N. Mac Donald

An ecological assessment of opportunities for fishery rehabilitation in the Pigeon River, Ottawa Co.

A report to The Pigeon River Watershed Advisory Council

M.J. Wiley and P.W. Seelbach

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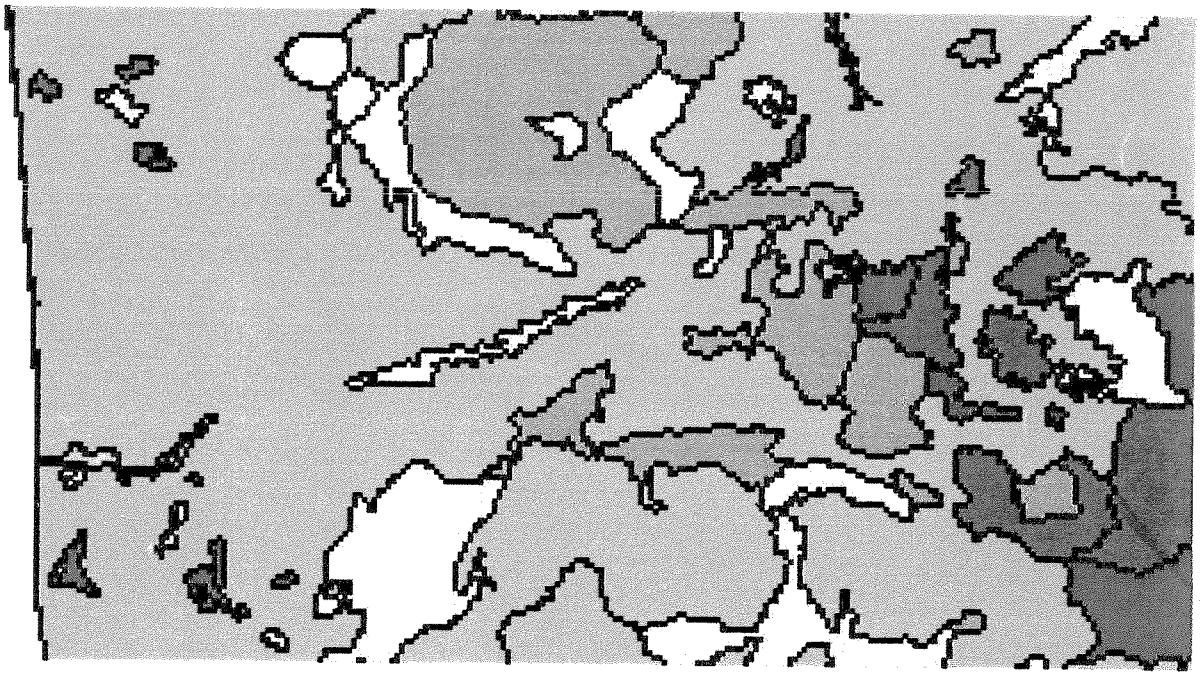

Figure 8. Pre-settlement vegetation in the Pigeon River basin.

Introduction and Problem Statement

The ecological character of a stream is determined by a combination of processes that operate at several spatial scales. These include the hydrology and geochemistry of the catchment, local valley hydrology and geomorphology, and placement within (and connections to) larger regional ecosystems and ecological processes. Geology, climate, and ecological history (including human activities) ultimately control these processes. Recognizing both large- and local-scale drivers; in this report we describe the character and status of the major, ecologically-distinct channel segments that comprise the Pigeon River system, and discuss potential management options. We specifically address fishery management issues, with a focus on the potential for managing a brown trout fishery in the middle segments. Such a fishery has existed in the past and assessing the current potential for its restoration is of primary concern to the many agencies that manage the Pigeon River ecosystem (Ottawa County Soil and Water Conservation District; Timberland Resource Conservation and Development Area Council; Ottawa County Drain Commissioner's Office; MDNR; MDEQ).

Methods

We followed the landscape-scale, systems-based conceptual approach to the study of rivers encouraged by the Michigan Rivers Inventory (MRI) project (Seelbach and Wiley 1997; Wiley and Seelbach *in prep.*). This approach stresses the examination of hydrologic, geomorphic, and ecological processes operating at both catchment and local scales. We also used several models of landscape--river relationships for southern Michigan developed within the MRI; specifically the Valley Segment Ecological Classification system (VSEC; Seelbach et al. 1997), and site-specific models of stream discharge (Wiley and Seelbach *in prep.*) and potential fish communities (Zorn et al. 1997).

We determined ecologically-distinct valley segments within the Pigeon system using methods established by Seelbach et al. (1997). Segment boundaries were identified by examining GIS maps for abrupt ecosystem changes marked by major junctures of the river network, or where the channel crosses clear boundaries in surficial geology or valley geomorphology. We then assigned attributes describing hydrology, summer temperature, valley morphology, and fish community structure by integrating interpretations from GIS maps (based on landscape-river relationships described in MRI models) with available local data and observations.

Hydrologic analyses were based on limited miscellaneous baseflow measures collected by Grand Valley State University (GVSU). No gaging nor miscellaneous measures were available from the U.S. Geological Survey. We estimated present discharge patterns (synthetic flow duration curves constructed from estimated discharges at a series of exceedence frequencies) for the Pigeon River based on summaries of catchment landscape characteristics and MRI regression models (Wiley and Seelbach *in prep.*). Summaries were developed for the Pigeon catchment using ArcView 3.0 software and map layers combiled within the MRI GIS (Seelbach and Wiley 1997; Table 1). In fact, the middle-lower Pigeon catchment is a fairly unique (sandy lakeplain) type that was not represented in the USGS flow-gage data used to build our models; thus it was initially difficult to develop realistic predictions. To better calibrate the models to observed data, we converted "sandy lakeplain" surficial landforms to "coarse-textured end moraines"—these were recognized by the models as capable of delivering substantial amounts of groundwater to the stream. We also estimated historical, pre-settlement discharge patterns by using pre-settlement vegetation summaries (Comer et al. 1995) where the models used landuse data as independent variables. Agriculture and Landuse were set at 0 % coverage. Forested wetlands, non-forested wetlands, and upland forests were set at 33.3 % coverage each for the upper watershed; at current values for the lower watershed; and at weighted average values for the entire watershed. We examined sources of localized groundwater inputs to the channel using a map of an index of potential groundwater loadings developed within the MRI (Wiley and Seelbach *in prep.*).

Assessments of water chemistry and temperature were based on data collected by GVSU personnel. We did not estimate thermal patterns using MRI models, as originally planned. Required model inputs include an index of estimated local channel groundwater loadings (extracted from the MRI map); however model (map) estimates did not match up well with observed groundwater loadings, indicating that it would not be worth running the temperature models. We assessed channel conditions from historical information (e.g., on dredging) and a visual reconnaissance.

Potential fish communities were assessed using MRI models (Zorn et al. 1998), which predict fish groupings likely to occur at a given catchment size and baseflow yield. Stream size and flow regime influence and constrain most of the proximal habitat variables important to fish: temperature, velocity, substrate, depth, and perturbations. Potential fish communities predicted by this method include species known to do well at comparable sites throughout Lower Michigan. We do not expect that all potential species would occur at any given site. Data on observed fishes were from MDNR surveys during 1969 and 1987, and GVSU surveys during 1996-97.

Ecologically-distinct valley segments

The Pigeon River is a small coastal stream (with a catchment area of approximately 150 km^2) that drains two large lakeplain depressions, the toes of several small, fine-textured moraines and a complex of old dune ridges (Figures 1 and 2). The lakeplain deposits are very sandy and relatively deep with high infiltration rates (likely 6-20 inches/hr). Infiltration on the dune ridges is even higher; on the moraine edges it is presumably much lower. Much of the lakeplain area has been adapted to agriculture, and extensive drainage extensions have been constructed throughout the upper 40% of the catchment.

We identified 3 ecological valley-segment units within the mainstem Pigeon River (essentially identical to those described by Van Hoeven 1996), and 1 that encompassed a major tributary (Table 2, Figure 1). The headwaters segment includes the river upstream of 116th Ave. (Figure 1—Segment 1). This segment drains a small catchment of mixed sandy loams, medium tills, and wet organic soils that are heavily drained and farmed (Figures 3, 4, and 5). Hydrology appears to be flashy with very low baseflows. Nutrient loadings are high from non-point and point sources, and summer DO is quite low. The channel network is largely artificial and well-dredged. Mean summer water temperatures are cool (according to the classification of Wehrly et al. 1998) but diurnally quite variable due to a lack of groundwater inputs, shallow and wide channels, lack of shading, and a warm point-source discharge. Potential fish communities are limited to the most tolerant, headwater species in the creek chub and brook stickleback groups (Table 3; Figure 6).

The next downstream segment (Figure 1—Segment 2) runs in a valley cut through sandy dune ridges down towards Lake Michigan; essentially from 116th Ave. downstream to just below West Olive Rd. No major tributaries enter this valley; and hydrology remains flashy but baseflows become fairly substantial due to substantial local groundwater influx (probably from the adjacent sand hills; Table 2). Nutrient and DO problems persist but diminish through this stretch. This low/modest-gradient channel has never been dredged and retains an impressive and active forested floodplain. Summer water temperatures appear fairly cold and are likely fairly stable through the day due to both groundwater influx and extensive shading. Potential fish communities under existing conditions include those species seen in marginal trout waters—we would expect representatives of the blacknose dace, creek chub, hornyhead chub, pumpkinseed sunfish, pirate perch, rockbass and white sucker groups to be present (Table 3; Figure 6).

The final mainstem segment begins where the valley opens up onto the lakeplain and runs to Pigeon Lake (Figure 1—Segment 3). Several small, groundwater-fed tributaries enter from the south, thus

size increases somewhat and hydrology remains fairly similar to Segment 2. Nutrient and DO problems are increasingly diminished . The channel has a low gradient with extensive floodplain wetlands. Summer water temperatures are cool-to-warm and fairly stable. Potential fish communities include pumpkinseed, pirate perch, rockbass, and white sucker groups (Table 3).

Ten Hagen Creek, tributary to Pigeon Lake, represents a final distinct ecological unit (Figure 1—Segment 4). This fairly-small creek drains the west slope of the sand hills at the southern edge of the watershed. It appears to have an intermediate hydrologic regime, with modest peakflows and fair baseflows (Table 2). Summer water temperatures are cool and moderately variable, and potential fishes include representatives of the blacknose dace and brook stickleback groups (Table 3; Figure 6).

Present hydrology

Baseflows

Low relief, coupled with relatively-fine textured sediments in the headwaters, yields very low baseflows to Segment 1 (Tables 2 and 4; Figure 7). Agricultural landuse practices also contribute to these reduced baseflows (Figure 5). Baseflows are nearly doubled by a point-source discharge, but this is a warm-water discharge and so its ecological function is very different from that of groundwater baseflow.

Catchment baseflow yield increases substantially in Segment 2 due to groundwater influx to this more-defined valley that cuts through higher dune deposits. This incised valley is rich in groundwater and historically supported a ribbon of wetland conifers along the stream corridor (Figure 8; Comer et al. 1995); today it supports forested wetland (Figure 5). The substantial groundwater influx was surprising for a stream draining sandy lakeplain; most such rivers are similar to the Pigeon's southern neighbor, the Macatawa River, which receives very little groundwater input. Indeed, our map of estimated groundwater loadings, which has proven useful across most of lower Michigan, did not suggest much influx from the dune ridge to the north of Segment 2 (Figures 1 and 2). However, in southern Michigan, the surficial aquifers generally drain from centrally-located northern and southern lowlands, down towards either the Great Lakes or the proglacial Grand River valley; a large, linear depression that runs from Saginaw Bay through the Saginaw, Maple, and Grand rivers to Lake Michigan (Figure 1; Mandle and Westjohn 1988). Thus there is likely a concentration of groundwater movement (and a high water table) to Lake Michigan, through sandy lowlands near the lower Grand River. The Pigeon River channel has been able to incise vertically to this water table through the deep sands bordering Segments 2 and 3; Segment 1 is perched above this water table, draining less-erodable clay landforms (Figure 1). Influx to the channel is likely enhanced in Segment 2 by the hydraulic head generated within the northern sand ridge. We were able to generate the observed groundwater influx by coding the sand ridge as coarse-textured end moraine; however this is somewhat misleading as the regression models interpreted this as a typically much higher elevation feature than is present along the Pigeon. Mandle and Westjohn (1998) suggested that upwelling of groundwater from shallow bedrock (Marshall sandstones) can also occur near the proglacial Grand River lowland, however water chemistry data from the Pigeon River do not suggest increasing concentrations of solids or salts in the lower segments (unpublished data, Pigeon River Watershed Council; Wuycheck 1990).

Catchment yield appears fairly small, when computed using the entire upstream drainage basin (0.06-0.09 cfs/km^2 based on 104 km^2; Tables 2 and 4). However, the high additive groundwater influx into Segment 2 originates from a small local land area; the groundwater yield to the channel from this local area is quite high (0.26-0.44 cfs/km^2 based on only 16 km^2; Tables 2 and 4). This locally-significant baseflow discharge is transported, however, within a channel that has been sized (in terms of width and depth) to accommodate the much larger peakflows generated by the entire upstream catchment. As a result the hydraulics and channel habitat are more similar to those seen in warmwater streams—in general fairly wide, shallow, slow-moving habitats. However in terms of temperature, this high local

yield has an immediate and dramatic cooling impact on this segment (see below). A major withdrawal for irrigation occurs at the lower end of this valley segment. Such artificial reductions of flow volumes, which apparently can be substantial during the summer, accelerate warming of the newly-aquired groundwater, and also reduce stream depths and velocities.

Baseflow yields are unknown for Segment 3 (down to Pigeon Lake) but likely diminish somewhat. If the Pigeon River is receiving significant regional groundwater, then this likely continues to accrue to the channel. Ten Hagen Creek (Segment 4) has a fair baseflow yield (Tables 2 and 4), receiving some groundwater flux as it drains upland dune deposits on its way to Pigeon Lake.

Peakflows

Data on peakflows are quite limited for this system. This discussion is based on the synthetic peakflows shown in Table 4 and Figure 7. The relatively fine-textured tills and lakeplain sediments in the upper headwaters likely produce high runoff. This would be accentuated (especially during saturated periods) by existing, extensive agricultural drainage modifications (Wiley and Seelbach *in prep.*). The sandier hills that dominate the downstream catchment likely only produce modest runoff.

Historic hydrology

A sense of historic hydrology was provided by running our regression models with historic land cover data as inputs. It must be noted, however, that this stretches the application of the models beyond the data ranges from which they were built; and thus these results are speculative.

Historic baseflows in the upper basin were likely only slightly higher (Table 4; Figures 9 and 10). We assumed that baseflows in the lower basin were similar to those seen today.

Historic spring (represented in this analysis by annual statistics) peakflows in the upper basin were likely much lower than those seen today (Table 4; Figure 9). The models suggest they were about 20% lower but we suspect this is an underestimate; the wetland-dominated, bowl-shaped upper basin should have stored a great deal of storm and melt water. Interestingly, the models suggest that historic summer peakflows in the upper basin were actually higher than today (Table 4; Figure 10). Agricultural practices (e.g., drainage) lowers the summer water table, exposing more dry soils that store small summer stormwaters; it is not clear how the presence of extensive wetlands would have offset this phenomenon. We assumed that peakflows in the lower basin were similar to those seen today.

Water quality

High nutrient levels and low dissolved oxygen conditions indicate severely-degraded water quality in much of the upper Pigeon system (Table 2). Concentrations diminish progressively downstream, as dissolved loads are diluted by the substantial mid-river groundwater influx, and as in-channel processing occurs. However, water quality appears to be a factor limiting fish distributions throughout both the upper and middle portions of Segment 2, as well as throughout Segment 1. Mid-day oxygen concentrations are quite low by stream standards and suggest minimum concentrations may drop below 4 ppm during the night in much of the upper river. These values are sufficiently low to induce avoidance reactions in many fish and are clearly below the incipient lethal levels for trout. Ammonia levels are also quite high, and in conjunction with observed pH values (approaching 8), may lead to toxic levels of un-ionized ammonia (NH_4OH). Un-ionized ammonia can interact synergistically with low oxygen, increasing the negative effects of both on fishes. Segments 2-4 are designated trout streams by the Michigan Department of Natural Resources (MNDR), Fisheries Division; and as such carry special standards for water quality protection by the MDEQ (O'Neal 1996). Wuycheck's (1990)

use of water quality summaries from more-northern trout streams seems appropriate as a reference set, since Segment 2 receives significant groundwater inputs. Historically, the upper Pigeon catchment was largely wetlands (Figure 8; Comer et al. 1995) that likely discharged little in the way of water or nutrients. We also note that current water quality measures at the lowest sampling station on the river approach Wuycheck's (1990) standards.

Summer water temperatures

Wehrly et al. (1998; Figure 11) developed a summer thermal classification matrix for streams that includes both the weekly mean and the weekly range (indicative of the diurnal range) of July water temperatures. Placement of temperature data (an educated guess for lower Segment 2) for the segments on this template provided a description of temperature dynamics within the system and an assessment of potential trout habitat within the system (Table 2; Figure 11). In July 1997, temperatures in Segment 1 showed cool means with moderate variability. The upper end of Segment 2 also had cool means but low variability; due to the substantial influx of groundwater, the remainder of Segment 2 became cold and with low variability (data from July 1998)—ideal for trout survival and growth (Table 2; Figure 11; Wuycheck 1990). Segment 3 is likely cool with moderate variability. Collection of temperature data throughout Segments 2 and 3, to clarify this analysis, should be a priority for river managers. Summer temperatures in Ten Hagen Creek were cool with low variability—borderline for trout.

We believe temperatures in Segment 2 of the Pigeon River are on the warmer edge of the temperature range suitable for trout survival, held there by the strong local influx of cold groundwater. Thermal conditions in this segment would be sensitive to any changes that would reduce the cooling capacity of this groundwater, including water withdrawals that reduce flow volume and channel/riparian alterations that increase solar heating.

Channel characteristics

The state of the channel system in the Pigeon River varies dramatically between segments. In the upper portion of the watershed the network is largely artificial and deeply dredged. Sand bars and eroding banks were commonly observed in the lower portions of the Pigeon mainstem in Segment 1. Given the sandy nature of the lacustrine deposits and the extensive drainage network, this is not very surprising. The problem likely needs attention only where bank erosion threatens property value or where drainage problems ensue. Given the ease with which sand is eroded, the artificially increased water load in the upper river will necessarily carry substantial sediment loads during high water. It is important to remember that in rivers--sediment load, water load, and channel shape exist in a dynamic equilibrium. Sand delivery by water from the drained portion of the catchment likely has played a role in keeping incision and bank erosion in Segment 2 to a minimum despite the artificial extension of the catchment area by almost 40%. Sand channels are extremely sensitive to the balance between water and sediment budgets. Reductions in sediment transport without reductions in water transport could lead to significant channel incision and/or bank erosion downstream in Segment 2.

In Segment 2 the channel has not been dredged and retains the wide and shallow profile typical of a sand-bottomed river. The abundance of woody debris plays an extremely important role in maintaining favorable channel conditions in this segment. Frictional resistance slows the mean flow velocity during high water periods, promoting overbank flow into the floodplain and helping to stabilize the channel cross-section. At the same time local turbulence around fallen trees and root-wads promotes localized scour pools and bank undercuts that are critical fish habitat features. Maintenance of the riparian floodplain forest and of the large woody debris in this channel segment is essential to its management as supportive of a fishery resource. Removal of the wood in an attempt to

improve drainage will result in serious bank erosion, the loss of most riffle-pool structure, and likely vertical channel incision.

The lack of significant gravel and cobble riffles is noteworthy throughout the river. Stream banks likewise indicated little to no available coarse till to supply the channel with gravels. Both Farrand and Bell's (1984) Quaternary Geology map, and the county soils survey data indicate that almost all of the catchment lies in deep sandy deposits devoid of coarser materials. This suggests to us that sand traps, wing dams, v-wiers, and other channel manipulations designed to enhance gravel availability for fish spawning via local bottom erosion are unlikely to be useful here. The sandy nature of this channel is natural and largely unavoidable. Natural spawning by salmonids will be unlikely, indeed a careful review of the evidence suggests, that despite reports to the contrary, self-sustaining populations of brown trout probably never occurred in the Pigeon River (see below). The artificial establishment of small gravel beds for spawning might be possible in Segment 2 given its high rate of groundwater input, shallow cross-section and relatively low slope. The primary question affecting feasibility is whether shear forces in the channels are insufficient to transport gravel at high flows, but sufficient to keep gravel clear of sand at low flows.

Fishery management issues

The Pigeon River is a small stream system and as such it can be expected to have a rather restricted fish fauna. It is also a coastal system with open connections to Lake Michigan and has available a substantial species pool by virtue of that connection. Our models (Table 3 and Figure 6) suggest that there are approximately 34 species (excluding stocked salmonids and potential lake migrants) which have a possibility of residing somewhere within this system. We do not expect all of these fishes to ever be present simultaneously, but the relatively low number of species occurring in fish samples taken during this past decade (21 in total) is indicative of a stressed river system. This discrepancy between potential and observed fauna is most extreme below 120th Avenue where thermal and structural habitats are quite good but water quality is poor. For example, at West Olive Rd the model predicts a potential fauna of over 30 species but only 9 have been recorded. Likewise, at Pigeon Creek Park our model predicts 36 species possible but only 10 have been found. By this standard the headwaters areas (represented in the analysis by the site at 96th Ave) look to be in relatively good condition (with 13 species compared to a potential of 17 species); this due to the fact that small flashy headwater streams naturally present a challenging environment to stream fishes. Ten Hagen Creek appears somewhat intermediate in this regard (11 species predicted but only 5 observed). There are some important differences between the four ecological segments in terms of their potential fish assemblages and in the likelihood of their supporting a significant sport fishery.

Ecological Segment 1: the headwaters

The headwaters of the Pigeon River contain a large number of very small to medium-sized channels with generally very low baseflow yields (.01 cfs/km^2 or less; Table 2; Figure 7). Both annual (spring) and summer peakflows are much higher than would typically be seen in a trout stream system (Figures 7 and 13). Both the model and existing collections suggest the fauna here is limited to small, relatively tolerant fishes in the brook stickleback, creek chub, and pumpkinseed groups (see Table 3 for individual taxa listings; Figure 6). There is little potential for sport fishing in these streams with the possible exceptions of angling for bullheads, small sunfishes, and occasional migrants from the lower reaches of the Pigeon. Much of the channel network here is close to being intermittent, and many locales may have significant fish populations only during the wettest portions of the year.

Ecological Segment 2: the upper Pigeon valley

Segment 2 is a special case for the Pigeon. Its relative high groundwater loading and intact riparian valley provide excellent potential trout habitat if water quality and stormflow problems can be solved (Figures 6, 7, 12, and 13). Substantial public ownership provides excellent access to this segment that

further enhances its sport fishery potential. This segment is a legally-designated trout stream although brown trout appear to have been absent for the last two decades.

Various reports have suggested that the Pigeon River has not been able to support stocked brown trout since the early 1970's, while prior to that time it contained a self-sustaining brown trout population. A careful re-examination of the MDNR survey data and stocking records indicated that the MDNR regularly stocked three trout species (brook, brown, and rainbow trout) into the Pigeon system from 1938-1971 (Table 5). Stocking ended in 1971 after a MDNR survey indicated the presence of large brown trout and staff suggested that the trout population was self-sustaining. MDNR survey records from 1969 report the presence of several brown trout in the 20-inch range, and a 16-inch rainbow trout. Interestingly, there is no record of young-of-year trout being taken in that survey; this would have been the definitive evidence for local reproduction. The youngest fish taken were in the 5-7 inch range; these were likely 1+ year old fish that were stocked that year. The decision to cease stocking was consistent with the MDNR policy of not stocking streams with naturally reproducing populations. Whether or not the trout were reproducing in the Pigeon is difficult to assess with certainty at this point. However, we found no historical data that supports such a conclusion and the sandy channels characteristic of this stream would certainly make widespread spawning difficult. At any rate, once stocking was discontinued it is not surprising that trout populations declined, and by the early 1970s, few if any of the fish stocked in the late sixties would have been left. When MDNR crews sampled the stream again in 1987, as might be expected no brown trout were found. An occasional steelhead has been observed in recent years, but these are migratory fishes that frequently stray into small coastal streams, and their presence indicates little about the habitat potential of such sites.

Based on the existing evidence it is difficult to conclude that water quality *alone* (as opposed to cessation of stocking) was responsible for the loss of the trout fishery in the Pigeon River. It is clear that today, oxygen concentrations at Pigeon Creek Park are sometimes below what most would consider incipient lethal levels for trout (5-6 ppm) during low flow periods (Table 2). Ammonia and nitrite levels may likewise be problematic. But water quality is much improved by the time the river gets to the end of Segment 2 (around West Olive Rd.), and little data are available on temperature or chemistry in Segment 3. It is possible that the lower parts of Segment 2 may be able to hold trout at the present time, although improved water quality upstream would certainly benefit this portion of the segment as well.

Ecological Segment 3: the lower Pigeon valley
Historical data from this section is lacking but local fisherman reportedly take northern pike. Pike were present in samples near US31, which is near the upstream end of this unit. Our predicted 30 potential species for this segment included a number of sport fishes: northern pike, bluegill, bullheads, and rock bass. Given the direct connection to Lake Michigan, yellow perch, suckers, and stray steelhead and salmon are likely as well. This connectivity is important to the character and ecological integrity of coastal streams. Maintenance of this free passage for fish populations should be a long-term principle for the management of this system.

Ecological Segment 4: Ten Hagen Creek
Ten Hagen Creek was regularly stocked with brook trout during the early-mid 1900s. It has distinctly more groundwater feed than most of the streams of its size in this basin, but it is very small. The catchment is also heavily forested which provides both habitat and shading. Our model suggests that this stream is marginal for cold-water species and is likely to be dominated by dace and sculpin (Table 3; Figures 6 and 11). However, we had no baseflow yield measurements from Ten Hagen. In order to make model runs we used discharge ratios from June 1997 to estimate Ten Hagen's late summer discharge. This approach could easily overestimate baseflow yields, giving Ten Hagen a cooler predicted fauna than it really has. Fish collections in Ten Hagen Creek were made by the MDNR in 1969 and 1987. Fishes found included the coolwater preferring blacknosed dace and mottled sculpin, but primarily were species tolerant of warmer and varied water temperatures: grass pickerel,

mudminnows, and creek chubs. There seems little potential for trout management in this stream unless subsequent data show that it is truly cold enough for trout. Future temperature and flow measurements should clarify this situation.

Overall impressions

The Pigeon River system includes a diverse set of fish habitats, ranging from warm and flashy headwaters to a cold, more stable central valley, to the cool and heavily-shaded Ten Hagen Creek. The potential fish fauna is diverse indeed, at least as predicted by our model. However, observed fish assemblages are not very diverse and are oddly similar throughout the catchment; being dominated by more tolerant species like the grass pickerel, blacksided-darter, bluntnose minnow, and creek chub. In our experience, metabolic stress in aquatic communities often leads to a shift towards a typically warm water fauna. Temperature, oxygen concentrations, and flow velocities interact in aquatic environments to regulate maximum rates of oxygen uptake. Declines in oxygen levels and/or flow velocity reduce metabolic scope and favor warmer-water organisms which are pre-adapted to increased metabolic stress. In this sense the currently surviving fish fauna may be not the best indication of what the potential of the Pigeon River really could be. Hydrologic data and long-term temperature monitoring should clarify the extent to which a trout fishery can be developed.

Conclusions and recommendations for management

1. The Pigeon River is a small coastal stream draining a sandy lake-plain catchment. Extensive agricultural development and significant point source effluents in Segment 1 have contributed to poor water quality and excessive stormflows which we believe has reduced the fish community to a relatively small assemblage of fairly tolerant species. This is particularly unfortunate with regards to fishery management because Segment 2 of this unique system has the potential to support stocked brown trout given adequate water quality and flow regime, and the lower valley already provides excellent habitat for northern pike. Rehabilitation of aquatic communities in the Pigeon River will require a dramatic improvement in its basic water quality. Oxygen demand, nitrite, and ammonia levels originating in Segment 1, in particular, will limit fish communities and development of a coldwater fishery downstream.
2. We strongly recommend that the highest priority be given to preserving the natural setting and exceptional habitat features of Segment 2: an intact riparian forest ecosystem is providing important shade, operational floodplains, extensive woody debris and channel heterogeneity, stable banks, and cooling groundwater inputs.
3. We recommend more extensive surveys of temperature, baseflow yields, and channel habitats. This is especially important within Segment 2, which has the potential to support a coldwater fishery; and in Segments 3 and 4, for which very little data are now available. We urge the advisory council to seriously consider funding the installation of a long-term gauge in Segment 3 of this system. Good flow data will be necessary to both manage the Pigeon's potential as a coldwater fishery, and to track changes in its hydrology associated with future changes in both natural and anthropogenic factors.
4. We recommend that watershed managers frame their concerns for sediment inputs within the larger picture of overall stormwater management. This system drains lacustrine and dune sand deposits and the sand bed of the stream is normal. There are essentially no sources of gravel or cobble to the river. Sand traps, extensive bank stabilization, and instream deflectors are unlikely to lead to significant improvements in substrate composition. (Although, additions of spawning gravel might be feasible in certain areas.) Since the channel runs through deep, movable sand deposits, any major changes in the sediment budget could induce significant new channel erosion (lateral and/or vertical).

The sources of the river's suite of nonpoint-source problems; stormflows, sediments, and nutrients; are the dramatic landscape and hydrologic modifications that have taken place in the headwater reaches of Segment 1. Much of this flat-bottomed, bowl-shaped region was originally extensive wetlands (Figures 3 and 8); releasing little in the way of water, sediments, or nutrients to Segment 2. This upper basin was likely not highly connected to the lower Pigeon River, which effectively began its catchment (catchments for both peak and low flows) just above the upper end of Segment 2. With wetland drainage, Segments 2 and 3 now receive the full stormwater load of the upper basin (but almost no baseflow from this flat, groundwater-poor basin).

Our vision for rehabilitation of the Pigeon River system is based on this perspective: an upper wetland basin, little connected to a small groundwater-charged lower river valley. We encourage rehabilitation of wetland areas in the upper basin that would store and process stormwaters, and associated nutrients and sediments. The lower river could be managed as essentially beginning with Segment 2, according to the above recommendations.

5. Brown and/or brook trout could be stocked into Segment 2 as an adaptive management experiment. A careful analysis of survivorship, growth, and dispersal through Segments 2 and 3 would provide a foundation for future decisions regarding development of a trout fishery. There are presently limited data on the ability of stocked trout to survive in this system. It seems possible that in the the lower parts of Segment 2 and the upper parts of Segment 3, some carry-over of stocked trout may be possible even under existing water quality conditions.

   We don't expect brown trout to reproduce, as they require well-aerated gravels. Brook trout, on the other hand, are known to reproduce in spring seeps within sand-bottomed streams (Latta 1965). As significant groundwater enters the channel within Segment 2, there might be some possibility of natural reproduction by stocked brook trout.

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Table 1. Summaries of characteristics for the Pigeon River (Ottawa County) sub-catchments that were used as input variables to multiple linear regression models that predict stream discharge that occurs at various frequencies (Wiley et al. 1999). Summary values are proportions of the sub-catchment comprised by each category. Variables used in the models but not listed were zeroes.

				Surficial geology		Soil texture		Land covers			
Sub-catchment	Drainage Area- km^2	Annual precip.-in	Catchm. Slope-%	Coarse tills	Lake plain	Sandy	All Wet	Agric.	Urban	Open wetland	Conif. forest
Upper Pigeon	92	32.8	0.22	0.06	0.79	0.02	0.98	0.76	0.03	0.002	0.08
Lower Pigeon	22	32.0	0.37	0.31	0.69	0.56	0.44	0.16	0.05	0.001	0.35
Entire Pigeon	114	32.7	0.24	0.11	0.76	0.12	0.88	0.65	0.03	0.002	0.12

Table 2. Ecological descriptions of Pigeon River segments. Data from Pigeon River Watershed Council and Michigan Department of Environmental Quality (Wuycheck 1990; Lesmez, 1998, Personal Communication).

Ecologically- distinct valley segments	Station ID	Catchment area (km^2)	Baseflow (cfs)	Baseflow - Point source Q (cfs)	Baseflow yield (cfs/km^2)	July Temps (°C) 1997-98 Mean	Min	Max	Min July DO (mg/l) ~'91	'96	Max July NH4 (mg/l) ~'91	'96
Segment 1: the headwaters Headwaters to 116th Ave; and upper tributaries • high peak, low base flows • warm, variable summer temps • very low gradient, channel unconfined across lakeplain, medium tills	P1 @ 96th Ave P2 @ 104th Ave SW @ Croswell Ave	27 33 13	0.3 3.1 0.2	0.3 0.1 0.2	0.011 0.003 0.015	20.6 21.1	16.5 16.5	25.9 27.1	6.2 5.9	2.0 1.5	1.1 4.7	0.2 3.7
Segment 2: the upper Pigeon valley 116th to just below US-31 • high peak, fair base flows; high local groundwater influx • cold, moderately-variable summer temps • low gradient, channel confined in glacial-fluvial valley incised into sand hills	P3 @ Pigeon Park P4 @ West Olive Rd P4: Valley only-- (P4-P3: yields from valley portion only; upstream ignored)	88 104 16	4.7 8.8-11.8 4.1-7.1	2.4 6.5-9.5 4.1-7.1	0.027 .063-.091 .256-.444	19.9 17.6	17.5 15.6	22.8 19.2	7.8 7.7	3.0 5.0	2.5 0.5	1.0 <0.1
Segment 3: the lower Pigeon valley Below US-31 to Pigeon Lake • high peak, fair base flows • cool, moderately variable summer temps • very low gradient, channel unconfined across lakeplain; floodplain wetlands •	At lake	150	??	??	??		??		8.0	??	0.9	??
Segment 4: Ten Hagen Creek • moderate peak, fair base flows • cool, moderately variable summer temps • moderate gradient, channel unconfined •	TH2 @ Butternut Dr TH3 @ Blair	3 6	0.5 0.7	0.5 0.7	0.167 0.117	19.4 19.9	17.1 18.3	21.7 22.6				

Table 3. Potential and observed fish fauna for a number of sites in the Pigeon River system. Observed fishes (data type = obs) were from 1969 and 1987 MDNR surveys (1996 GVSU surveys are included within obs/87). Predicted fishes (data type = pred) are based on MRI database modeling (Zorn, Seelbach, and Wiley unpublished model). Potentially good populations are shown by "G"; with likely marginal populations shown by "M". Actual presence is shown by "X". Presence of stocked fish is shown by "S". Bolded taxa are indicator species for groups of fishes with similar ecological requirements (distributional guilds). For the Lower Segment 2, predicted fishes are shown both for the present catchment and considering the lower valley catchment only.

Channel segment	Segment 1 Headwaters			Upper Segment 2 Upper Valley			Lower Segment 2 Lower Valley			Segment 4 Ten Hagen Creek		
data type/year	pred	pred	obs/87	pred	obs/69	obs/87	pred	obs/69	obs/87	pred	obs/69	obs/87
road crossing	96th	104th	96th	park	park	park	WOlive / Valley	WOlive	WOlive	upper	upper	upper
brook trout							M / G			M		
slimy sculpin							M / G			M		
coho salmon							M / G			M		
blacknose dace	M	M		G			G / G			M		X
mottled sculpin				G			G / G			M	X	
brown trout					S		. / M	S		M		
chinook salmon							. / M			M		
rainbow trout						S	. / M	S		M		
brook stickleback	G	G		G			G / .			M		
n. redbelly dace	G	G		G			G / .			M		
hybrid sunfish	G	G	X	G			G / .			M		
burbot												
longnose dace												
creek chub	G	G	X	G			M / .				X	X
redfin shiner	G	G		G			M / .					
stoneroller minnow	G	G		G			M / .					
common shiner	G	G	X	G			M / .					
bluntnose minnow	G	G	X	G	X		M / .					
Johnny darter	G	G		G	X	X	M / .	X	X			
freshwater drum												
quillback carpsuck.												
gizzard shad												
hornyhead chub				M			G / M					
grass pickerel			X	M	X	X	G / M		X		X	
lake chubsucker				M			G / M					
logperch												
brook silversides												
mimic shiner												
shorthead redhorse												
sand shiner												
tadpole madtom				M			M / .					
flathead catfish				M			M / .					
white crappie				M			M / .					
common carp				M		X	M / .					
bowfin				M			M / .		X			
black crappie				M			M / .					
spotted sucker				M			M / .					
pirate perch			X	G		X	G / .		X			
golden shiner			X	G		X	G / .					
northern pike			X	G		X	G / .	X	X			
blacksided darter				G	X	X	G / .	X	X			
mudminnow			X	G	X	X	G / .	X	X		X	X
pumpkinseed	M	M	X	G		X	G / .		X			

Channel segment	Segment 1 Headwaters			Upper Segment 2 Upper Valley			Lower Segment 2 Lower Valley			Segment 4 Ten Hagen Creek		
data type/year	pred	pred	obs/87	pred	obs/69	obs/87	pred	obs/69	obs/87	pred	obs/69	obs/87
road crossing	96th	104th	96th	park	park	park	WOlive / Valley	WOlive	WOlive	upper	upper	upper
bluegill	M	M		G	X	X	G / .		X			
green sunfish	M	M	X	G		X	G / .		X			
yellow bullhead	M	M		G	X		G / .	X				
black bullhead	M	M	X	G	X		G / .					
rock bass				G			G / M	X				
brown bullhead				G			G / M					
longear sunfish				G			G / M					
largemouth bass				G			G / M		X			
rainbow darter				G			G / M					
silver redhorse												
golden redhorse												
greater redhorse												
smallmouth bass						X			X			
black redhorse												
striped shiner												
river chub												
northern hog sucker												
stonecat												
greenside darter												
walleye												
channel catfish												
spotfin shiner												
white sucker	M	M	X	G	X	X	G / .	X	X		X	X
fathead minnow	M	M		G			G / .					
yellow perch												
rosyface shiner												
species richness	17	17	13	38	10	14	41 / 16	9	13	11	5	4
game fishes	2	2	3	4	3	4	5 / 2	4	2	1	0	0
trout					X	X	M / G	X		M		
northern pike			X	G		X	G / .	X	X			
sunfishes	M	M	X	G	X	X	G / .		X			
bullheads	M	M	X	G	X		G / .	X				
rock bass				G			G / M	X				
smallmouth bass												
walleye												
channel catfish												

Table 4. Discharge yields (cfs/km^2) at specific exceedence frequencies for Pigeon River (Ottawa Co.) subcatchments. Summaries are shown for both annual and summer (August) time periods.

Subcatchment	Drainage area– km^2	05% exceedence	10% exceedence	25% exceedence	50% exceedence	75% exceedence	90% exceedence	95% exceedence
Annual								
Upper Pigeon	92	0.03	0.03	0.05	0.12	1.38	0.65	0.91
Lower Pigeon	22	0.32	0.33	0.34	0.46	0.55	0.93	1.04
Entire Pigeon	114	0.08	0.09	0.10	0.19	1.22	0.70	0.93
UP-historical	92	0.04	0.05	0.07	0.16	1.38	0.65	0.72
LP-historical	22	0.32	0.33	0.34	0.46	0.55	0.93	1.04
EP-historical	114	0.10	0.11	0.12	0.22	1.22	0.70	0.78
Summer								
Upper Pigeon	92	0.00	0.01	0.02	0.03	0.07	0.14	0.21
Lower Pigeon	22	0.13	0.20	0.25	0.30	0.42	0.70	1.06
Entire Pigeon	114	0.03	0.04	0.06	0.09	0.14	0.25	0.35
UP-historical	92	0.02	0.02	0.05	0.08	0.13	0.21	0.31
LP-historical	22	0.13	0.20	0.25	0.30	0.42	0.70	1.06
EP-historical	114	0.04	0.05	0.09	0.12	0.18	0.31	0.41

Table 5a. History of stocking trout in the Pigeon River, Ottawa County. Data from Anonymous (1934-present). Stocking rates are shown as fish per year. Fish ages are shown as "fr" for fry, "f" for fingerlings, and "y" for yearlings.

Year	Stocking site	Brook trout	Brown trout	Rainbow trout
1934-39	128th, 136th Ave.'s	0	933 f	0
1940-44	120th—152nd Ave.'s	0	4,800 fr; 140 f; 645 y	0
1945-49	152nd Ave.	0	0	120 y
1950-54	120th, 152nd Ave.	400 y	140 y	260 y
1955-59	120th Ave.	220 y	135 y	310 y
1960-64	120th Ave.	270 y	240 y	235 y
1965-69	120th—152nd Ave.'s	0	300 y; 1200 f	0
1970-97		0	0	0

Table 5b. History of stocking brook and brown trout in Ten Hagen Creek, Ottawa County. Data from Anonymous (1934-present). Stocking rates are shown as fish per year. Fish ages are shown as "fr" for fry, "f" for fingerlings, and "y" for yearlings.

Year	Stocking site	Brook trout	Brown trout	Rainbow trout
1934-39		0	0	0
1940-44	160th Ave.	800 f; 70 y	0	0
1945-49	160th Ave.	140 y	0	20 y
1950-54	160th Ave.	240 y	0	0
1955-59	160th Ave.	60 y; 160 f; 2,000 fr	0	0
1960-64	160th Ave.	520 y	0	40 y
1965-97		0	0	0

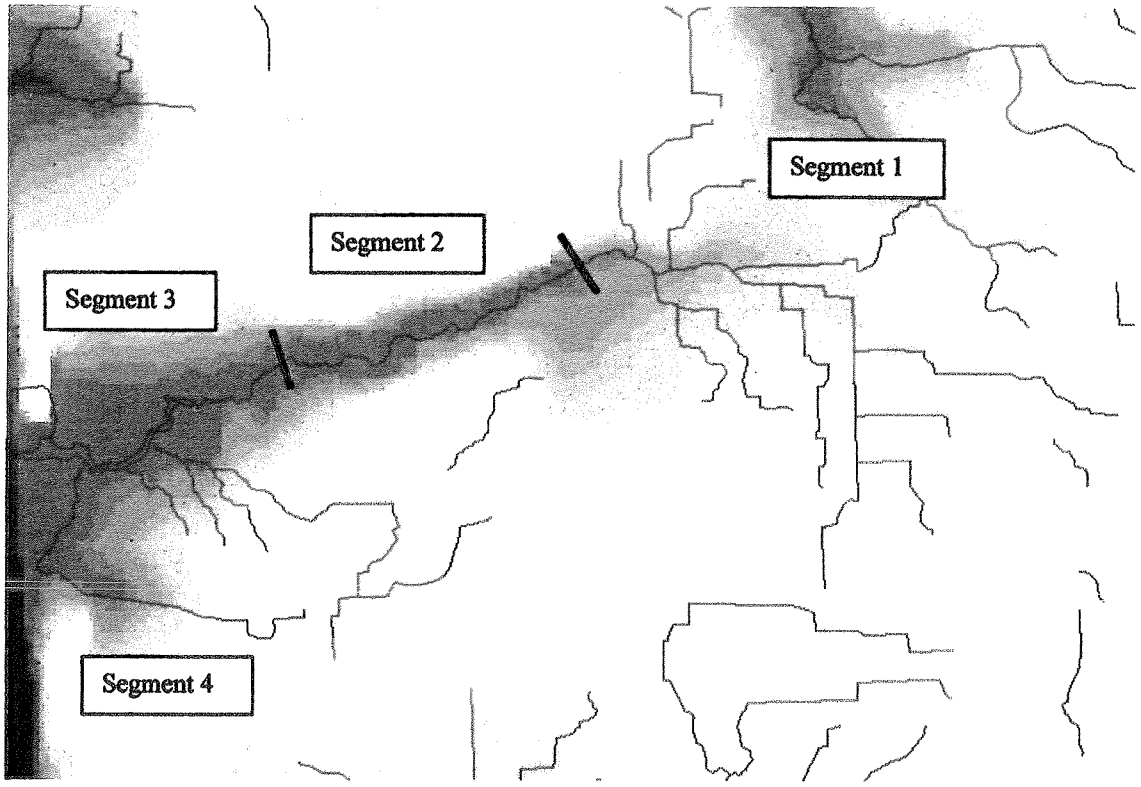

Figure 1. Elevation map of the Pigeon River (Ottawa Co., MI) watershed, showing the incised middle-lower river valley. Lower elevations are shown as darker shades of gray. Ecological valley segments are shown by break lines and labels.

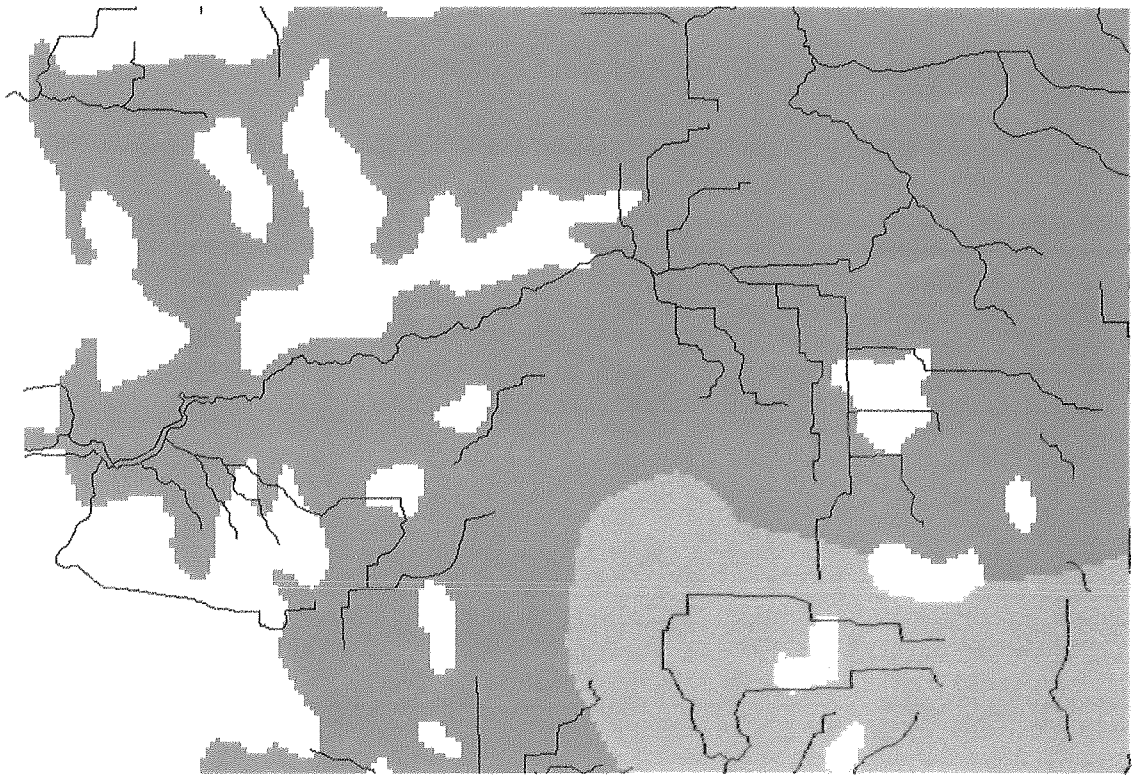

Figure 2. Quaternary geology of the Pigeon River (Ottawa Co., MI) watershed. Colors represent the following geologic types: blue—sandy lacustrine plain; lime green—fine textured moraine; white—dune sand.

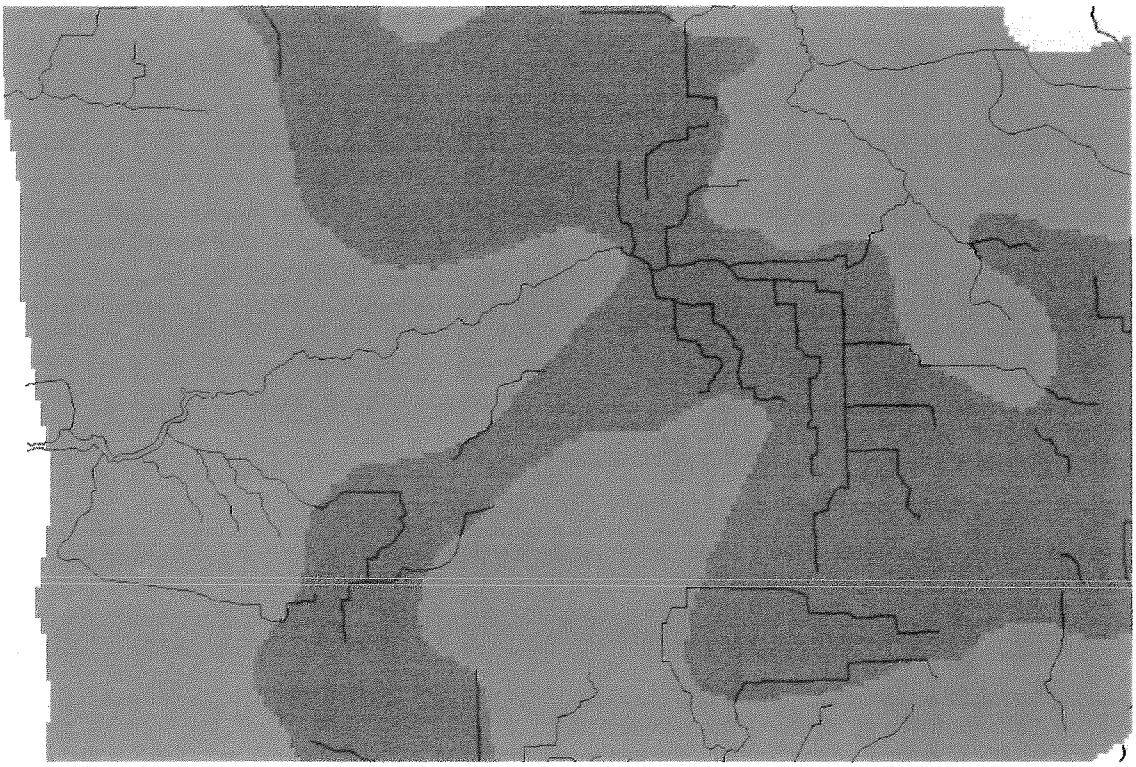

Figure 3. Hydric soils classification of the Pigeon River (Ottawa Co., MI) watershed, based on a recoding of the soil textures map. Colors represent soil groups as follows; light green—highly permeable; blue and dark green—highly impermeable.

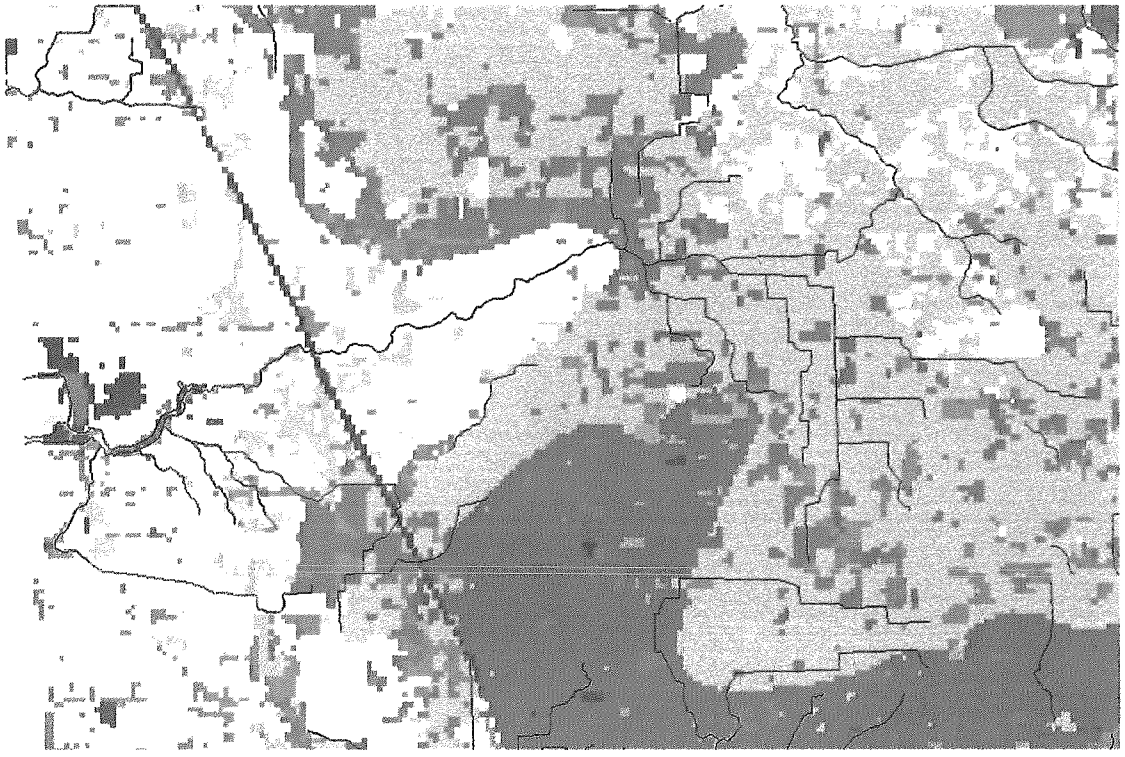

Figure 4. Soil Conservation Service Runoff Curve numbers for the Pigeon River (Ottawa Co., MI) watershed. Yellow represents the least runoff; grading to red representing very high runoff.

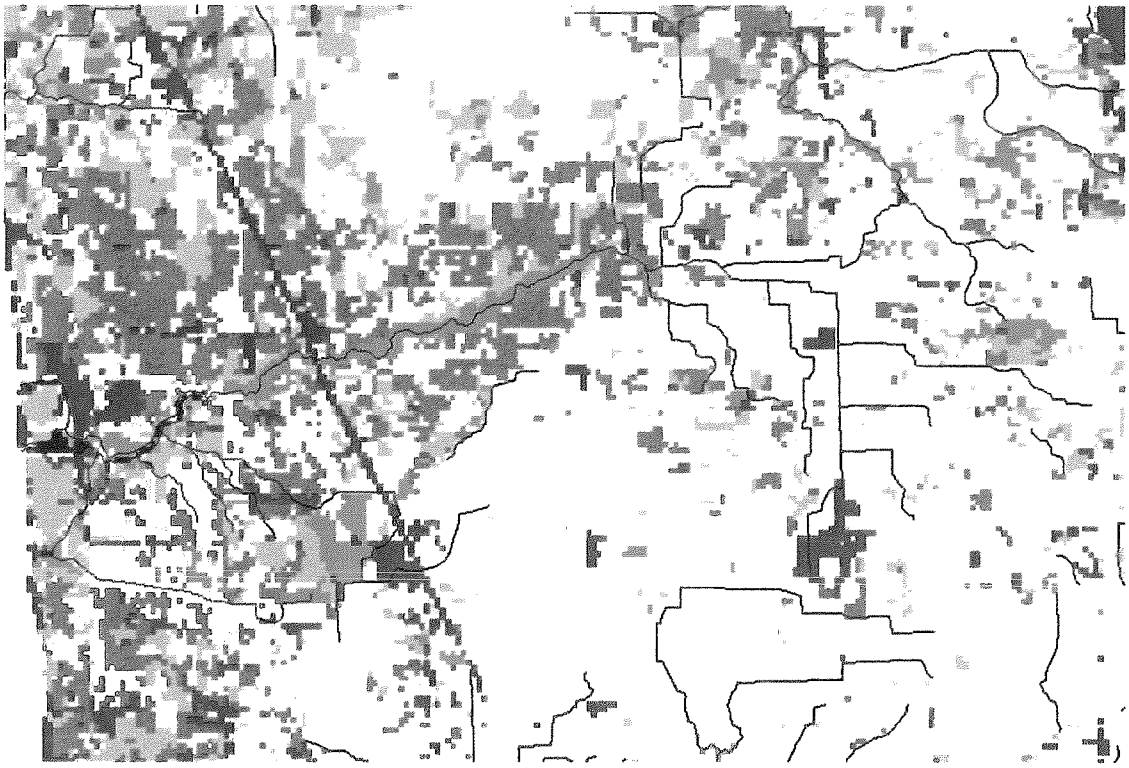

Figure 5. 1978 Landcovers in the Pigeon River (Ottawa Co., MI) watershed. Colors represent the following landcovers: yellow—agriculture; red—urban; light green—deciduous forest; dark green—coniferous forest; pale blue—forested wetland.

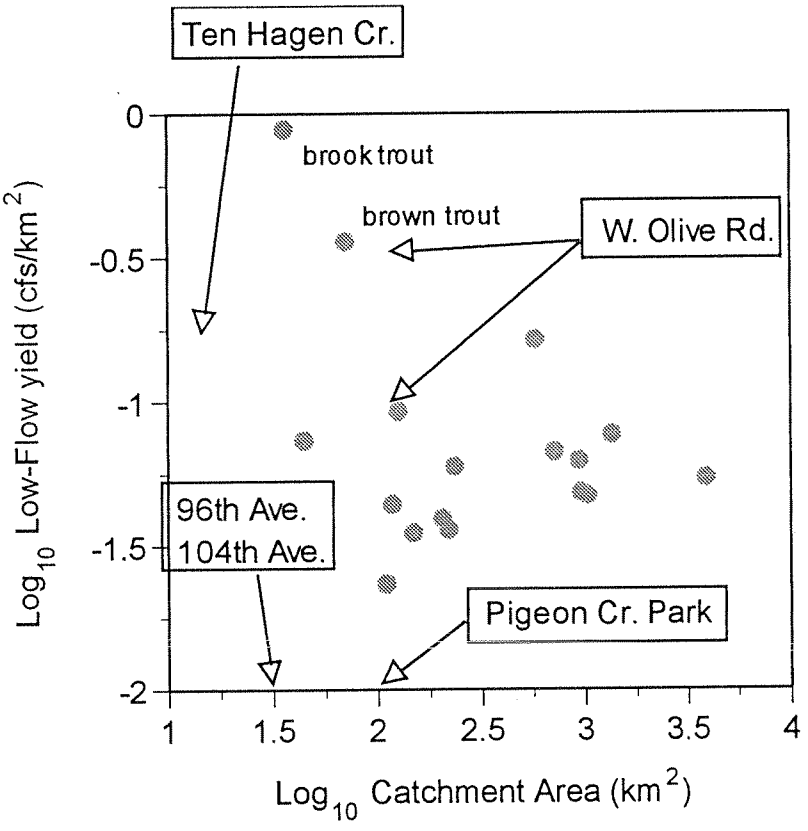

Figure 6. The position of sites within the Pigeon River (Ottawa Co., MI) plotted on key ecological axes of low-flow yield and catchment area (Zorn et al. 1998). The positions of fish association clusters common to lower Michigan are also shown, with trout groups noted (Zorn et al. 1998).

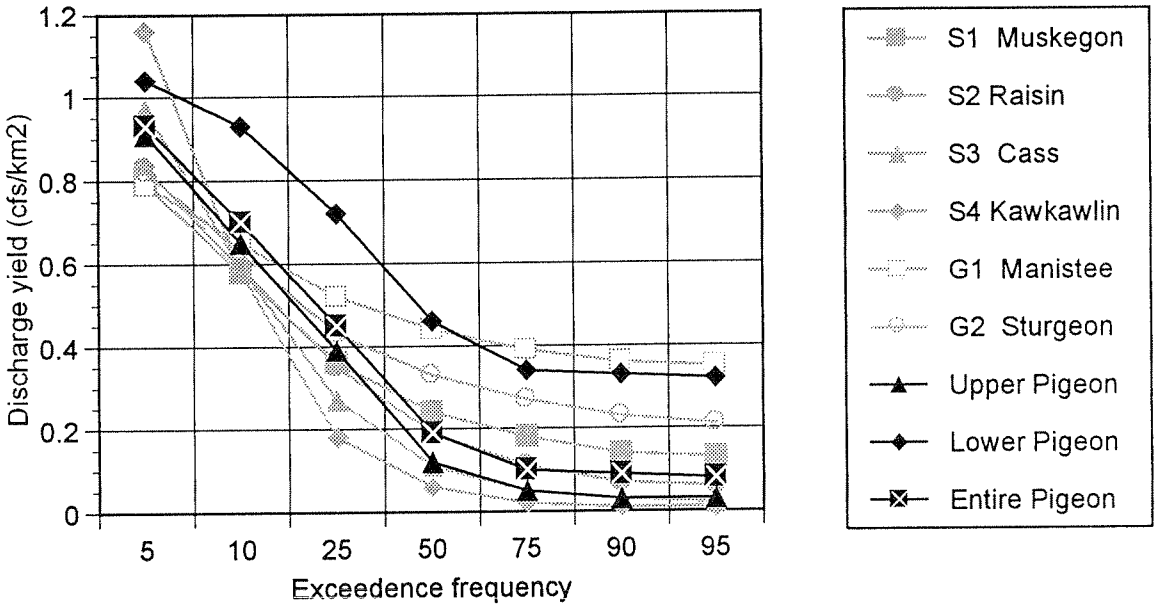

Figure 7. Synthetic annual flow duration curves for the portions of the Pigeon River (Ottawa Co., MI) basin, plotted against the range of curves typically seen in lower Michigan for groundwater (G1-G2) and surfacewater (S1-S4) rivers (Seelbach et al. 1997).

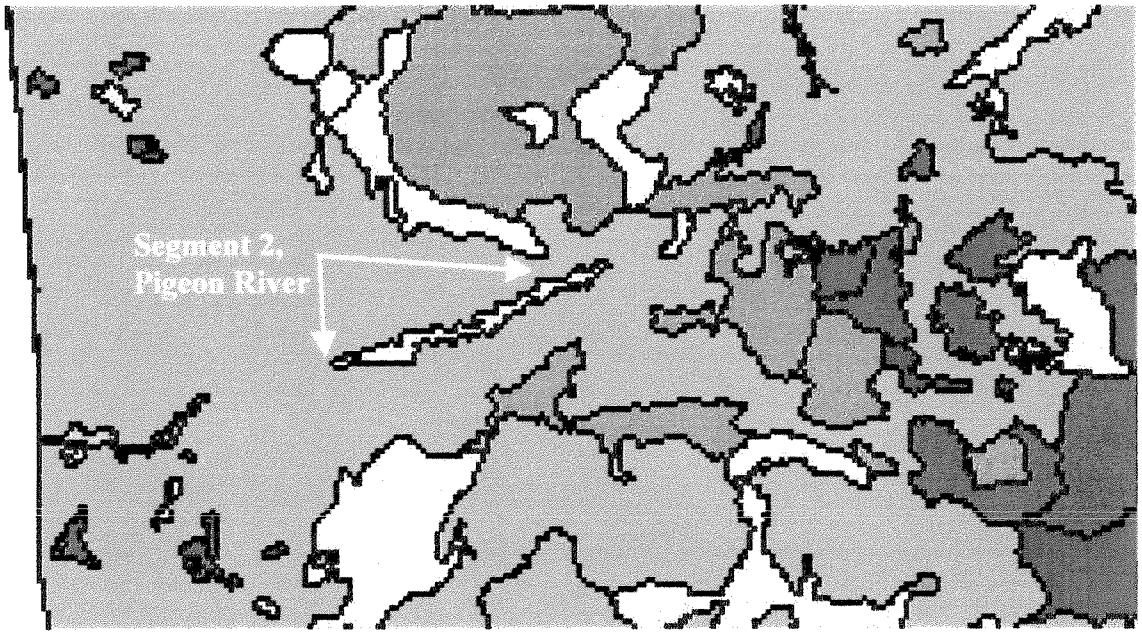

Figure 8. Pre-settlement vegetation in the Pigeon River (Ottawa Co.) basin (from Comer et a. 1995). Colors represent the following vegetation groups: dark green—coniferous forest; medium green—beech/hemlock forest; light green—lowland conifer wetland; orange—shrub wetland; brown—lowland hardwood wetland. Segment 2 of the Pigeon River is clearly represented here by a linear, groundwater-fed, lowland conifer wetland.

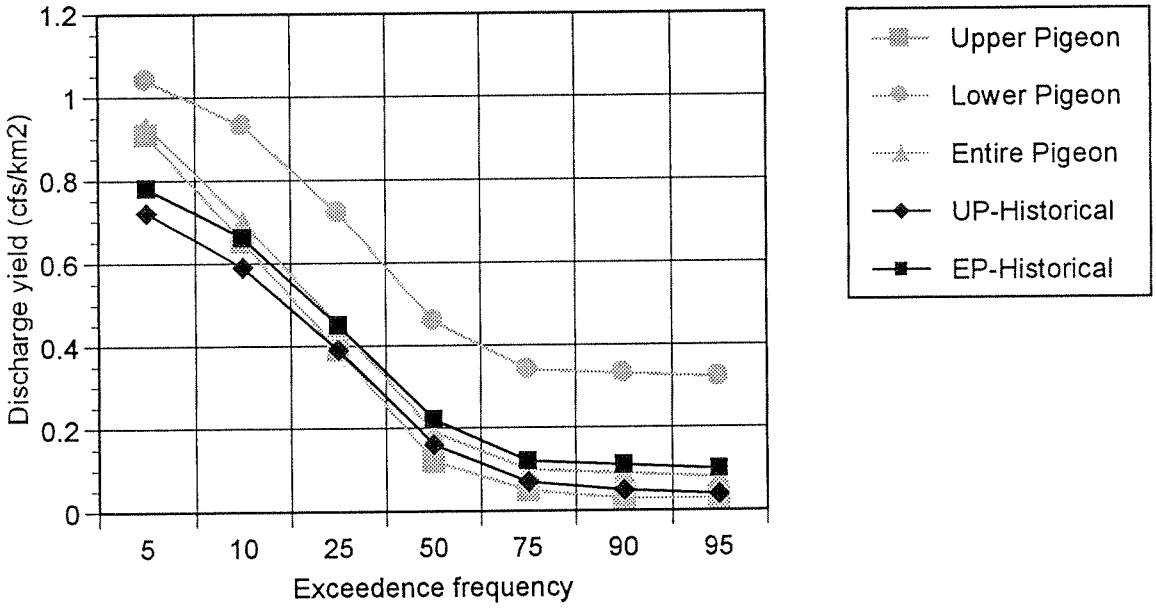

Figure 9. Synthetic annual flow duration curves for portions of the Pigeon River (Ottawa Co., MI) basin, plotted against synthetic curves estimated for pre-settlement land cover conditions.

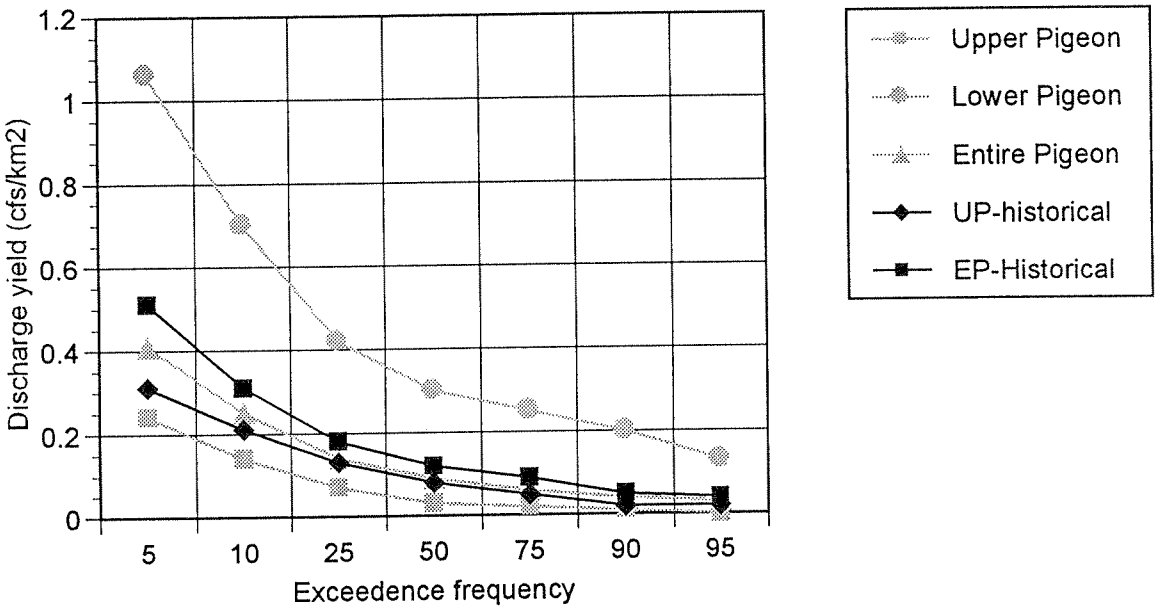

Figure 10. Synthetic summer flow duration curves for portions of the Pigeon River (Ottawa Co., MI) basin, plotted against synthetic curves estimated for pre-settlement land cover conditions.

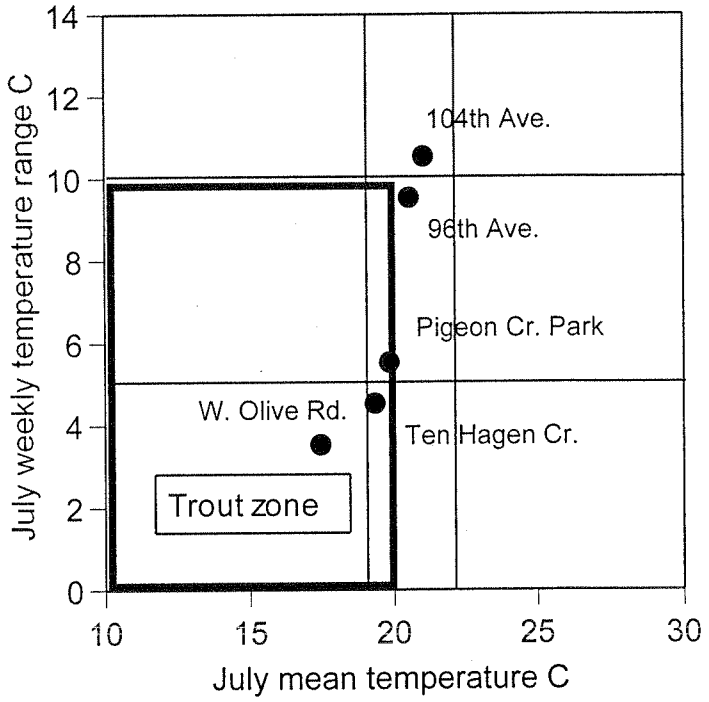

Figure 11. July temperature regimes at sites within the Pigeon River (Ottawa Co., MI), plotted on Wehrly et al.'s (1998) thermal classification for lower Michigan rivers. The zone where trout typically flourish is within the dark outline.

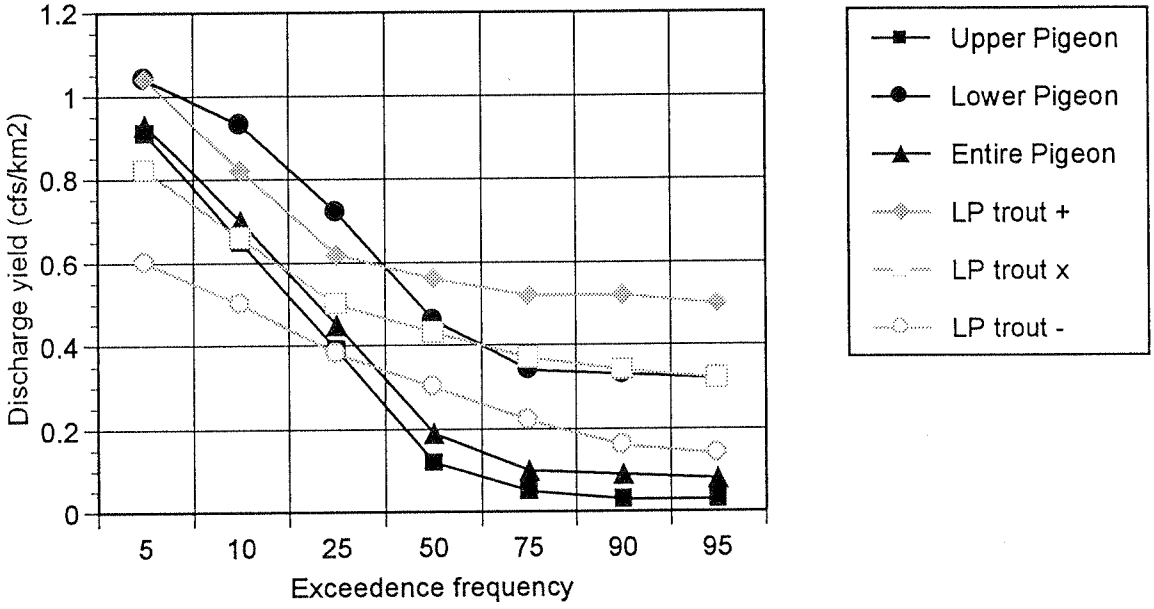

Figure 12. Synthetic annual flow duration curves for portions of the Pigeon River (Ottawa Co., MI) basin, plotted against curves representing streams in lower Michigan with abundant trout populations. "LP trout x" represents the mean value for these streams. "LP trout +" and "LP trout –" represent ± 2 standard errors of this mean.

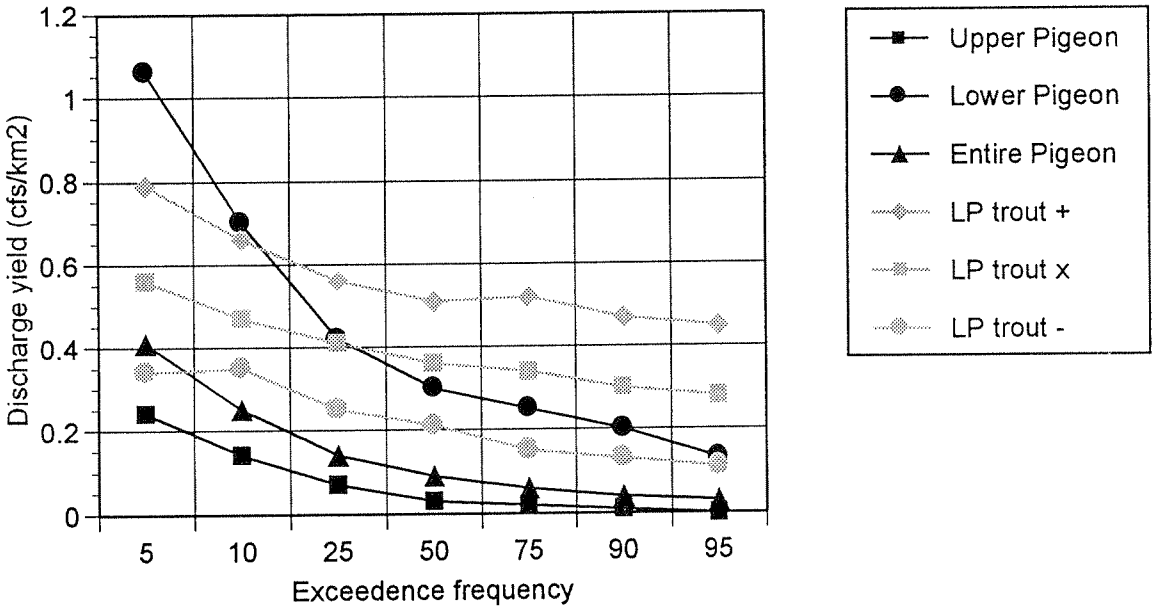

Figure 13. Synthetic summer flow duration curves for portions of the Pigeon River (Ottawa Co., MI) basin, plotted against curves representing streams in lower Michigan with abundant trout populations. "LP trout x" represents the mean value for these streams. "LP trout +" and "LP trout –" represent ± 2 standard errors of this mean.