Journal of Environmental Management 100 (2012) 52–58

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Costs of abandoned coal mine reclamation and associated recreation benefits in Ohio

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ARTICLE INFO

Article history:
Received 24 April 2011
Received in revised form
7 January 2012
Accepted 16 January 2012
Available online 22 February 2012

Keywords:
Externalities
Water quality
Coal mining
Ecosystem services
Recreational value
Coal mine reclamation
Policy

ABSTRACT

Two hundred years of coal mining in Ohio have degraded land and water resources, imposing social costs on its citizens. An interdisciplinary approach employing hydrology, geographic information systems, and a recreation visitation function model, is used to estimate the damages from upstream coal mining to lakes in Ohio. The estimated recreational damages to five of the coal-mining-impacted lakes, using dissolved sulfate as coal-mining-impact indicator, amount to $21 Million per year. Post-reclamation recreational benefits from reducing sulfate concentrations by 6.5% and 15% in the five impacted lakes were estimated to range from $1.89 to $4.92 Million per year, with a net present value ranging from $14.56 Million to $37.79 Million. A benefit costs analysis (BCA) of recreational benefits and coal mine reclamation costs provides some evidence for potential Pareto improvement by investing limited resources in reclamation projects.

1. Introduction

Two hundred years of coal mining in Ohio have degraded land and water resources, imposing social costs on Ohioans. The federal and state governments have reclamation programs for coal mines abandoned before 1977, and regulations to prevent pollution from mines after 1977. The Surface Mine Control and Reclamation Act (SMCRA) of 1977 mandates mining companies to return the land to its approximate original contour and minimize disturbances to nearby hydrologic systems. The reclamation of the abandoned mines is funded by federal and state taxes on current coal-mining companies (Ohio Department of Natural Resources, ODNR). However, the long-lasting nature of these impacts, along with insufficient funding for the reclamation of abandoned mines, perpetuates the problem. Government is lagging behind by 135,650 abandoned mine reclamation units (ODNR), which continue to incur societal losses through deteriorated ecosystem services. Their reclamation is expected to cost $814 Million (2006 dollars).

A limited budget is allocated for reclaiming mines classified by three priority levels. Mines posing health and safety risks are in priority 1 and 2, and those posing environmental problems are in priority-3. Better estimates of the social losses from these unreclaimed mine sites and the potential post-reclamation benefits are needed to evaluate the efficiency of current reclamation efforts. A full evaluation of the damages associated with coal mining (Fig.1) and benefits of restoration would provide a sound basis for efficient reclamation decisions. We evaluate here a major component of social losses, the effect of acid mine drainage (AMD) on downstream recreation. We expect that this component is significant because the recreational returns from air and water quality improvements have been found in the past to constitute a significant share of the total benefits from restoration [50% according to Freeman (1979); 95% according to Federal Water Pollution Control Report (1966)].

Because the recreational benefits of improved environmental quality are not completely observable as market transactions, non-market valuation methods are needed to fully evaluate these benefits. Earlier studies have estimated the non-market benefits from reclaiming damaged ecosystems, using environmental valuation techniques such as conjoint analysis, contingent valuation, travel cost method, and hedonic pricing methods. Farber and Grinner (2000) estimate coal-mining damages to both the use

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doi:10.1016/j.jenvman.2012.01.021

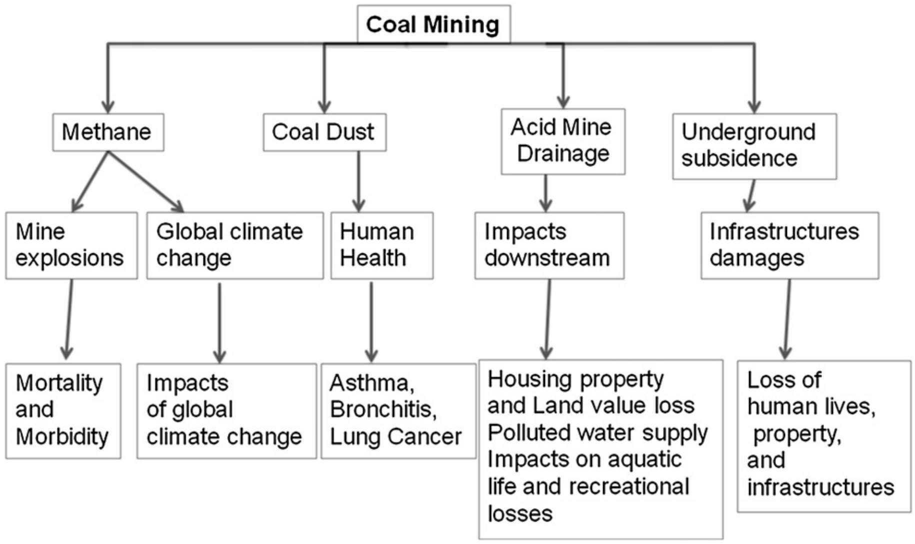

Fig 1. Coal mining externalities.

and non-use value of a stream, while other studies focus only on stream-use value. Randall et al. (1978) evaluate the damage from coal mining in terms of water treatment costs, recreation restoration costs, damages to land and buildings, and the value of damages to the aesthetics of the area. Sommer and Sohngen (2007) focus on recreational damages, using the travel cost method. Hitzhusen et al. (1997) evaluate losses of housing property value and recreational losses, while Williamson et al. (2008) estimates the AMD damages to housing property values. These foregoing analyses involve the estimation of the recreational damage in a stream/river or lake in a single watershed. In contrast, our Eastern Ohio study area includes multiple watersheds in the coal bearing counties of the state, and therefore is of major significance to state regulators.

In this research, we estimate the value of water quality change in lakes in Eastern Ohio. People respond to change in environmental quality by increasing or reducing the use of the resource. The value of lost recreation due to water quality change is a good measure of damages to lakes from coal mines. The incremental recreation value of post-restoration water quality improvement is the measure of restoration benefits.

We face some limitations in the empirical estimations. In order to estimate the revealed preference for water quality, the best method would be to take a survey on trips taken and to estimate a recreation demand model to derive the trade-off between water quality and trips taken. Given the regional extent of the analysis, primary data collection would have been time and budget intensive, and was not feasible. Our estimation approach is therefore based on secondary data collected by government agencies, GIS-derived variables, and data available in the literature. Given these data limitations, a visitation function is estimated to measure the damages to ecosystem services from coal mining and the benefits of restoration, and is believed to provide robust estimates than other non-market valuation techniques.

The visitation function method is used to estimate the changes in the number of visits to a lake as a result of changes in water quality. We also use the benefit transfer method and metrics, when reliable. Our aim here is to quantify (1) coal-mining damages to lakes at the regional scale, and (2) post-reclamation welfare gains from improved water quality in the region. As components of a benefit cost analysis (BCA), the reclamation costs for the coal mines located in the watersheds of the lakes are estimated and compared to the benefits attributed to the reclamation efforts.

2. Methodology

The Eastern Ohio counties housing abandoned coal mines are the site of this study (Fig 2). This section first examines the relationship between coal mining and lake water quality, using a Geographic Information System (GIS), hydrology, and water chemistry. Next, the visitation function model is developed and used to estimate damages and post-reclamation benefits. Reclamation costs are then estimated. Finally, a BCA of coal mines reclamation and improved ecosystem services from the lakes is discussed for prioritizing coal mine reclamation projects.

2.1. *Identification of coal-mine-impacted lakes*

2.1.1. *Geographic information system analysis*

GIS analysis is used to identify the spatial distribution of ongoing coal mining areas, reclaimed coal mines, and unreclaimed abandoned underground and surface coal mines located in Eastern Ohio (Fig. 2). A Digital Elevation Model (DEM) (USGS, 2009a), a watershed map (Natural Resources Conservation Services, 2009), a streams map and a lakes map (USGS, 2009b), and slope and flow accumulation maps derived from the DEM using the Spatial Analyst function of ArcGIS 9.3 (ESRI, Redlands, CA) are used to identify the lakes and streams impacted by coal mines. Thirteen lakes are identified as receiving runoff from the abandoned mines (Table 1), and therefore could potentially be impacted by these mines. The lake chemistry of these thirteen lakes is further investigated to quantify coal-mine-specific impacts.

2.1.2. *Lake chemistry: coal-mining-impact indicators*

Coal mines deteriorate downstream water quality with heavy metals, acid mine drainage, sulfur and other chemicals. The literature on the chemical conditions of lakes has been reviewed to find an appropriate variable representing coal-mine impacts. Physical, chemical, and biological measures, such as the Integrated Biotic Indices (IBI), Lake Condition Index (LCI), color, turbidity, chemical indices, pH, alkalinity, oxygen indices, and Coliform bacterial count, have been used in previous studies to evaluate water quality impacts on water-based recreation demand. The Ohio Environmental Protection Agency (OEPA) developed the Ohio LCI, based on 14 parameters, ranging from 10 to 100, where 100 is most impaired. This index is used to assess the overall lake ecosystem (Davic et al., 1997). The LCI measures overall nonpoint source pollution but not