A MODELING PROCEDURE FOR CONSERVING WETLANDS AND WATERFOWL HABITATS ON ABANDONED MINE LANDS AND OTHER RECLAMATION PROJECTS IN WYOMING RESULTS AFTER FIVE YEARS[1]

by

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Abstract. Since 1986, a modeling procedure has been used in the Wyoming Abandoned Mine Land Program for conserving wetland values for waterfowl and other species. The model was initially applied to the reclamation of abandoned bentonite workings but was adapted for use on abandoned uranium pits and other reclamation projects. Use of the procedure produced repeatable output and provided an accounting system that facilitated the resolution of differences in program and agency goals, and quickly became a negotiating medium that provided a basis for agreement on reclamation design. The model was designed to conserve wetland habitat values for waterfowl, but experience showed that this process also conserved other functional values of wetlands. Model parameters reflect habitat needs of breeding and migrating Anatidae species. The process was applied to 976 wetlands on eight Abandoned Mine Land project sites and resulted in post-reclamation conditions that included: a 9.7% gain in wetland habitat values, a reduction in both numbers (65.3%) and acres (33.2) of wetlands, and a 90% increase in the average size of wetlands (1.00 to 1.90 A). Costs can be paid back within as little as three years, with recreational fishing providing most of the pay-back.

Additional Key Words: Mitigation banking, Anatidae

Introduction

A modeling procedure has been used in the Wyoming Abandoned Mine Land (AML) Program since 1986 for evaluating and conserving wetland functional values for waterfowl and other wildlife species. The model was initially applied to the reclamation of abandoned bentonite workings in northeastern and northcentral Wyoming, but was subsequently adapted and used on abandoned uranium pits and other reclamation projects throughout the state. Use of the procedure produced repeatable output and provided an accounting system that greatly facilitated the resolution of major differences in program and agency goals, and quickly became a negotiating medium that provided a basis for agreement on reclamation design. The model was designed specifically to conserve wetland habitat values for waterfowl, but experience showed that the application of this process also resulted in the conservation of other associated functional values of wetlands.

Rationale for the development, mathematical derivation, and structure of the model have been described in detail by Hayden-Wing et al. (1987), and

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earlier assessments of results were reported by Hayden-Wing et al. (1989) and Hayden-Wing et al. (1990). The purpose of this paper is to summarize and evaluate the results of the program after five years of application to the reclamation planning process. This evaluation involves the analysis and integration of previous assessments with recent, previously unreported data, into an overall review of the program. Relevant portions of the previous papers (Hayden-Wing et al. 1987, 1989, and 1990) on this subject have been incorporated into this paper for the sake of collecting all of the information into a single document to facilitate comprehensive review and analysis.

Background

A wetland habitat evaluation model was developed in 1986 for the purpose of comparing existing and post-reclamation conditions on bentonite reclamation sites in the Wyoming AML Program (Hayden-Wing et al. 1987). The fact that many of the sites scheduled for reclamation contained water impoundments of various sizes which had developed wetland characteristics that provided substantial habitat value to migratory waterfowl created a need for such a model since the AML Program was justifiably charged with filling many of these ponds and pits in order to reduce hazards to livestock, wildlife, and humans, to retard soil erosion, and restore land productivity. The accomplishment of the objectives of the AML Program, while simultaneously preserving wetland habitat values, presented challenges of major proportions, in that, in order to accomplish AML goals it was necessary to eliminate or drastically alter large numbers of existing waterbodies. Other regulations, such as Section 404 of the Clean Water Act, the Fish and Wildlife Coordination Act, various Executive Orders, and consultation with the Wyoming Game and Fish Department (WGFD), collectively made it necessary to protect the wetland habitats and ensure that reclamation activities did not reduce the value of such habitats below preexisting levels. Also contributing to the challenge were economic considerations, engineering limitations, and the wishes of land and mineral rights owners.

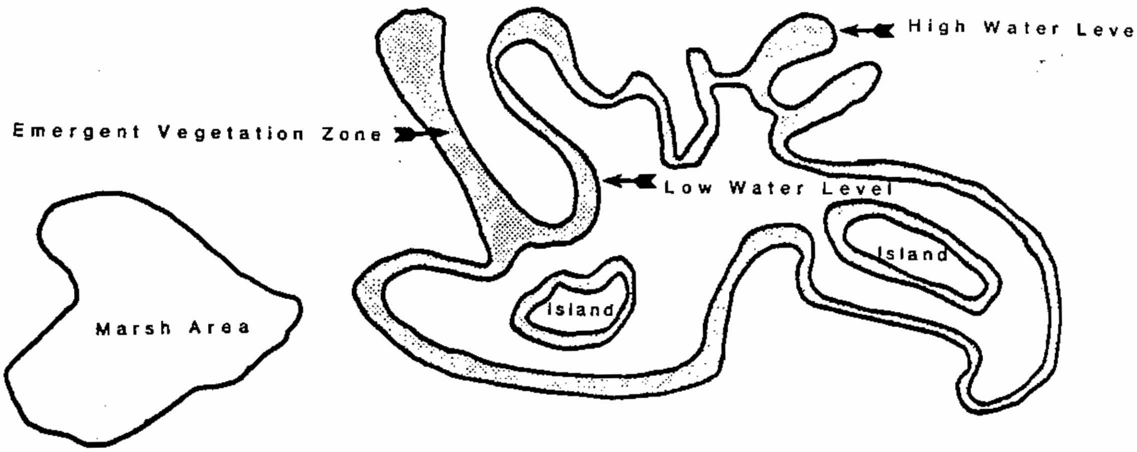
Basic decisions and agreements had to be made concerning the mechanism by which wetland values would be measured before solutions could be addressed. Such a process needed to measure "before" and "after" wetland values on reclamation sites in a quantified, repeatable manner. In response, an ecological book-keeping system or model was developed that measured relative changes in several key wetland parameters that reflect the general habitat needs of breeding and migrating waterfowl species. The model reflects relative habitat improvement or degradation, and provides a repeatable output upon which management decisions can be based. In general, the key parameters used deal with wetland size, quality, and longevity. Values of wetlands are quantitated into points or habitat units and represent the cumulative value of all input parameters.

The wetland evaluation program was developed specifically for the abandoned mine land program but has, after some trial and error and appropriate adjustments and revisions, been applied to other programs and circumstances.

The Model

The model is sufficiently specific to be useful in guiding the development of reclamation designs that will achieve desired mitigation goals. Model parameters are based upon general habitat needs of breeding and migrating Anatidae species and include: wetland size, proportion of emergent vegetation, fraction drawdown exposure, water quality (including ph), permanence of water supply, sedimentation rate, sinuosity of shoreline, associated marsh zones, numbers of islands, bays, and peninsulas, status of adjacent terrestrial vegetation, and relationship to other wetlands. For a detailed description of model derivation, parameters, applications, and assumptions see Hayden-Wing et al. (1987).

In general, relatively more habitat points were assigned as: (1) wetland size increased, (2) proportion of wetland covered with emergent vegetation approached the optimum of 40%, (3) fraction of drawdown exposure approached the optimum percentage for wetland size, (4) water quality and permanence increased, (5) sedimentation rate decreased, (6) sinuosity of shoreline increased, (7) acreage and proximity of associated march zones increased, (8) numbers of islands, bays, and peninsulas increased, (9) quality of associated adjacent terrestrial vegetation increased, and (10) the number of wetlands less than 2 acres in size, that are within 1/2-mile of wetlands larger than 2 acres in size, increased. Optimum drawdown percentage is relatively higher (approximately 60%) for smaller wetlands (1-acre) and decreases as wetland size increases, until it levels out and remains nearly constant (20%) for wetlands 10 acres in size and larger. The pond design illustrated in Figure 1 exemplifies a hypothetical, idealistic



Emergent vegetation occupies 40% of surface area.

Water visibility exceeds 2 ft. with fair to good water quality.

Low sedimentation rate with pond longevity expected to exceed 50 years.

Presence of associated marsh area.

40% of surface area is drawn down or exposed during a median precipitation year.

Permanent water supply with annual drawdown not normally exceeding 50% of surface area.

Highly sinuous shoreline.

2 Islands, 5 Bays, 3 Peninsulas.

Value added for pond less than 2 acres in size occurring within 1/2 mile of a pond 2 acres or larger in size.

Proximal 2 acres pond is not shown.

Figure 1. Top view of an idealistic pond configuration designed to maximize wetland values of a 1.9 acre waterbody.

configuration which would maximize wetland values relative to the size shown.

The model was originally developed specifically for the Hewlett-Packard Model 11 hand calculator, but most programmable calculators can be used. A GW BASIC program was subsequently developed by Tessmann (1986) and can be run on any personal computer.

Applications

The application of this book-keeping process allowed reclamation planning that compensated or more than compensated for the wetland habitat values lost from the elimination of numerous ponds that was necessary in order to achieve other important AML Program goals. The issue of avoiding substantial reductions in post-reclamation values of wetland habitats on the sites while simultaneously eliminating large numbers of ponds was resolved by: (1) saving or enhancing existing ponds which had high values and presented little or no hazard, and (2) designing and building new ponds that met all the AML safety and environmental requirements while providing higher wetland habitat values than ponds which were eliminated.

In order to retain or increase wetland habitat values on reclamation sites it was necessary to make more efficient use of annual precipitation. Since other requirements of the AML Program reduced the total amount of water available for impoundments, it was essential to utilize the reduced water supply in the most efficient way possible. Factors which reduced water availability included: (1) loss of water used to periodically flush or turnover impoundments in order to eliminate stagnation and maintain water quality standards, (2) the decreased runoff and increased retention of precipitation as ground water due to the pitted surfaces and increased vegetation cover produced during reclamation and (3) a substantial increase in evapo-transpiration losses due to the revegetation of extensive disturbed areas.

Methods

Wetland Values

Project summary data on pre and post-reclamation wetland numbers, acreages, and habitat values were obtained from 404 Permit Applications and the files of the Wyoming Department of Environmental Quality - Land Quality Division in Cheyenne. These data were then synthesized and analyzed to produce summary figures for the eight completed projects evaluated in this paper.

Comparative Design and Construction Costs

Construction cost data were summarized for the 349 ponds that were processed on one of the largest single AML projects to date. Estimates of what the project would have cost if wetland values were not considered were developed for comparison with what the project actually did cost. This project site was selected for construction cost comparisons because wetland considerations were brought into the design from the onset of the project and because of the large number of ponds involved.

Project construction costs were analyzed to establish average excavation and reclamation unit prices. Bid prices and measured quantities were used for completed tasks and for tasks under construction. Engineers' estimates were used for tasks that were not bid yet.

Site-specific Geomorphology and Reports of Investigation (ROI) that were prepared prior to the required application of wetland conservation measures were compared with design summary reports. These studies included topsoil and overburden analysis; hydrology; sedimentology; geomorphology; water quality; vegetation analysis; and landowner, mineral owner, and lessee contacts. Through comparisons it was possible to recognize the design changes that were attributable to the wetland considerations. Such comparisons were possible because the wetland conservation requirements were implemented during the early stages of the project design phase. Typical pond characteristics and weighted mean construction unit prices were used to determine the project costs and savings resulting from the design changes. Average wetland sizes and staking point densities were assumed for newly constructed wetlands to estimate additional surveying costs.

Design and permitting considerations were analyzed to estimate additional costs in the pre-construction phases of the project. The preparation costs for three U.S. Army Corps of Engineers (ACE) 404 Permit Applications and thirty-five Wyoming State Engineer Reservoir Permit Applications were totalled. The additional engineering design costs attributable to the wetland considerations were estimated and factored to include computer and clerical charges.

Governmental agency costs related to the additional review and administration of the wetland policies were not considered in this study.

Values of Associated Benefits

Since a variety of recreational uses occur on and in the proximity of wetlands on AML project sites it is reasonable to assume that expenditures generated by such activities would increase if the value of wetland habitats in the area were increased. Increasing the useful life span of wetlands, raising the water quality level, and increasing the volume of use by waterfowl and other water-loving organisms should also increase the amount of use they receive by wetland-oriented recreational users. Increased use and monetary expenditures would be expected from such recreational activities as waterfowl hunting, sport fishing, swimming, picnicking, trapping of furbearers, nature hikes, outdoor education, etc.

Since no statistics on such recreational activities are available for the AML project sites we do not know to what extent an increase in wetland values will increase associated recreational activities and it is not possible to accurately project increases in expenditures likely to be generated. In order to derive at least a gross quantitative estimate of the potential value of these associated benefits, a series of calculations was made. These calculations were applied only to one of the single largest AML projects completed to date and made the following three basic assumptions:

1. The County's share of annual expenditures made by hunters, trappers, and sport fishermen in the state of Wyoming is directly proportional to the fraction of the total state population which lives in the county (1.5%).

2. The proportion of County hunter, trapper and fisherman expenditures which comes from the AML project area is directly proportional to the fraction of the County occupied by the project (15%).

3. Increases in hunter, trapper, and fisherman spending on the project area are directly proportional to increases in wetland habitat values there (14.6%).

These assumptions were not made because we think they are true, but because they provide a basis for making relative comparisons of potential increases in expenditures among the various recreational activities.

Results

AML Wetland Statistics

Between December 1986 and December 1990 the model was used in determining wetland habitat values on a total of 976 ponds of varying size on 8 AML reclamation projects. These projects were concentrated in the Northeastern quarter of the state, but extended westward into the Big Horn Basin and the Gas Hills region of central Wyoming (Figure 2).

The 976 ponds present before reclamation activities commenced collectively occupied 963.6 acres and represented 2,212.31 wetland habitat value points (Table 1). Upon completion of reclamation activities 339 ponds, representing 643.4 acres and 2,426.34 wetland habitat value points, remained. The reclamation activity on the eight sites resulted in a 65.3% reduction in total number of ponds, a 33.2% reduction in the total wetland acreage, and a 9.7% increase in total wetland habitat values (Table 1). These numbers reflect the filling of relatively large numbers and acreages of small, low-quality and/or hazardous ponds and saving, enhancing, or rebuilding relatively smaller numbers of the higher-quality larger ponds. In the process, the average size of wetland increased 90.0% from 1.00 acres to 1.90 acres (Table 1).

The percent change in "before" and "after" wetland habitat values varied considerably between the eight sites. Part of this variation is due to inherent differences among site environments, amounts of water available, and corresponding differences in potential for retaining and increasing point values. Part is also due to the timing of application of the point evaluation process to individual projects. For example, reclamation work was already well underway and many ponds had been filled when several of the projects were subjected to the evaluation process. Projects which showed the greatest increase in point values, were subjected to the process at or near the beginning of the work and had relatively much more total water and many more ponds available to work with. One project area was extremely dry and had very little water and few ponds to work with. It produced only a modest gain in absolute habitat points (27.18), but showed the greatest single percentage gain in points (64.7%) of all the projects.

The different point-saving and-gaining potentials among sites exemplifies one of the

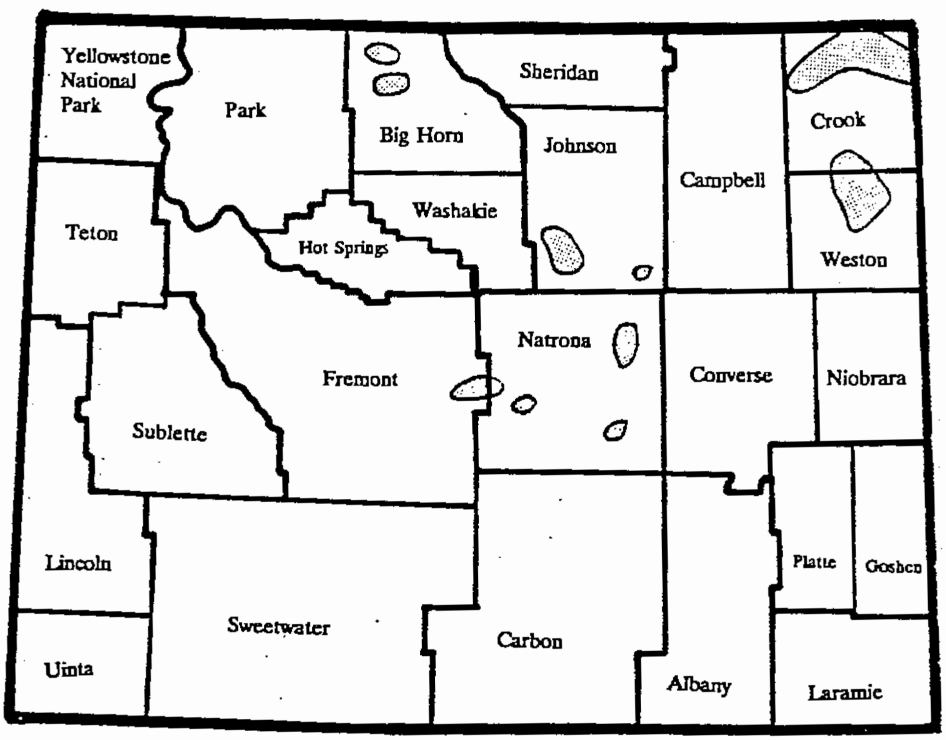


Figure 2. AML Project Locations in Wyoming, by County.

Table 1. Comparison of wetland parameters before and after reclamation on eight project areas.

Wetland Parameter	Before Reclamation	After Reclamation	Difference
Numbers	976	339	-637.0 (65.3%)
Acres	963.6	643.4	-320.0 (33.2%)
Habitat Value*	2,212.31	2,426.34	+214.0 (9.7%)
Mean Size	1.00 A	1.90 A	+0.9 (90.0%)

advantages in maintaining a running total of wetland habitat values gained or lost between projects as it facilitates the transfer of points among projects to balance deficits with surpluses. Although not extensively applied, the transference of points between projects is a manifestation of the increasingly common practice of "mitigation banking". Such an approach is often used in resolving wildlife impacts that occur over large areas and extended time periods.

Project Costs and Savings

Additional project costs associated with the implementation of wetland considerations are discussed below and illustrated in Table 2. Actual construction costs for completed tasks and estimated construction costs for tasks not completed were analyzed to determine the weighted mean construction costs for two phases of construction: 1) unclassified excavation, and 2) revegetation with soil amendment applications. The unclassified excavation prices on tasks varied from $0.36 per cubic yard (c.y.) to $0.75 per c.y., with quantities ranging from 30,500 c.y. to 1.2 million c.y. The wetland features were not considered significant to the unclassified excavation unit prices because of the relatively small amount of additional work (when compared to the total task required to incorporate them). The weighted mean price for unclassified excavation was $0.544 per c.y. for an estimated total quantity of 7.7 million c.y.

The revegetation phase of construction consisted of spreading and incorporating lime, gypsum, wood residue, nitrogen and phosphorous into the soil prior to drill seeding or pitting and seeding. The costs for the revegetation phase were totalled for each construction task and then analyzed for the total project to determine a weighted mean cost per acre. The costs varied from $1,155.75 per acre to $2,678.12 per acre. The weighted mean cost for the revegetation and soil amendment phase of construction was $1,797.26 per acre for 1,871 acres of revegetated area.

In implementing the design changes necessary to comply with the wetland preservation restrictions, the following points became evident:

1. The addition of islands, bays, peninsulas, and shallow areas increases the wetland value of ponds. The proximity of wetlands to each other is also a key factor in their value. In some cases, it was more feasible to fill an existing wetland and build a new one in a more advantageous location in order to gain proximity to other wetlands, to gain wetland value by incorporating the above mentioned features, and to make more efficient use of the available water supply. For these reasons, five less ponds were saved than planned in the ROIs.

2. The review of the 404 Permit Applications by the ACE, U.S. Fish and Wildlife Service

TABLE 2. Additional costs associated with the implementation of wetland considerations on a Wyoming AML project involving 339 wetlands.

Item		Cost Per Additional Acre of Wetland* (Dollars)	Total Cost (Dollars)
1.	Construction Costs*		
	a. Increased Excavation	$1,982.22	$158,875
	b. Decreased Revegetation	-1,797.26	-144,050
	c. Increased Surveying	129.76	10,400
	Subtotal	$ 314.72	$ 25,225
2.	Pre-Construction Costs*		
	a. Develop Wetland Model, COE 404 Permits	$ 986.28	$ 79,050
	b. Wyoming S.E. Permits	118.53	9,500
	c. Increased Design Cost	305.68	24,500
	Subtotal	$1,410.48	$113,050
Total For Additional Wetlands		$1,725.20	$138,275
Total For AML Project ***		$ 64.92	$138,275

* There were 80.15 additional acres of wetland habitat built.
** Governmental Agency costs were not included.
*** There were 2,130 total acres of reclamation on this AML Project.

(FWS), U.S. Forest Service, and the WGFD, as well as construction feasibility reviews, resulted in two less ponds being filled than planned in the ROIs.

3. The reclamation designs were influenced by the need to maintain existing wetland habitat and to also mitigate wetland habitat lost by dewatering and filling numerous small wetlands of little individual value, but of significant value when considered collectively. As previously mentioned, in some cases it was more efficient to fill an existing pond and rebuild it in a more suitable location to better utilize the available water supply, to incorporate valuable wetland features, and to change its proximity to other wetlands. For these reasons, thirty-eight more new ponds were built than planned in the ROIs.

The mean sizes of wetlands on the project before reclamation and after reclamation are 1.15 acres and 2.20 acres, respectively. Assuming that the average maximum depth of a pond initially planned for saving was eight feet, the average maximum dept of a pond planned for filling was two feet, and the average maximum depth of a new pond was six feet, results in an increase of 292.050 c.y. of unclassified excavation and a decrease of 80.15 acres of revegetation (because of the increased wetland water surface areas). Applying the unit costs previously derived indicates that the application of the wetlands model cost roughly $158,875 because of increased excavation, but saved roughly $144,050 because of decreased revegetation acreages. These and other costs are further summarized in Table 2.

Surveying costs for grade staking prior to commencement of construction and for quantity calculations after construction grading were increased by an estimated $10,400 as a result of the wetland program. The additional design and permitting considerations necessary to comply with the wetland requirements were significant. Three ACE 404 Permit Applications were prepared for the project, and the Wetland Evaluation Model was developed and revised on this project through the application and review process. The existing wetlands were evaluated and the Wetland Evaluation Model was used to establish additional design criteria. The site-specific ROIs were scrutinized to determine the natural wetland development limitations and to also establish the maximum feasible wetland development. The reclamation plans were then revised and evaluated with the Wetland Evaluation Model. The revised reclamation plans were then used to prepare the 404 Permit Applications. The cost of the model development and preparation of three 404 Permit Applications was $79,050. The one-time developmental cost of the model is estimated to be $34,311 and is included in the $79,050.

As previously discussed, the reclamation plan revisions resulted in five less ponds saved, two less ponds filled, and thirty-eight more ponds built, which necessitated the preparation and filing of thirty-five additional Wyoming State Engineer Reservoir Permit Applications. The preparation and filing costs were $9,500.

The additional engineering design costs attributable to the wetland habitat preservation and mitigation responsibilities were considered. The reclamation plan changes related to the wetland protection efforts were evaluated and the manhours of design time required to incorporate those changes were estimated. The estimated time was then factored to reflect computer and clerical charges. The estimated additional design charges were $24,500. These and other charges are summarized in Table 2.

The costs of applying the model and the "no-net-loss" policy to 349 waterbodies on this project resulted in a net increase in one-time construction and pre-construction costs of $103,964.

Values of Associated Benefits

Projected estimates of expenditures of wetland bird hunters, fur trappers, and sport fishermen for Weston County are presented in Table 3 along with calculated estimates of increases in these expenditures that might result from increasing wetland habitat values in the area. Since these projections are based on untested assumptions, little credence can be assigned to the absolute values. At the very least, however, these calculations offer a relative comparison of potential increases in expenditures among the various recreational activities. Although the 14.6% increase in wetland habitat values would probably result in moderate increases in spending by bird hunters and fur trappers in the area, by far the greatest potential for increasing revenues lies in the improvement of recreational fishing opportunities.

Although there will very likely be an increase in the quantity of local waterfowl production that is exported each year to other states and countries

Table 3. Projected expenditures of wetland bird hunters, fur trappers, and sport fishermen in Weston County, Wyoming during 1988.

	State of Wyoming - 1988 (1)			Estimated Total Expenditures		Total Increase(4)
	Non-License Expenditures	License Revenue	Total Expenditure	Weston(2) County	AML(3) Project Area	in Expenditures in the AML Project Area
Duck Hunting	1,475,376	57,700	1,533,076	22,996	3,449	504
Goose Hunting	1,051,992	41,177	1,093,169	16,398	2,460	359
M.Dove Hunting	407,089	15,736	422,825	6,342	951	139
Rail/ Coot/Snipe Hunting	33,579	1,337	34,916	524	79	11
Furbearer Trapping	1,706,838	29,656	1,736,494	26,047	3,907	570
Sport Fishing	99,450,047	2,521,991	101,972,038	1,529,581	229,437	33,498
					Hunting/Trapping	1,283
					Sport Fishing	33,498
					TOTAL:	34,781

(1) Wyoming Game and Fish Department 1988.

(2) Calculated by taking 1.5% of total state expenditure. 1.5% of Wyoming's population lives in Weston County (Furtney 1988).

(3) Calculated by multiplying Weston County expenditure by 15%. The AML Project occupies approximately 15% of Weston County.

(4) Calculated by multiplying AML Project expenditures by 14.6%. Wetland Habitat Values on the AML Project were increased by 14.6%.

during the fall months when the birds migrate south, no estimates of this cost benefit were made. Other activities which undoubtedly benefit from the increase in wetland values include swimming, picnicking, nature hikes, outdoor education, the incidental sightings of wildlife associated with the wetlands, and the aesthetic pleasure that many humans derive from the mere awareness that such enhanced habitats exist. Increases in values associated with these activities could not be assessed.

The cost and recreational expenditure estimates in this analysis represent a set of site-specific conditions and the degree to which they can be applied to other sites and circumstances will vary considerably.

Model Adjustments

When the evaluation procedure was applied to waterbodies in abandoned uranium pits in the Gas Hills in central Wyoming the model was found lacking in parameters to adjust for the highly acidified waters that exhibited no signs of biological productivity. Although the specific relationship between ph and biological productivity varies between sites and geographic regions, the general relationship is very consistent. Acidified waterbodies show marked decreases in their biological communities of decomposer, primary producer, invertebrate, and fish populations.

Based on available information, a curvilinear adjustment to the calculated wetland value, consisting of a multiplier of 0.0 to 1.0, was derived. The curve assumes a sigmoid configuration asymptotic to 0 and 1, with the greatest change occurring between 5.0 and

6.0 (Hayden-Wing et al. 1990). The application of this adjustment formula reduced the uncorrected wetland values for the acidic waters in the Gas Hills to levels that were more reflective of true values to waterfowl.

Wetland Banking System

In 1988, the WGFD, Wyoming Highway Department (WHD), and several other state agencies, along with the Federal Highway Administration (FHwA), FWS, Environmental Protection Agency (EPA), and the ACE began discussions regarding wetland banking for highway construction projects. The WHD felt there were opportunities to create wetlands during project construction which could be considered "credits" when circumstances precluded avoidance or on site mitigation at certain locations.

In conjunction with formulation of a wetland banking Memorandum of Understanding (MOU), WGFD Environmental Biologist Steve Tessmann, who was instrumental in developing the wetland habitat evaluation model SUPERBOG, devised a banking program named BOG BANK. BOG BANK is a mitigation accounting system integrated with the wetland habitat evaluation model which chronologically tracks impacts and credits within 4 broad wetland categories, 9 major drainage basins, and 3 biotic regions.

Conditions set by the involved parties for the banking system include:

- the bank will operate with no deficits.
- mitigation credits will apply to the same drainage basin, biotic region, and wetland type.
- credits or deficits will be calculated using acreage, however habitat unit values will be used to assure habitat values of mitigation wetlands area at least equivalent to those lost from wetland impacts.

The last condition listed above addresses the concern that SUPERBOG only evaluates habitat values and does not account for other wetland functions. It is assumed that by maintaining an account by wetland type some of the functions other that habitat values will be replaced by virtue of the fact that there will be no overall loss of each of the various types. In addition, by maintaining a bank that requires no deficits within biotic regions and major drainages, wetland losses within those categories will be minimized.

The wetland banking MOU is in it's final revision, and all involved parties with the exception of ACE and EPA are willing to sign. These two agencies have supported development of the system, but feel they should remain outside this process for several reasons, including the fact that they are regulatory agencies.

Interest has been expressed in using this wetland banking system as the foundation for a similar system for all Wyoming state agencies that may impact wetlands. The governor has recently signed a state wetland policy, which has set the stage for creation of a state wetland banking system.

Discussion

The application of the wetland evaluation system resulted in post-reclamation conditions that included: greater habitat values, lower total numbers and acres of wetlands, and a larger average size wetland. The increase in average wetland size reflects the tendency to build larger wetlands to replace smaller ones in order to maximize habitat point values while minimizing construction costs. Care must be taken not to over-respond to this tendency in that it can quickly imbalance the wetland size class distribution by disproportionate reduction of smaller wetlands (0-1 acre). The ground rule of not allowing the transference of wetland values among size classes prevents undue modification of original size class distribution of wetlands but, allows agency regulators to modify original distributions when such changes result in a better wetland complex. e.g. Creating smaller ponds in areas which originally had none.

On the basis of cost/benefit information analyzed, it appears that the $103,964 net cost for wetland considerations on a large AML project involving 349 ponds could potentially be paid back to society within three years if the benefits ($34,781/year) described in the study are realized. It is not likely that the full extent of these cost benefits will be realized since most wetlands were not specifically designed for sport fishing, the principle source of cash returns. Because of the great potential sport fishing has for returning revenue to the state of Wyoming, priority consideration should be given on future AML projects to designing as many wetlands as possible to support sport fisheries.

The wetland model, its applications, and results are still in a developmental stage and continue to be improved and changed in response to new circumstances and the knowledge provided by a growing experience base. Because the system was developed for application to an environment which supported small and shallow wetlands with neutral to basic ph values and non toxic water it is not equally applicable to other dissimilar environments. Although the ph modifications previously described have expanded the range of circumstances to which the system can be applied, we continue to encounter new circumstances in which the model tends to produce apparently distorted values. One such case involves large, deeply excavated pits fed by groundwater which is non toxic with normal ph values, but apparently biologically very sterile. The model as it currently is configured assigns much higher values to such waterbodies than they appear to be worth.

Political and administrative issues raised by the suggested potential application of the model as a mitigation banking medium for use by other agencies and application to private lands within the state include: (1) the consideration of whether or not man-made wetlands on private lands should be subjected to the same evaluation process as naturally occurring ones or whether preexisting credits should be assigned to wetlands created by human activities, (2) the issue of how much flexibility is allowable in mitigating a wetland loss in an environment physically distant from the site of wetland impact, and (3) inter-agency territoriality created largely by differences in goals, policy, and programs.

In Wyoming, the ACE, WGFD, and FWS all have immediate and direct input to determining which wetlands qualify for replacement in a mine reclamation, highway construction or private development activity. The EPA, although deferring to the above listed agencies, has final regulatory authority over the findings and determinations. On occasion, conflicts - differences - have arisen between the agencies in their determination of jurisdictional wetlands, with on-site coordination and communications ultimately leading to resolution.

The fact that the current model generates habitat values that are based entirely on parameters which rank values of wetlands to waterfowl has produced criticism that other water uses and values are not adequately represented. Water that is suitable for waterfowl habitat may not meet standards for other uses because of acidity, alkalinity or chemical constituents such as heavy metals (selenium, for instance) or radioactivity. Other critics feel that issues involving private land owner preferences, economics, and goals of public land management agencies are overshadowed by the objective of no-net-loss of waterfowl habitat.

The wetland model, its applications, and results are still in a developmental stage and continue to be improved and changed in response to new circumstances and the knowledge provided by a growing experience base. The results presented in this paper are meaningful and significant, but should still be regarded as preliminary. As follow-up evaluations are made over time of the effectiveness of reclamation and man-constructed wetlands an even more accurate assessment will be possible. Furthermore, the adaptive extension of the process to new environments and types of wetlands will lend additional perspectives.

This wetland evaluation process exemplifies or embodies several of the key issues under consideration across the country at this time. Specifically, it: (1) employs an indexing system based on wetlands value to waterfowl for achieving a no net loss goal, (2) exemplifies one effective method for creating and restoring wetlands, (3) constitutes one way in which wetland impacts can be mitigated, and (4) illustrates the application of a wetlands accounting system at both ecological as well as state-wide levels.

By applying this system we have been able to resolve major differences in program and agency goals and have achieved a total net gain in waterfowl habitat values over the past five years. Key ingredients in the success of this program and in effectively dealing with the complex issue of no net loss of wetlands proved to be: an interdisciplinary approach, and a high degree of interagency cooperation.

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