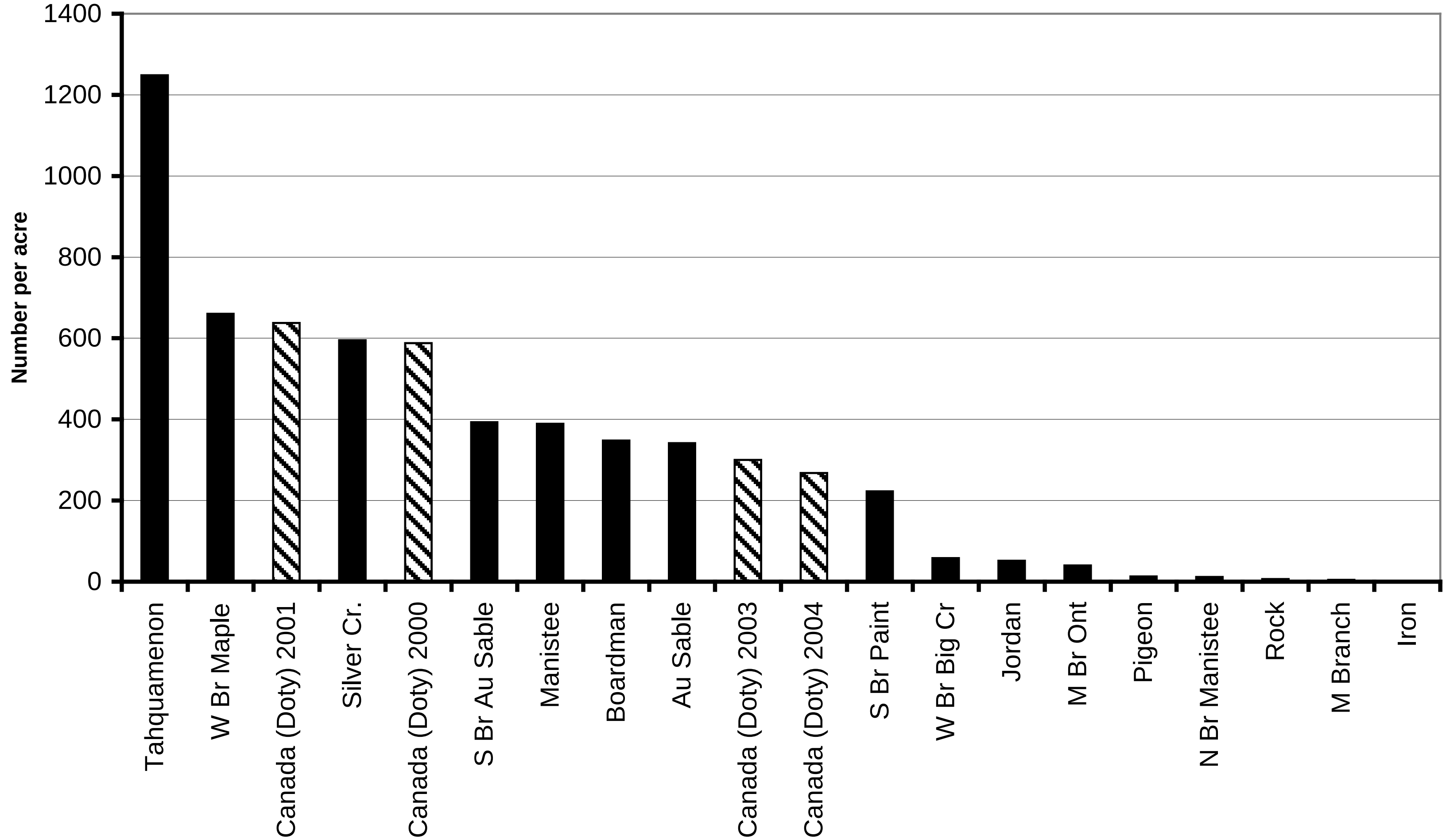

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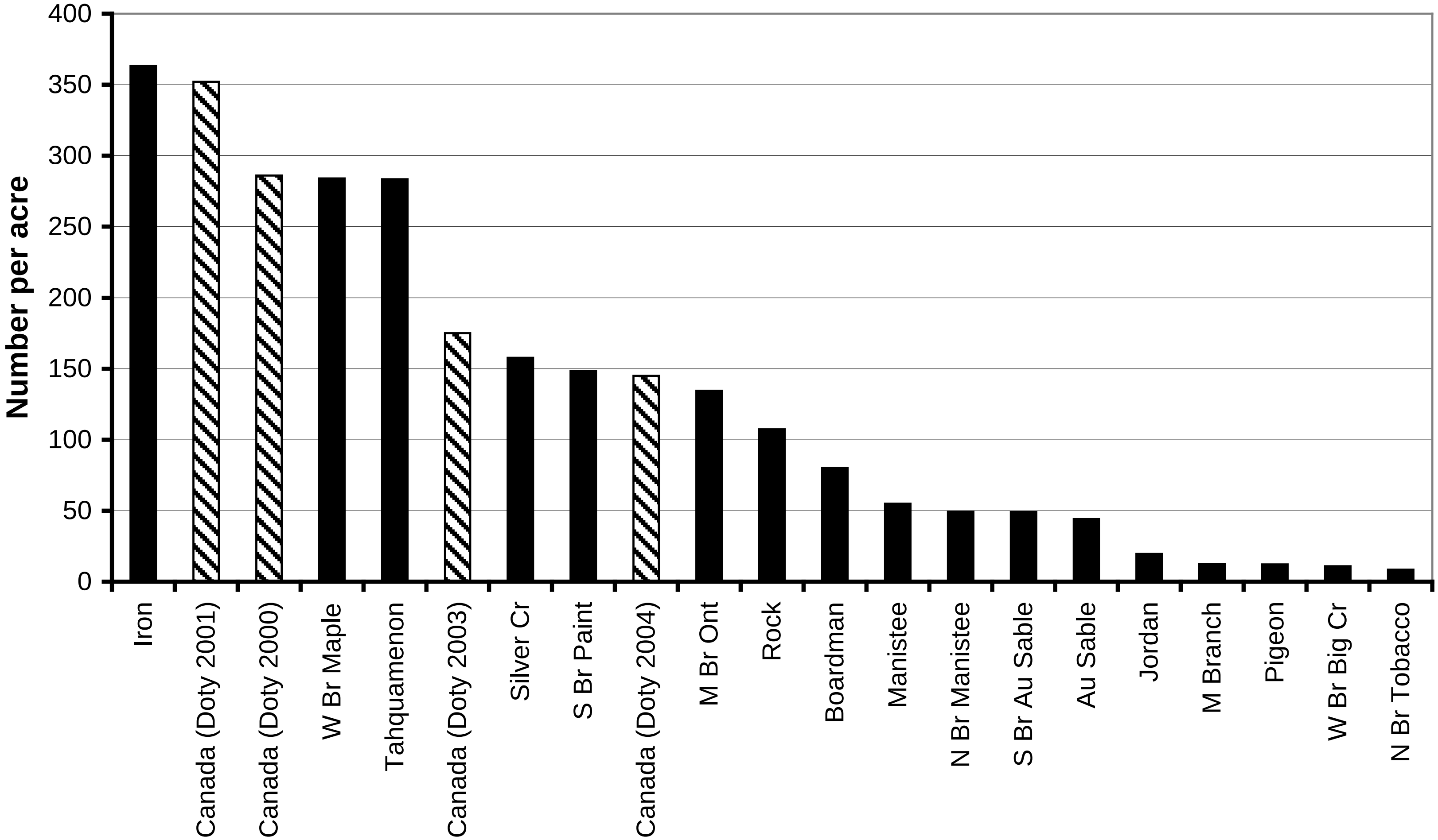
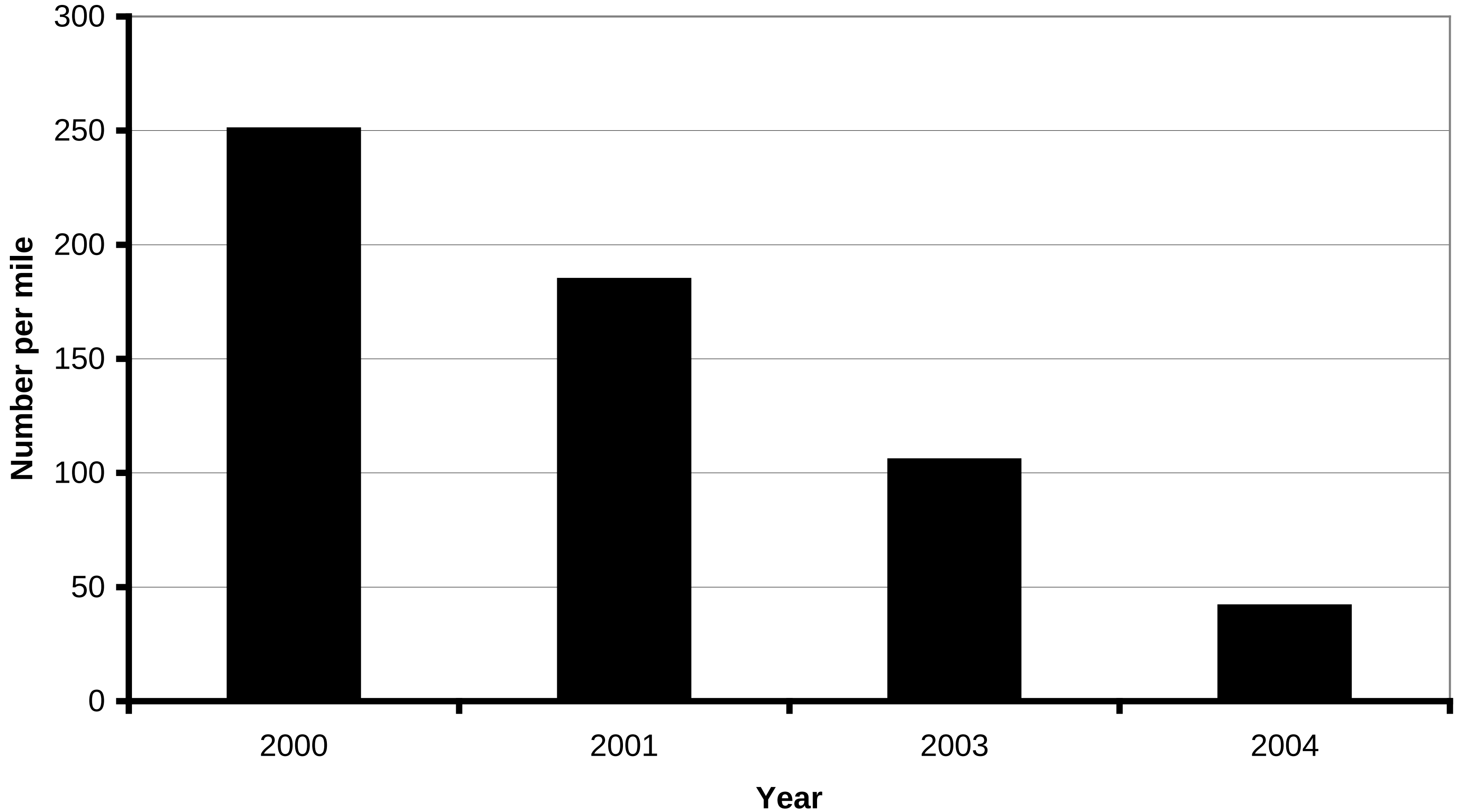
**Figure 4 - Brook trout yearling-and-older density at status and trends sites during 2002-2004 compared to densities in Canada Creek near Doty trail**



Analysis by: Andy Nuhfer, Hunt Creek Fisheries Research StationAnalysis by: Andy Nuhfer, Hunt Creek Fisheries Research Station~~Analysis by: Andy Nuhfer, Hunt Creek Fisheries Research Station~~~~Analysis by: Andy~~ Nuhfer, Hunt Creek Fisheries Research Station

**Numbers of brook trout longer than 8.0 inches in Canada Creek near Doty Trail**



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