Executive Summary

This investigation, a cooperative study between FDEP's Bureau of Mine Reclamation and Bureau of Laboratories, was conducted to determine the biological success of stream reclamation or creation efforts in phosphate mining areas. Four of the oldest created streams (13- 15 years), that had sufficient portions of their contributing watersheds reclaimed, were chosen for this initial study. Our hypothesis was that if these created streams had adequate habitat and water quality, they would support healthy biological communities. We collected standard habitat assessment data and water quality samples, and performed rapid surveys of aquatic biological communities (Bio-Recon). It was hoped that this study could begin to identify the most successful stream reclamation techniques so they could be incorporated into future projects.

Dogleg Branch was the "healthiest" site sampled, suggesting the restoration techniques used here were effective. It passed all three Bio-Recon metrics and scored in the "optimal" category for habitat assessment. Snags, roots and leaf packs were all available for invertebrate colonization. Except for moderately low dissolved oxygen, water quality was good at Dogleg Branch.

McCullough Creek passed two of the three Bio-Recon thresholds (total taxa and EPT), although the exceptionally low Florida Index score (2) is cause for concern. Habitat quality was suboptimal at McCullough Creek, with no leaf packs available and woody debris and root mats being somewhat limited here. Turbidity, suspended solids, phosphorus, Kjeldahl nitrogen and nitrite-nitrate were quite elevated at this site, potentially affecting the biological results.

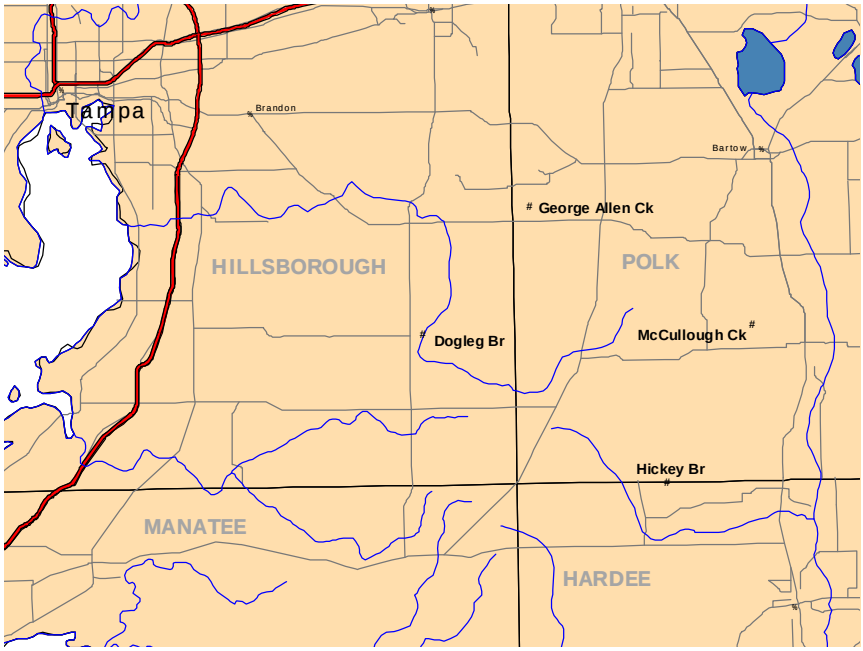
Hickey Branch passed only one of the Bio-Recon metrics (total taxa), although it fell short of the Florida Index and EPT Index scores by a narrow margin. The habitat assessment score at Hickey Branch was in the "suboptimal" category. Again, snags and leaf packs were extremely rare. Silt smothering was noted at this site related to dam failure and subsequent spills from a clay settling area in October of 1994. Silt smothering from this event probably continues to exert a negative influence of the biota.

George Allen Creek failed all three macroinvertebrate parameters, although it missed the Florida Index and EPT thresholds by one point each. Habitat here was in the suboptimal category, with snags and leaf packs being very scarce, and with only roots present at an expected abundance. While moderate silt smothering was noted here, the system's overall small size (0.4 m wide, 0.3 m deep) may have been a factor explaining this system's failure to meet the Bio-Recon thresholds.

It is recommended that additional restored sites be evaluated using the Bio-Recon technique to establish a better relationship between restoration strategy and biological response. Additionally, sites failing the Bio-recon could be sampled using Stream Condition Index methods to better resolve the status of biological health in those streams.

Introduction

Figure 1: Overview Map



This investigation, a cooperative study between FDEP's Bureau of Mine Reclamation and Bureau of Laboratories, was conducted to determine the biological success of stream reclamation or creation efforts in phosphate mining areas. Four of the oldest created streams (13- 15 years), that had sufficient portions of their contributing watersheds reclaimed, were chosen for this initial study. Our hypothesis was that if these created streams had adequate habitat and water quality, they would support healthy biological communities. We collected standard habitat assessment data and water quality samples, and performed rapid surveys of aquatic biological communities (Bio-Recon). The Bio-Recon is a screening tool used to determine which systems are biologically healthy. Measurements of community health are calculated and compared to minimum expected values based on reference sites in the region (see methods). It was hoped that this study could begin to identify the most successful stream reclamation techniques so they could be incorporated into future projects.

Methods

Benthic macroinvertebrate communities were evaluated using Bio-Recon techniques. Invertebrates were collected from multiple substrates (e.g., roots, snags, leaf packs, vegetation) using 4 discrete dip net sweeps (FDEP 1996, Biology Section Standard Operating Procedure #BA-7), field picked, and finally brought back to the laboratory for identification under the dissecting microscope. Bio-Recon results were then compared to existing criteria for three categories (minimum expected values for peninsular Florida streams are in parentheses): total taxa richness (18), total Florida Index (10), and total EPT (Ephemeroptera/Trichoptera/Plecoptera) Index (4). These threshold values represent the 25th percentile distribution for a given metric at several peninsular reference sites (Tetra Tech, 1995). Therefore, the biological expectations at the reference sites (unimpacted streams determined by landuse and local knowledge) were used as the threshold for acceptability in judging impairment. If two or more of the metrics are greater than or equal to the target values, the site is considered "healthy". If less than two of the metrics are within target range, the site is "suspected to be impaired" and more rigorous, follow-up sampling (using the Stream Condition Index) is necessary to confirm the evaluation and determine the degree of impairment. A physical/chemical characterization (FDEP 1996b, BA-17) and habitat assessment (FDEP 1996b, BA-18) were also performed at each study site.

Explanation of Measurements of Community Health

Selected measurements of macroinvertebrate community health were employed to assess each site. These are briefly discussed here.

Habitat Assessment: Eight attributes known to have potential effects on the stream biota were evaluated and scored, with 20 points possible for each factor. Based on the sum of these individual scores, overall habitat quality is assigned to one of four categories: Optimal (121-160 points); Suboptimal (81-120 points); Marginal (41-80 points); and Poor (0-40 points).

Taxa richness: This measurement is based on the total number of taxa found at a site. Stress tends to reduce the number of different types of organisms present in a system. Reference stream values used to establish thresholds for the peninsular region of Florida for the Bio-Recon had a range of 16-33 taxa, with an average of 19.

Numbers of pollution sensitive taxa: Some organisms become rare or absent as the intensity or duration of disturbance increases. For example, the Florida Index assigns points to stream-dwelling macroinvertebrates based on their sensitivity to pollution (see Ross 1990). A site with a high Florida Index score is considered healthy. Reference stream values used to establish thresholds for the peninsular region of Florida for the Bio-Recon had a range of 7-29 points, with an average of 11.

Ephemeroptera/Plecoptera/Trichoptera (EPT) Index: This index is the sum of the number of EPT taxa present. Higher EPT values are associated with healthier systems. Reference stream values used to establish thresholds for the peninsular region of Florida for the Bio-Recon had a range of 2-9 taxa, with an average of 5.

Personnel from the FDEP Central Laboratories and Bureau of Mine Reclamation performed sampling for this investigation on October 19 and 20, 1998. The FDEP Bureau of Laboratories performed the biological and chemical analyses.

Study Sites

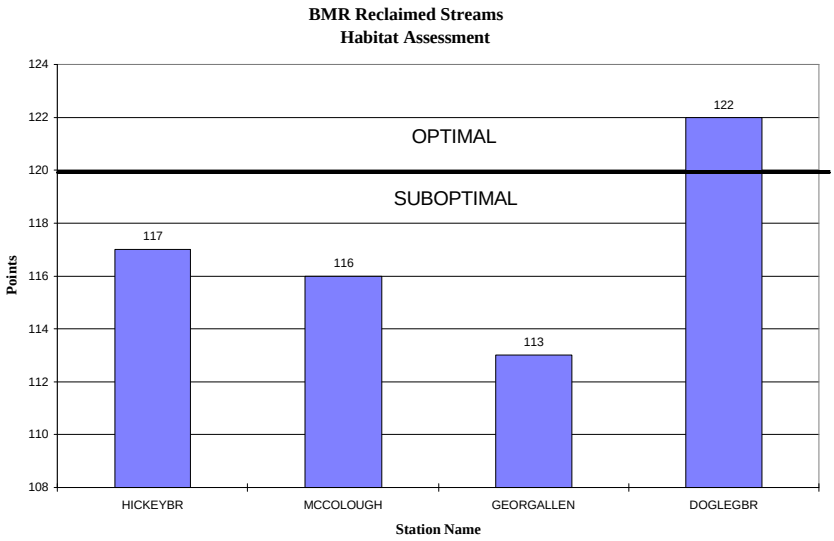
Hickey Branch is a tributary of Payne Creek, which drains into the Peace River. The reclamation project consisted of three phases and was completed in 1989. The areas sampled were part of the first phase that was completed in 1985. In order to ensure that a near-surface water table would be sustained, the basin was lined with sand/clay mix and capped with overburden and/or muck. The stream was designed to meander through a broad floodplain. The area was planted with small trees in copses. The channel is bordered on either side by reclaimed floodplain and upland forest. The stream receives direct drainage from several reclaimed sand/clay areas. Portions of the drainage basin are active clay settling areas, however, they do not currently contribute flow. A clay settling area dam failure (upstream) in October of 1994 adversely affected the area.

McCullough Creek is a tributary to Whidden Creek, which also drains into the Peace River. This reclamation project, completed in 1985, was created on sand tailings capped with 2-4 inches of wetland topsoil. The adjacent landuse includes an upland forest buffer and pasture. Immediately upstream of the reclaimed portion of the creek is an unmined segment of the stream with a mined and reclaimed headwater area further upstream. The area receives flow from upstream portions of the creek offsite and overflow from a series of reclaimed lakes to the north and northeast.

George Allen Creek is a tributary of Thirty Mile Creek, which drains into the North Prong of the Alafia River. This 4-acre stream project was completed in the sum-

mer of 1984 from contoured overburden and was designed with a narrow floodplain of upland forest and pasture including a series of riprapped areas and stilling pools in the upper reaches. The pools received muck from a bayhead. The permit associated with this project required freshly cut stumps to be placed in the channel as logjams. Two active clay settling areas border the stream on either side. Most flow is received from offsite sources south of SR 640.

Figure 2: Habitat Assessment Chart



Dogleg Branch is a minor tributary of the South Prong of the Alafia River. This restoration project includes 20 acres of wetlands and was completed in 1983 on contoured overburden. This project utilized several innovative techniques to enhance the restoration. Numerous mature cabbage palms were planted, as were many live tree stumps, and to encourage channel formation, stacks of 5 to 7 logs were placed across the channel at 100-ft intervals. A small portion upstream was preserved. The wetlands were mucked and live tree stumps were placed along the channel. Areas to the south and west were reclaimed between 1982 and 1989, while most of the area to the east was reclaimed in 1992. A small portion of the watershed was left unmined and the rest was reclaimed with various materials including sand tailings, sand-clay mix and overburden.

Results and Discussion

Habitat

Eight parameters are measured in the habitat assessment procedure: substrate diversity, substrate availability, water velocity, artificial channelization, bank stability, habitat smothering, riparian zone buffer width, and riparian vegetation quality (see habitat assessment sheets in Appendix). Of these, providing adequate substrate diversity (and availability) and water velocity are probably the most difficult challenges when creating or restoring a stream.

Except for Hickey Branch (with 31% available habitat, mostly aquatic plants), substrate availability scored in the "marginal" (6-15% habitat) category at the remaining sites. A wide variety and abundance of submerged structures in the stream are necessary to provide the macroinvertebrates with a large number of refugia or niches. The greater the variety and extent of available microhabitats or attachment sites, the greater the variety of invertebrates a stream can support. Snags and submerged logs, roots/ undercut banks, leaf packs, and aquatic vegetation are productive habitat structure in low-gradient streams. Moderate habitat smothering from silt was noted at Hickey Branch and George Allen Creek.

Water velocity was ranked as optimal at Hickey Branch (0.3 m/s) and George Allen Creek (0.4 m/s), and suboptimal at Dogleg Branch (0.15 m/s) and McCullough Creek (0.13 m/s). The velocity of water flowing through the system influences the amount of dissolved oxygen in the water and the movement of materials and food particles through the system. Velocities lower than

0.1 m/sec will support progressively fewer taxa as dissolved oxygen and food movement is reduced. During storm events, the occurrence of high-velocity spates is an indication of the inability of the channel morphology to moderate the energy from these high-runoff storms. High water velocities (> 1 m/s) may result in catastrophic drift, reducing both the abundance and types of macroinvertebrates present.

In summary, Dogleg Branch was the only site that scored in the "optimal" category for habitat quality (122 points). The remaining three sites scored between 113-117 points, which is in the upper range of the "suboptimal" category.

Water Chemistry Parameters

Dissolved oxygen concentrations were below the Class III standard of 5.0 mg/L at Hickey Branch (3.5 mg/L), McCullough Creek (2.9 mg/L), and Dogleg Branch (3.7 mg/L). Dissolved oxygen in this range can limit the diversity of organisms found at a site. Dissolved oxygen at George Allen Creek was 6.4 mg/L. Specific conductance values ranged from 216 µmhos/cm to 356 µmhos/cm.

Turbidity values were acceptable at all sites except McCullough Creek, which had a value of 35 NTU. This possibly represents a violation of Class III water quality standards, which prohibits turbidity from exceeding 29 NTU above background (2.8 NTU is the average turbidity for a Florida stream, see *Typical Water Quality Values* in Appendix). Turbidity at George Allen Creek (21 NTU), Hickey Branch (7.7 NTU) and Dogleg Branch (7.5 NTU) were only slightly to moderately higher than this average value (2.8 NTU). Total suspended solids (TSS) mirrored turbidity measurements, McCullough Creek the highest (40 mg/L), followed by George Allen Creek (12 mg/L) and finally Hickey Branch and Dogleg Branch (9 and 7 mg/L, respectively).

Station	HICKEY BR	MCCOLOUGH CK	GEORGE ALLEN CK	DOGLEG BR
Storet #	25020602	25020601	24020086	24020087
Date	10/19/98	10/19/98	10/19/98	10/20/98
Habitat Assessment	117	116	113	122
# Taxa	29	33	14	24
Florida Index	9	2	9	13
EPT	3	6	3	4
Cond. (umhos/cm^2)	356	216	302	250
DO (mg/l)	3.5	2.9	6.4	3.7
pH (SU)	7.09	6.83	6.34	6.68
Temp (C)	24.6	26.2	22	23.9
Turb (NTU)	7.7	35	21	7.5
TNOx (mg/l)	0.01	0.29	0.03	0.14
TKN (mg/l)	0.73	1.2	0.36	0.31
TSS (mg/l)	9	40	12	7
Color (PCU)	80	150	75	60

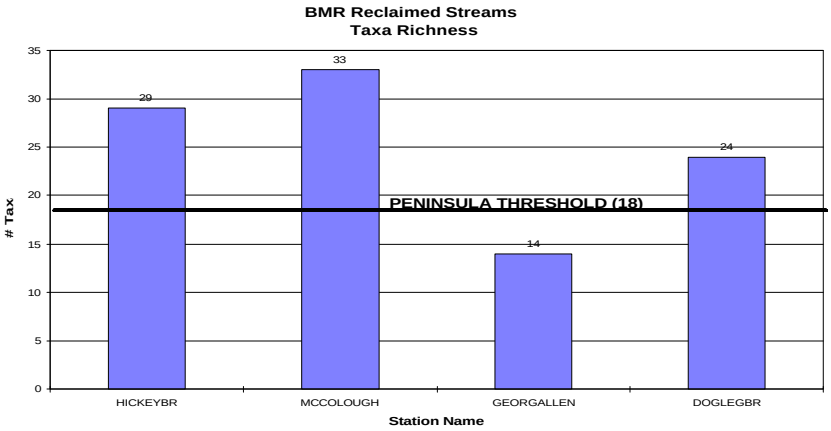
Figure 3: Data Table

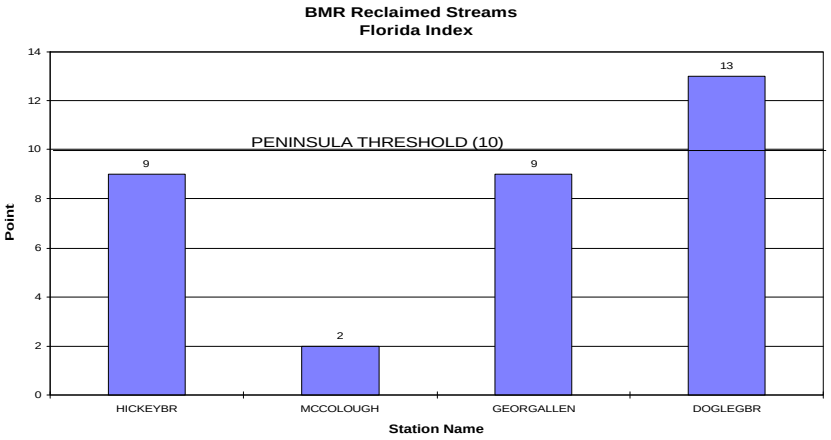
Nitrite-nitrate values were moderately elevated at Dogleg Branch (0.14 mg/L) and McCullough Creek (0.29 mg/L). Hickey Branch (0.01 mg/L) and George Allen Creek (0.03 mg/L) had levels lower than 80% of Florida Streams. Similarly, total Kjeldahl nitrogen (TKN) levels were low compared to other Florida streams (in the lower 30th percentile or better) except for McCullough Creek, which had a TKN value of 1.2 mg/L.

Phosphorus enrichment was observed at all four sites, which may be expected due to the high concentration of phosphorus in the area's soils. Dogleg Branch had the lowest value (0.20 mg/L), followed by Hickey Branch and George Allen Creek (0.59 mg/L for both). McCullough Creek (1.4 mg/L) had a total phosphorus value which exceeded those found in 93 percent of other Florida streams.

Macroinvertebrate Parameters

The Bio-Recon thresholds a site must meet or exceed to be considered "healthy" for peninsular Florida are as follows: total taxa (18), the Florida Index (10), and the EPT Index (4) (see Bio-Recon forms in Appendix). With a taxa richness of 24, a Florida Index of 13, and an





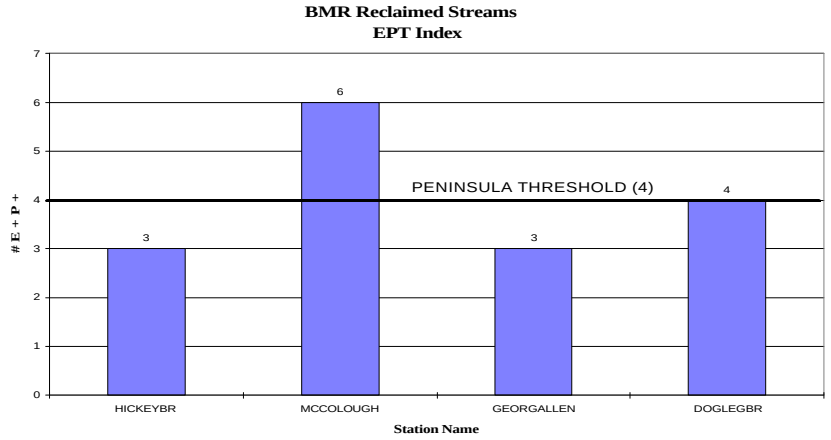


Figure 4: Macroinvertebrate Parameters of the Bio-Recon

EPT Index of 4, Dogleg Branch passed all three Bio-Recon metrics.

McCullough Creek passed two of the three Bio-Recon metrics. Total taxa in McCullough Creek (33) and the EPT index (6) surpassed their respective thresholds. However, the Florida Index score (2) at McCullough Creek was the lowest of the four streams and well below the Peninsula threshold of 10.

Of the three Bio-Recon metrics, only total taxa richness at Hickey Branch (29) met or exceeded its respective threshold. The Florida Index (9) at Hickey Branch was one point lower than the threshold (10), while the EPT Index there was 3, also one short of the threshold (4).

George Allen Creek, with a total taxa of 13, a Florida Index score of 9, and an EPT Index of 3, failed to meet any of the Bio-Recon thresholds. Note however, that this stream was very close to achieving both the Florida Index (10) and EPT Index (4) thresholds.

Conclusions

To successfully recreate a stream, proper habitat, water quality, and energy flow (leaf litter to fuel the detritus based food web) must all be provided. Based on the limited amount of data in this study, biological communities suggested that restoration efforts at Dogleg Branch could be classified as successful, while such efforts at the remaining streams could be considered partially successful.

Dogleg Branch was the "healthiest" site sampled, suggesting the restoration techniques used here were effective. It passed all three Bio-Recon metrics and scored in the "optimal" category for habitat assessment. Snags, roots and leaf packs were all available for invertebrate colonization. Except for moderately low dissolved oxygen, water quality was good at Dogleg Branch.

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