AQUATIC MACROINVERTEBRATE BIOTIC CONDITION INDEX (BCI) TREND 1986-2002

The following information concerning aquatic macroinvertebrate monitoring discusses trend from 1996-2002. Data was collected in 2003 and 2004, however, due to the 2-year analysis time that these samples take from the laboratory, current data is still not available.

Aquatic macroinvertebrates are invertebrates that live in water and can be seen by the unaided human eye. They provide an important ecological link between microscopic food organisms and fish. Because of their strict habitat requirements they are useful indicators of aquatic habitat conditions and changes (Mangum 1986). Aquatic macroinvertebrates include insects, such as the commonly thought of mayflies, stoneflies, caddisflies, and diptera (two-winged flies), crustaceans, mollusks, and freshwater earthworms (Mangum 1986). Many of these groups are most highly developed in running water environments, as still water lakes and ponds are generally short-lived geologically (Hynes 1970). Stony fast water streams have remarkably similar major fauna groups throughout the world (Hynes 1970). The current force exerted by fast water streams is one of the most significant characteristics of their habitat, and aquatic macroinvertebrates have evolved a variety of anatomical and behavioral adaptations to it. These include a flattened body, streamlined shape, suckers, friction pads and hooks, small size, secretions, ballast (such as caddisfly houses), living in slow water among vegetation or friction layers on the stream bottom, upstream movement in the water, and upstream dispersal of winged adults (Hynes 1970). Many small insect stages utilize habitat deep in the gravel of streams (the hyporheic zone). For example, a study in southern Colorado found the nymphs of many chlorperlid stoneflies were not available in surface sediments until just before emergence; the authors surmised their use of hyporheic habitat (DeWalt and Stewart 1995).

Hafele and Roederer (1987) provide a short summary of aquatic insect life cycles in a stream. Aquatic insects go through a series of life stages in a stream. Insects with incomplete metamorphosis go through three stages: egg, nymph, and adult. This group includes the mayflies and stoneflies. Insects with complete metamorphosis go through four stages: egg, larva, pupa, and adult. This group includes the caddisflies and dipteria. The eggs hatch into young nymphs and larva. The majority of their life will be spent in the nymph or larva stages. While growing these go through a variety of stages called instars. It is these nymph and larval stages that are usually collected in aquatic macroinvertebrate samples. The nymphs and larva (which go through a pupal stage first) then leave the water through emergence to become winged adults. The adults reproduce and lay eggs, completing the cycle.

The most resistant life stage of many aquatic insects is the egg. Hynes (1970) noted eggs of many aquatic insects could survive dry for many months and gave an example of several taxa that survived a D.D.T. treatment of a tropical stream, presumably as eggs. According to Hynes (1970) extended hatching periods are common in many aquatic stream insects. Aquatic insects have a variety of life cycles with a few having multiple generations per year, many having one generation per year and some taking more than a year for each generation. Even with species that have annual generations, there may be overlapping generations (Hynes 1970). These factors increase the likelihood that the more resistant egg stages are present over prolonged periods, reducing the impacts of a short-term environmental disturbance such as flooding. These cyclic and highly variable populations also mean that monitoring of individual taxon populations is unfeasible for land management monitoring purposes.

Aquatic macroinvertebrates are responsive to changes in aquatic habitat condition due to land management actions. Mangum (1975) found a reduction in numbers and biomass of aquatic macroinvertebrates in the North Fork of Three Creeks, Utah, likely due to sedimentation from construction. In the Provo River, Utah, low numbers of macroinvertebrates were attributed by Mangum (1975) to artificially low winter streamflow and scouring from artificially high summer flows resulting from interbasin water transfers. In the Fremont River, Utah, Mangum (1975) found very low numbers of taxa at the station below Johnson Reservoir. Water chemistry, low winter flows, and siltation were likely causes of the depauperate flora at this site. Many land management actions have resulted in chronic impacts. These chronic impacts likely have long-term impacts on macroinvertebrate community structure.

Evaluations of aquatic invertebrates are complicated by the naturally dynamic nature of their communities. For example, Hynes (1970) found large variations in species composition for no apparent reason. He described a nine-year study where composition of the fauna varied considerably among years despite consistent sampling, timing of samples to avoid emergence, and a lack of obvious change in the stream. Seven years into the study *Baetis* became very abundant and several other species quite scarce. This change persisted for two more years.

Biomass and numbers of aquatic insects can undergo patterns of seasonal change. Losses are caused by predation and emergence of adults (Hynes 1970). A study in eastern Idaho found large unexplained changes in aquatic macroinvertebrate numbers over 3 years (Platts and Andrews 1980). In some cases natural disturbances can result in new taxa being found. Hynes (1970) relates two examples of streams that dried up and then refilled which had new species appear for a while and then disappear again.

Robinson et al. (1993) noted a loss of 10 taxa (almost a third of all taxa) during the spring runoff season of a snowmelt stream subject to high seasonal runoff. The snowmelt stream had more mobile taxa compared to a stable flow groundwater stream.

Hynes (1970) discussed how summer high water flows had reduced the macroinvertebrate fauna in a stream. Cloudburst flood in early August left the streambed barren two weeks later. Macroinvertebrate numbers increased dramatically, peaking about 2 months later, with the initial recovery dominated by Chironomidae and Simuliidae. The Ephemeroptera, Trichoptera, and Plecoptera reappeared more slowly. While flooding may lead to an upstream decrease of insects, it can increase drift and numbers of insects downstream, which can rapidly recolonize lower stream reaches (Hynes 1970).

Low streamflows are another natural factor that affects aquatic macroinvertebrates. Winget and Mangum (1979) describe macroinvertebrate samples from the West Fork of the Duchesne River, Utah, which dropped from 36 taxa to 30 taxa over the course of one year. Analysis showed clean water species were eliminated by drought conditions. Hynes (1970) discussed a rapid resurgence of aquatic macroinvertebrates (Chironomidae) after a drought. Fire is also a natural disturbance that affects aquatic macroinvertebrates. A study in central Idaho showed that wildfire disturbed streams had lower species richness than streams in nearby undisturbed watersheds (Richards and Minshall 1992).

Biotic Condition Index (BCI)

The Biotic Condition Index (BCI), developed by Winget and Mangum (1979), provides a quantitative measure of aquatic health due to overall watershed condition, land management activities, and natural disturbances. The BCI incorporates water quality (sulfate and alkalinity), stream habitat (substrate and gradient), and a database of environmental tolerances of aquatic macroinvertebrate taxa. The environmental tolerances database is a rating of each taxon's tolerance to organic enrichment and sedimentation. The BCI is calculated by dividing the predicted community tolerance quotient based on the water quality and stream habitat by the actual sampled community tolerance quotient. Advantages of the BCI is that it is sensitive to different types of stress, gives a linear assessment of conditions from unstressed through all levels of stressed, and it evaluates a streams condition against its own potential (Winget and Mangum 1979). A BCI rating above 90 is considered excellent, 80-90 good, 72-79 fair, and below 72 poor.

Since the BCI measures the average community tolerance quotient based on all of the taxa found at a site, it is robust to changes in individual taxon population levels. While one taxon may be temporarily absent due to the recent emergence of adults and reproduction, other taxa with similar tolerance quotients will still be collected. Averaging the individual tolerance quotients to obtain the community tolerance quotient then obtains a mean representative value which has minimal fluctuation despite changes in individual taxon population levels.

The intent of the Fishlake N.F. Forest Plan to use the BCI rather than population as the trend indicator is shown in the Forest Plan Standard and Guideline "Maintain a Biologic Condition Index (BCI) of 75 or greater" (page IV-19). This is also why the "Macroinvertebrate" estimated population level in MIS Table II-8A (page II-29) is listed as N/A, or Not Applicable.

Aquatic macroinvertebrates respond to natural events, which can affect the BCI values and confound making interpretations of changes due to land management actions. This can be dealt with both through good study design (such as including a control station above a study area where management changes will occur) and detailed notes taken during sampling noting both ongoing land management activities and natural events and changes.

Aquatic Macroinvertebrate Sampling

Sample collection has followed the standard R-4 protocol in the Forest Service Handbook (FSH) 2609.23, also described in Mangum (1986). Three similar riffle sites within a 100-foot stream section are selected for sampling. At each site a 250 micron Surber frame is placed over the gravel/cobble substrate with the net on the downstream side. Rocks within the frame are hand scrubbed and the current carries the macroinvertebrates into the net. After the larger rocks are scrubbed the underlying gravel within the frame is stirred by hand to a depth of 3-4 inches. The net is then inverted into a pan containing a saturated saline solution to help float organisms to the top for easier collection. Larger, heavier items such as caddisfly cases are collected separately and placed in a sample bottle. The sample is gently stirred and the saline solution is poured through a sieve several times. Finally, the sample in the sieve is placed in the sample bottle and preserved in an alcohol solution. Additional data is collected at each station including alkalinity, sulfate, gradient, and substrate composition, which are used to calculate the BCI.

The Forest Plan monitoring schedule is to sample macroinvertebrates in 5 streams/year. This has been met on average. Sampling location selection has primarily been driven by interest in key watersheds on the Forest or for baseline data or monitoring for specific project activities. In other words, sampling has been more tactically oriented than strategically oriented.

Laboratory Analysis

The 1986-1997 samples were sent to the Aquatic Ecosystem Laboratory (AEL) located at Brigham Young University in Provo, Utah. Laboratory analyses procedures are described in Mangum (1997). The macroinvertebrates were keyed to species when keys were available (generally mayflies), and others generally to genus, but some groups were keyed only to family, class, or order. The BCI index was then calculated. By 1999 the AEL was no longer in operation, requiring a change in laboratories. The 1999-2001 samples were sent to the National Aquatic Monitoring Center at Utah State University in Logan, Utah. Methodology is similar but does not include the DAT diversity index.

Loa Ranger District

Loa RD	**YEAR**																
STATION	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**
7 mile 1	88	-	-	-	-	-	-	-		70/83	81/83	-	-	-	76	-	-
7 mile 2	89	89/100	85/100	79	80/95	-	-	78	-	75/86	73/83	-	-	-	74	73	-
7 mile 3	88	89/82	79/79	88	78/81	-	-	70	-	67/72	71/71	-	-	-	82	-	-
7 mile 4	85	92/81	72/81	76	61/74	-	-	-	-	-	-	-	-	-	69	-	-
UM Cr	-	92	81/96	82	82/91	-	-	57	-	-	-	61	-	59	60	-	-
RF UM	-	-	-	-	-	-	-	-	-	-	-	-	-	72	74	77	-
LF UM	-	-	-	-	-	-	-	66	-	-	-	65	-	-	-	-	-
UM Dan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70	-
UM Can	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65	-
UM For	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77	-

Note: BCI data for the table is found in Mangum (various dates) and Vinson (various dates). These reports are on file at the Fishlake N.F. Supervisor's Office.

Overall trend on the Loa Ranger District is down slightly after peaking in the late 1980s, with generally static trend since the early 1990s.

The Loa Ranger District has one of the best long-term aquatic macroinvertebrate data sets on the Fishlake N.F. on Seven mile and UM Creeks. BCI values on both creeks peaked in the late 1980s, and have since been on a downward trend. Three of the four sites on Seven mile Creek are basically still at or above Forest Plan standards in the most recent samples. One site is slightly below standards. UM Creek has been basically static at below standards since the early 1990s, including one of the two headwater stations. The other headwater station is slightly below standards. UM Creek has been visually observed to be in relatively poor condition. In addition, rotenone treatments in the early 1990s may have had an effect on BCI values. Whelan (2002) found another Forest creek to rebound after treatment, but notes that poor habitat conditions might delay recovery after treatments.

Richfield Ranger District

Richfield RD	**YEAR**																
STATION	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**
Salina 1	-	75/70	72	71/75	65/67	-	-	-	-	-	-	-	-	67	-	-	-
Beaver trib	-	-	-	-	-	-	-	-	-	-	-	-	-	64	-	-	-
Salina 2	-	76/91	74	82/71	71/71	-	-	-	-	-	-	-	-	71	-	-	-
Manning T	-	-	81	-	77/84	-	-	-	-	76	-	73	-	79	-	-	-
Manning 7.0	-	-	-	-	-	-	-	-	-	-	-	-	-	79	-	-	-
Manning L	-	-	-	-	-	-	-	-	-	66	-	65	-	63	-	-	-
Manning 3	-	-	-	-	-	-	-	-	-	-	-	70	-	-	-	-	-
Willow Up	-	-	-	-	-	-	-	-	-	76	-	-	-	65	-	-	-
Willow Lo	-	-	-	-	-	-	-	-	-	78	-	-	-	70	-	-	-

Box Cr 1	-	-	-	-	-	-	-	-	-	67	-	-	-	-	-	-	-
SF Box 2	-	-	-	-	-	-	-	-	-	-	-	-	-	53	-	-	-
NF Box 2	-	-	-	-	-	-	-	-	-	-	-	-	-	69	63	65	-
NF Box 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	76	73/78	-
NF Box 4	-	-	-	-	-	-	-	-	-	-	-	-	-	--	73	73/76	-
Gooseberry5	-	-	-	-	-	-	-	-	-	74/71	77/82	-	-	-	79	-	-
Gooseberry7	-	-	-	-	-	-	-	-	-	-	71/75	-	-	-	-	-	-
Gooseberry8	-	-	-	-	-	-	-	-	-	-	70/76	-	-	-	-	-	-
Goose FSB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77	-	-
Goose.URdC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65	-	-
Goose.BelSC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80	-	-
Niotche 4	-	-	-	-	-	-	-	-	-	71/85	81/82	-	-	-	-	-	-
NiotcheL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	83	-	-
NiotcheU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80	-	-

Note: BCI data for the table is found in Mangum (various dates) and Vinson (various dates). These reports are on file at the Fishlake N.F. Supervisor's Office.

Overall trend on the Richfield Ranger District is down slightly after peaking in the late 1980s, with generally static trend since the early 1990s. Long-term data sets are limited to the upper Salina Creek and Manning Creek watersheds.

Salina Creek peaked at levels at or slightly above Forest Plan standards in the late 1980s. Trend between 1990-1999 was static at slightly below standards.

Upper Manning Creek peaked in the late 1980s. The BCI declined in 1997 following the 1995 and 1996 rotenone treatments, which indicated a loss of some of the more sensitive invertebrate species. The BCI index basically recovered to pre-treatment levels (above standards) by 1999. It is believed other land management activities may have prevented the BCI recovery of a more recent downstream station that was below standards and declined slightly following treatment (Whelan 2002).

Other streams sampled on the district have only been sampled in 1995 or later. Willow Creek declined in trend and is now below standards. Other creeks appear to be static in trend, with lower North and South Forks of Box Creek below standards and the remaining creeks at or above standards.

Fillmore Ranger District

Fillmore RD	**YEAR**																
STATION	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**
Corn FSbdr	-	-	-	-	-	-	-	-	-	-	65/68	-	-	-	-	-	-
Corn Cr 1	-	90/79	70/72	71/82	73	-	-	-	-	-	-	65	-	-	59	-	-
Corn Cr 2	-	77/75	79/78	82/86	80	-	-	-	-	-	-	74	-	-	61	-	-
Chalk Cr 1	-	-	-	80	67	-	-	-	-	-	-	-	70	-	-	-	-
Chalk Cr 2	-	-	-	78	73	-	-	-	-	-	-	-	99	-	-	-	-

SamStowe	-	-	-	-	78/71	-	-	85	75	-	-	-	-	64	-	-	-
Meadow 1	-	-	-	-	-	-	-	-	70	-	-	-	59	56	-	-	-
Meadow 2	-	-	-	-	-	-	-	-	68	-	-	-	70	65	66	-	-
Oak Cr 1	-	-	-	-	-	-	-	-	-	-	-	-	67	-	-	-	-
Oak Cr 2	-	-	-	-	-	-	-	-	-	-	-	-	64	-	-	-	-

BCI data for the table is found in Mangum (various dates) and Vinson (various dates). These reports are on file at the Fishlake N.F. Supervisor's Office.

Overall trend on the Fillmore Ranger District is down slightly after peaking in the late 1980s, with generally static trend since the early 1990s.

Corn Creek BCI values peaked in the late 1980s. More recent samples in the late 1990s have declined to below standards, probably showing continued after effects from the severe 1996 wildfire in the drainage. Chalk Creek showed a downward trend at one station, but an upward trend at the other station. One station was above standards and the other slightly below.

Sam Stowe Creek had relatively static trend through the early 1990s, but a drop in trend to below standards by 1999. This could be due to long-term drought effects, possibly in combination with the stream renovation treatment. One Meadow Creek station showed downward trend, but the other station was basically static. Both were below standards.

Beaver Ranger District

Beaver RD	**YEAR**																
STATION	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**
Birch Cr	-	75/85	74/85	82	-	-	-	-	-	-	-	-	63	69	-	-	-
Birch Cr 2	-	-	-	-	-	-	-	-	-	-	-	-	66	68	-	-	-
Merchant	-	96/94	91	94	-	-	-	72	-	-	-	-	79	86/76	-	-	-
Merchant2	-	-	-	-	-	-	-	79	-	-	-	-	-	-	-	-	-
WF Merc.	-	91/92	92	98	100	-	-	-	-	-	-	-	-	72	-	-	-
NF 3Cr 1	-	-	98/82	100	100/100	-	-	-	-	-	-	-	-	79	-	-	-
NF 3Cr 2	-	-	78/91	91	100/94	-	-	-	-	-	-	-	-	87	-	-	-
Indian Cr1	-	-	-	-	-	-	-	72	-	-	-	-	-	75	-	-	-
Indian Cr2	-	-	-	-	-	-	-	66	-	-	-	-	-	-	-	-	-
Whisky 1	-	-	-	-	-	-	-	-	-	61	-	-	-	-	-	-	-
Pine 1	-	-	-	-	-	-	-	-	-	-	-	-	62	71	-	-	-
Pine 2	-	-	-	-	-	-	-	-	-	-	-	-	-	71	-	-	-
NFNC 1	-	-	-	-	-	-	-	-	-	-	-	-	68	68	-	-	-
NFNC 2	-	-	-	-	-	-	-	-	-	-	-	-	73	71	-	-	-
Beaver R	-	-	-	-	-	-	-	-	-	-	-	-	-	78	-	-	-
10Mile UP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	81	-	-
10Mile Lo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	94	-	-

Birch E 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	76	-
Birch E 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70	-

Note:

BCI data for the table is found in Mangum (various dates) and Vinson (various dates). These reports are on file at the Fishlake N.F. Supervisor's Office.

Overall trend on the Beaver Ranger District is down slightly after peaking in the late 1980s, with generally static trend since the early 1990s.

The upper Beaver River watersheds of Merchant Creek, West Fork of Merchant Creek, and North Fork of Three Creeks all peaked in the late 1980s, and have declined slightly since, but generally remain at or above Forest Plan standards.

Birch Creek (W) also peaked in the late 1980s, and has declined to slightly below standards by the late 1990s. Visual observation has noted both habitat problems and reduced water flows due to drought, which are both probably responsible for the decline. The district has taken recent action in 2001-2002 to rebuild and repair exclosure fences, which should result in improved habitat conditions on the creek.

Other streams sampled on the district have only been sampled from 1993 on and are generally only 1 sample per station or two samples in back to back years precluding long-term trend analysis. One Indian Creek station with two samples showed slightly improving trend, reaching the Forest Plan standard.