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USDOI Office of Surface Mining Reclamation and Enforcement

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QUANTIFYING THE FUNCTIONAL VALUE OF STREAM AND WETLAND MITIGATION STRUCTURES ON RECLAIMED SURFACE MINES IN WEST VIRGINIA

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Project Description and Objectives:

The over-riding objective of our research was to provide a comprehensive assessment of ecological functions of aquatic habitats on reclaimed surface mines in southern West Virginia. The specific objectives were to 1) compare and contrast the functional value of reference headwater streams and of post-reclamation aquatic features, 2) determine whether ecological functions are adequately replaced after mining and reclamation, and 3) develop recommendations for surface mine reclamation and direction for future studies.

Applicability to Mining and Reclamation:

The results from our research can be used to identify strengths and short-comings of current surface mine reclamation processes as they relate to aquatic ecosystem functions. This information can then be used to determine which ecological functions can be effectively recovered through improved reclamation processes and which functions need to be recovered through off-site mitigation actions. Finally, this information can be used to determine which functions can only be maintained through protection of undisturbed headwater catchments. The specific results of our study are directly applicable to large scale surface mine reclamation in the central Appalachian region. Nevertheless, we believe that the general approach we have used may be applicable nationwide.

Methodology:

We studied aquatic ecosystem functions at five reclaimed mine perimeter channel sites and five paired native headwater channel sites in southern West Virginia. Both ecosystem structure and function measures were taken at study locations and included: riparian vegetation, channel morphology and habitat quality, water temperature, dissolved oxygen, dissolved inorganic water chemistry,

ABOVE PHOTO: Perimeter channel on a surface mine approximately 20 years post-reclamation.

nutrient chemistry, dissolved carbon, organic matter retention and decomposition, benthic macroinvertebrate assemblages, and amphibian assemblages. All parameters were measured seasonally from May 2006-April 2008. Reclaimed mine sites varied in age from 3 years post mining up to approximately 20 years post mining.

We used a variety of statistical approaches to test for structural and functional differences between reclaimed mine and native stream channels. Central to the analysis was an ANCOVA that tested for interactive effects of site type (mined vs. native) and specific conductance on key ecological processes, including: biological assemblages, dissolved carbon production, and organic matter decomposition.

As a final, integrative analysis, we calculated "functional ratios" that allowed us to quantify differences in reclaimed mine functions to native catchment functions. These ratios were calculated for the key ecological processes listed above and can be used to inform the reclamation and mitigation process.

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Highlights:

There are three major aspects of this study to highlight. First, it represents the first comprehensive study to quantify ecological structures and functions associated with aquatic habitats on reclaimed mines. Second, our results clearly show that elevated conductivity and TDS concentrations are the dominant factor limiting ecological functions on reclaimed mines and must be the target of progressive reclamation and mitigation practices. Finally, our results were used to produce a table of "functional ratios" that allow objective comparison of ecological functions on reclaimed mines with native catchments.

Results/Findings:

This study produced the following results and recommendations:

1) Aquatic habitats on reclaimed mines were highly altered structurally relative to the native channels. Structural differences included: a) a shift from forested riparian vegetation to grasses and shrubs; b) a shift from coarse bed load such as gravel and cobble to sand and silt; and c) a reduction in overall habitat quality.
2) Major changes in structural characteristics occurred on mine sites over time as newly reclaimed mines possessing fluvial channels develop more lentic (standing or still water) characteristics as wetland vegetation matures.
3) Reclaimed mine channels possessed water quality characteristic of alkaline mine drainage with elevated total dissolved solids, conductivity, hardness, and sulfate concentrations. Dissolved metal concentrations were somewhat variable from site to site and over time. Nevertheless, while slightly elevated relative to unmined streams, dissolved metal concentrations remained relatively low on mine study sites.
4) The productivity and diversity of biological assemblages (macroinvertebrates and amphibians) on reclaimed mines remained surprisingly high relative to unmined streams. However, we observed distinct shifts in assemblage structure between mined and unmined channels. In native catchments, biological assemblages were dominated by sensitive taxa characteristic of lotic (flowing water) habitats (e.g., mayflies and stream dwelling salamanders). On reclaimed mines, the biological assemblages were dominated by relatively tolerant taxa characteristic of lentic habitats (e.g., true flies and frogs and toads).
5) Organic matter decomposition rates were significantly lower on reclaimed mines. Nevertheless, due to high organic matter retention on reclaimed mines the overall organic matter processing rates, which incorporates retention and decomposition, did not differ significantly between mined and unmined streams. In fact, organic matter processing was slightly higher on mined sites and ultimately produced significantly higher dissolved organic carbon concentrations relative to native catchments.
6) The dominant cause of ecological impairment in this region can be attributed to elevated conductivity and TDS concentrations of water draining reclaimed mines. ANCOVAs testing for interactive effects of mining and conductivity on ecological functions demonstrated a significant effect of conductivity independent of mining. This suggests that managing for TDS is the key to maximizing stream ecological functions on reclaimed mines.
7) A key outcome of our research was calculation of "functional ratios". These ratios can be interpreted as the degree to which aquatic habitats on reclaimed mines function relative to the native catchments that are typically impacted by the mining process. Variables with ratios less than 1 represent functional "deficits" (mined relative to native). Variables with ratios greater than 1 represent functional "benefits" (mined relative to native).
8) We strongly encourage managers and mining engineers to focus reclamation and mitigation efforts on actions that will maintain acceptable TDS concentrations in water flowing off of reclaimed mines and at the watershed scale as a whole. Doing so will likely require a combination of: a- headwater conservation actions that protect source areas for dilute freshwater; b- mine reclamation actions that focus on construction of wetlands capable of reducing sulfates on-site; and c- off-site mitigation actions that focus on reducing watershed scale sources of elevated TDS and conductivity.

Website Information:

The final project report can be found at **http://www.techtransfer.osmre.gov/NTTMainSite/appliedscience/2007/Projects/WV2007PettyQuantifying AS FR.pdf**

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