RESEARCH

The Effect of Wetland Mitigation Banking on the Achievement of No-Net-Loss

PHILLIP H. BROWN
U.S. Army Corps of Engineers
St. Louis District, 1222 Spruce Street
St. Louis, Missouri 63103, USA

CHRISTOPHER L. LANT*
Department of Geography
Southern Illinois University at Carbondale
Carbondale, Illinois 62901-4514, USA

ABSTRACT / This study determines whether the 68 wetland mitigation banks in existence in the United States through 1 January 1996 are achieving no-net-loss of wetland acreage nationally and regionally. Although 74% of the individual banks achieve no-net-loss by acreage, overall, wetland mitigation banks are projected to result in a net loss of 21,328 acres of wetlands nationally, 52% of the acreage in banks, as already credited wetland acreages are converted to other uses. While most wetland mitigation banks are using appropriate compensation methods and ratios, several of the largest banks use preservation or enhancement, instead of restoration or creation. Most of these preservation/enhancement banks use minimum mitigation ratios of 1:1, which is much lower than ratios given in current guidelines. Assuming that mitigation occurs in these banks as preservation at the minimum allowable ratio, ten of these banks, concentrated in the western Gulf Coast region, will account for over 99% of projected net wetland acreage loss associated with banks. We conclude that wetland mitigation banking is a conceptually sound environmental policy and planning tool, but only if applied according to recently issued guidelines that ensure no-net-loss of wetland functions and values. Wetland mitigation banking inevitably leads to geographic relocation of wetlands, and therefore changes, either positively or negatively, the functions they perform and ecosystem services they provide.

The use of wetlands often brings about a conflict of interest between groups that derive direct and indirect benefits from the ecosystem services that wetlands generate in their natural state and landowners who perceive that they would derive greater private benefits from converting wetlands occurring on their land to other uses, such as real estate development, agriculture, or oil and gas production, that generate marketable commodities. The list of ''wetland functions and values'' is long and has been often cited. Among classes of terrestrial ecosystems, wetlands provide by far the largest package of ecosystem services on a per-acre basis (Costanza and others 1997). The economic value of these services has been calculated as greater than the economic value of converted uses in some instances (Lant and Roberts 1990). The high value of ecosystem services provided by wetlands is largely attributable to their high rate of biological productivity and habitat diversity as well as their beneficial role in stabilizing hydrologic processes at a watershed scale (Mitsch and Gosselink 1993).

Throughout most of the last two centuries, the federal government has encouraged or subsidized conversion of wetlands to other uses, especially agriculture. Since the 1970s, this policy has been reversed. The two most important wetland protection laws in the United States currently are the Swampbuster program, passed as part of the 1985 Farm Bill and directed toward conversions of wetlands to agriculture, and the Clean Water Act (CWA) Section 404 program, first passed as part of the Federal Water Pollution Control Act of 1972, which is focused on nonagricultural wetland conversions. Implementation of these policies has been controversial and problematic. The essential conflict of interest outlined above has been manifested in claims that wetland regulation is a ''regulatory taking'' in violation of the fifth amendment of the US Constitution and a decade-long battle over the definition and on-the-ground determination of wetlands that is not yet resolved at the time of this writing, despite the release of the National Research Council's recommendations in May 1995 (National Research Council 1995). (The report allows evidence of hydrology to be inferred from observations on soils and vegetation, notes that the relevant zone for evaluation is the upper 30 cm, and generally identifies 14 days as the period of saturation necessary for wetland status.) As evidence of the intensity of conflict and widespread interest in wetland protection policy in general, and the delineation issue

KEY WORDS: Mitigation banking; Wetlands; Army Corps of Engineers; No-net-loss

*Author to whom correspondence should be addressed.

 © 1999 Springer-Verlag New York Inc.

specifically, an unprecedented 80,000 comments were received from a large variety of sources and interest groups on the ''Federal Manual for Identifying and Delineating Wetlands'' manual proposed in 1991 (Hays 1997).

The conterminous United States contained about 220 million acres of wetlands at the time of European colonization, comprising about 9% of the landscape (Dahl and Johnson 1991). Since that time, conversion of wetlands to alternate land uses decreased their total extent to an estimated 103 million acres by the mid-1980s (Lewis 1995, Dahl and Johnson 1991). The annual net loss of wetlands from the mid-1950s to the mid-1970s was 455,000 acres, mostly due to conversions to agriculture. In the decade 1974–1983, this rate slowed to 288,900 acres/yr due to a rapid decline in agricultural conversions. In the decade 1982–1992, annual net loss fell to 79,300 acres, with nonagricultural conversions accounting for over 80% of all conversions (Wiebe and others 1996). These data indicate that the substantial decline in wetland loss that has occurred nationally is almost entirely due to a near cessation of wetland drainage for agriculture, with wetland conversions to nonagricultural purposes, the focus of this study, peaking at 185,700 acres per year in the decade 1974–1983 and slowing to an annual rate of 125,200 in the decade 1982–1992 (Weibe and others 1996).

As mandated under the CWA, impacts to wetlands and all other aquatic systems are under the joint regulation of the US Army Corps of Engineers (Corps) and Environmental Protection Agency (EPA) (Kruczynski 1990). The 404 Program handles a large volume of permit applications and wetland conversion activities. For example, in fiscal year 1994, over 48,000 people applied to the Corps for a Section 404 permit. Of these, 82% were covered by general permits, and less than 1% were denied (Dennison and Schmid 1996). General permits also cover an estimated 50,000 conversions that do not require any notification to the Corps. This causes difficulty in managing cumulative impacts of incremental losses of small tracts (K. McMullen, US Army Corps, personal communication 1996, T. Kelsch, EPA, personal communication 1996). In the case of individual permits, EPA has the authority to veto 404 permits approved by the Corps; however, it has used this authority to veto only 12 permits out of 150,000 permit applications received by the Corps in 1979–1995.

Regulatory agencies have attempted to minimize impacts on wetlands by developing a sequence of mitigation guidelines to be followed before impacts can occur (Kruczynski 1990). Simply defined, the concept of mitigation is the requirement of means and measures to prevent habitat loss or damage. Mitigation may be accomplished by following the sequence of guidelines established by NEPA:

1. Avoiding the impact altogether by not taking a certain action or parts of an action;
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and,
5. Compensating for the impact by replacing or providing substitute resources or environments. If compensation must be used, the preferred order of methods is: (1) restoration, (2) creation, (3) enhancement, and (4) preservation, the latter two with reference to existing wetlands under threat of conversion.

In 1990, a Memorandum of Agreement between the Corps and the EPA was signed (MOA 1990), reestablishing guidelines to achieve a national goal of no overall net losses of wetland functions and values. This MOA is the primary document establishing a national policy of no-net-loss of wetlands by acreage and function as recommended by the National Wetlands Policy Forum (1988).

Wetland Mitigation Banking

Wetland mitigation is, ''the restoration, creation, enhancement and, in exceptional circumstances, preservation of wetlands and other aquatic resources expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources'' (Federal Register 1995). The concept of using wetland ''banks'' to achieve mitigation developed in the late 1970s as a response to two important concerns. First, a number of requests were made on behalf of environmental concerns that regulatory agencies consider mitigation banking as a management instrument for future developmental plans (Reppert 1992). Second, there was a need for a simpler way to mitigate the loss of wetlands caused by development projects. In most situations, those planning to convert wetlands to other uses lack the expertise to mitigate wetlands through restoration or other means, and in fact, the issue is viewed as an expensive and time-consuming requirement. However, a third party (i.e., mitigation banker) could mitigate wetlands by establishing a bank of wetland credits that could be sold or conveyed to a developer, who could then spend the credits in compensation for conversions

occurring due to the project. The banked lands would continue to be held and operated by the banker or its successor to conserve the wetlands in perpetuity, with appropriate assurances to this effect provided to the agencies (Marsh and others 1996). The first major bank to be established was the Fina LaTerre Mitigation Bank in Louisiana in 1984 following a 1982 presentation to the Corps by the Tenneco Corporation (Graves 1995).

Various techniques are used to establish credits for mitigation banks. Some examples of wetland functional methodologies used for assessment are the Hydrogeomorphic Classification System or Model (HGM) (Hart 1995), and the Wetland Evaluation Technique (WET) (Adamus 1983). Due to limitations of wetland functional assessment methods, credits and debits can also be measured simply as a mitigation ratio (acres compensated–acres converted). Draft guidelines for mitigation banking issued by EPA Region IV in 1992 give the following compensation ratios: 2:1 for restoration, 3:1 for creation, 4:1 for enhancement, and 10:1 for preservation (Dennison and Schmid 1996). In this case, the compensation ratio used should attempt to replace to the fullest extent the functions and values of the type of wetland classes produced and lost. Case studies of the 46 banks existing in 1992 by Brumbaugh and Reppert (1994), showed that 20 banks used some form of functional methodology assessment. Thus, the other 26 were simply based on acreage ratios. The bank's available credits are progressively debited as development occurs. When credits are reduced to zero, the bank's account is exhausted and considered defunct (Brumbaugh and Reppert 1994). Credits placed in deposit by a sponsor can only be spent by a user if the regulator approves the action. The important issue here is maintaining the ecosystem services that wetlands (as well as other ecosystems) provide. The delineation of land into wetland and upland and the measurement of wetland acreages serves as a surrogate for detailed scientific information on the contribution that particular plots of land and broader landscapes make to the generation of various ecosystem services. That is, current policies preserve wetlands rather than ecosystem services directly.

Participants on the committee for the negotiation of the mitigation banking instrument are referred to as the mitigation banking review team (MBRT). Included in the MBRT are the state and local resource planning agencies, the bank sponsor, and federal agencies. Under the guidelines of the 1995 Federal Register, the Corps is assigned to chair the MBRT committee, except in cases where the bank is proposed solely for the purpose of complying with the Food Security Act (FSA) of 1985, in which case the Natural Resources Conservation Service (NRCS) will be chair. EPA, Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and state and local agencies also oversee and approve the operation of mitigation banks (Brumbaugh and Reppert 1994).

Any department, agency, entrepreneur, or group entity may request to sponsor a bank in the mitigation banking process. The party requesting sponsorship must comply with the MBRT-authorizing instrument, the memorandum of agreement or understanding (MOA or MOU) (Shabman and others 1996). The MOA/MOU should describe in detail the physical and legal characteristics of the bank and how the bank will be established and operated. Information that is to be contained in each individual MOA/MOU, according to the guidelines of the 1995 Federal Register, are as follows:

1. Bank goals and objectives,
2. Ownership of bank lands,
3. Bank size and classes of wetlands proposed for inclusion into the bank,
4. Description of baseline conditions at the bank site,
5. Geographic service area,
6. Wetland classes or other aquatic resource impacts suitable for compensation,
7. Methods for determining credits and debits,
8. Accounting procedures,
9. Performance standards for determining credit availability and bank success,
10. Reporting protocols and monitoring plan,
11. Contingency and remedial actions and responsibilities,
12. Financial assurances,
13. Compensation ratios,
14. Provisions for long-term management and maintenance.

The overall goal of mitigation banking is the establishment or reestablishment of self-sustaining, functioning aquatic systems that replace the function and acreage of wetlands and other aquatic resources anticipated to be adversely impacted (Brumbaugh and Reppert 1994). However, based upon short-term monitoring periods, an estimated 50% of wetland restoration and creation projects have failed to produce designated functions in the last decade, largely due to problems of establishing necessary hydrologic regimes. Thus, the Federal Guidance (Federal Register 1995), states that "the bank sponsor is responsible for securing sufficient funds to cover contingency actions in the event of bank default or failure. In addition, the bank sponsor is responsible for securing adequate funding to monitor and maintain

the bank throughout its operational life.'' Financial assurance can be provided in a variety of forms: security bonds, trust funds, escrow accounts, sinking funds, insurance, self-bonds, and corporate guarantees. However, very few existing or proposed banks have any provisions for financial assurance (Marsh and others 1996).

Cited advantages of mitigation banking as a policy tool for addressing conversion of wetlands to other uses include:

1. Consolidation of mitigated wetlands (with the potential for mitigation to occur on small projects now granted general permits),
2. Economies of scale in restoration/enhancement, expertise, financing, management,
3. Cost-effectiveness,
4. Reduced permit processing times,
5. Credits are put in place in advance of debits,
6. Contribution to no net loss, and
7. High rates of failure on small, on-site mitigation projects.

Thus mitigation banking is a modern form of a quasi-market solution that creates geographic flexibility in mitigating for wetland conversions so that developers can find cost-effective solutions, while maintaining a polluters-pay principle. That is, it utilizes the net in no-net-loss. Nevertheless, it is not known whether mitigation banking is achieving this goal. Thus, the research questions addressed in this study are:

1. Does wetland mitigation banking result in a net gain or a net loss of wetland acreage nationally and regionally? and
2. What impact do wetland mitigation banks have on the geographic distribution of wetlands, and how is this important to the functions and values that wetlands provide?

Geographic Service Area of Mitigation Banks

Mitigation banking should be recognized as a policy instrument that has the potential to re-configure the type and spatial distribution of wetland ecosystems over large geographic areas (Salvesen 1995). Congress has expressed an interest in ''the appropriate geographic scope for which wetlands loss may be offset by restoration, creation, and enhancement efforts'' (Water Resource Development Act of 1990, Section 307d).

Viewed very broadly, two ends of a spectrum can be established. At one end, a national mitigation bank would be established, perhaps in southern Florida or Louisiana or even northern Alaska, that is used to compensate for wetland conversions throughout the country. At the other end of the spectrum, no-net-loss is changed to no *absolute* loss by rejecting the concept of mitigation, or somewhat less at the extreme, by requiring on-site mitigation in all cases. That is, the concept of no-*net*-loss implies changing the geography of wetlands, while maintaining the total quantity, whether by acreage or function. Within this broad spectrum lie possibilities for establishing mitigation banks based on watersheds, ecological regions, absolute distance, or political jurisdictions of any kind. The scope of the service area has varied throughout the nation, ranging from watershed, county, coastal plain, statewide, Corps district, and DOT districts (Table 1). There is tension between the desire of regulatory and natural resource agencies to replace lost wetland values and functions as close to the impacted site as possible and the interest of wetland converters or private bank owners and their clients who desire as large a geographic range as possible to maximize the size and fluidity of the market for credit availability (Shabman and others 1996).

Study Design

In the spring and summer of 1996, specific data and information were compiled from the authorizing instruments (i.e., permit, memorandum of agreement, memorandum of understanding) for all 68 mitigation banks in existence through 1 January 1996. [More than 60 proposed banks are reported to be under review in 1996 (Marsh and others, 1996)]. To increase the efficiency of obtaining the status of existing banks, it was determined that utilizing the 10 EPA regions of the country would be most practicable. By this procedure, direct points-of-contact for individual bank authorizing instruments were made in a timely manner. Once all points-of-contact were obtained, personnel were contacted via electronic mail (e-mail) or personal conversations. Data on location, acreage, compensation method, wetland type, geographic scope of the mitigated area, and mitigation ratio were obtained for all 68 banks (Table 1).

At the time the above contacts were made, the ledger of transactions for individual banks was requested. However, this information was available for only six of the banks. The impacted areas obtained in the ledgers were identified and mapped. Acreage, rather than functional value, was used as the basis of comparison among mitigation banks. Methods utilized to replace natural wetland functional value vary nationally and are beyond the scope of this study.

Banks were evaluated individually with respect to

projected acreage gain or loss by a simple procedure utilizing the compensation method and the mitigation ratio. Restoration and creation were projected to add wetland acreage brought into the bank. Thus, a 100-acre bank using restoration or creation as the compensation method with a mitigation ratio of 2:1 would result in a projected net *gain* of 50 acres (100 acres restored/created as compensation for 50 acres converted to other uses). Enhancement and preservation were treated as not adding acreage since the wetlands in the bank were jurisdictional wetlands prior to the establishment of the bank. Thus a 100-acre preservation or enhancement bank with a mitigation ratio of 2:1 would result in a projected net *loss* of the 50 acres converted to other uses. Note that this projected loss is not actualized until the 50 acres of credits are used. Note also that enhancement should result in an improvement in ecological functions and services provided by wetlands without adding acreage. The right-hand column of Table 1 provides the projected acreage gain or loss for each of the 68 banks using this method. In several cases, the form of mitigation method or mitigation ratio were not explicitly identified in the authorizing instrument, thus allowing a case-by-case negotiation of individual transactions. In these cases, the predominant method of compensation, and the specified minimum compensation ratio were used as a basis of analysis. These conventions probably result in an overestimate of wetland loss that will ultimately occur in some banks.

Thematic mapping was used to analyze the spatial patterns of mitigation banking and wetland loss and gain nationally and the pattern of converted and mitigated wetlands within selected banks.

Results

Wetland mitigation banks were established in every year from 1984 to 1995, with a peak of 10 banks established in 1988 and again in 1995 (Table 2). By acreage, the peak year is 1994, even though 56% of total acreage in mitigation banks as of 1 January 1996 was established in the period 1982–1986. The period 1989–1992 represents a lull in mitigation banking activity.

Wetland mitigation banks range in acreage from 1 acre (Sea World Eelgrass, San Diego, California) to 7014 acres (Fina LaTerre Bank, Louisiana). The distribution of bank acreages is roughly log-normal with a mean of 602 and a median of 109. Approximately 83% of the 40,964 total acres of mitigation banks (equivalent to an area 8 miles $\times$ 8 miles) occurs in 12 banks that exceed 1000 acres.

There are equal numbers (18) of banks projected to gain and lose acreage; nearly half have a neutral effect on wetland acreage. Thus 74% of the individual banks achieve no-net-loss by acreage. However, the net losing banks average 1488 acres compared to 380 acres for neutral banks and 112 acres for gaining banks. Thus, the 68 banks together create a projected net loss of 21,328 acres or 52% of the banked acreage.

Categorized by compensation method, restoration accounts for nearly half of the banks, followed by creation, enhancement, and preservation, reflecting the priorities given in the Federal Guidelines. However, restoration and creation banks average only 284 acres compared to 1031 for enhancement banks and 2059 for preservation banks. Due to the manner in which acreage gains and losses were calculated, banks using enhancement and preservation account for all of the projected net loss. Of 16,273 acres in the eight banks that use preservation as the compensation method, 99% of the acreage contributes to net loss.

The pattern of wetland acreage gain and loss varies little by wetland type. Palustrine emergent wetlands (usually freshwater marsh) is the largest type, followed by palustrine forested, estuarine, and lacustrine as measured by either number or acreage. The pattern of wetland acreage losses by type also follows this ranking.

Nearly half of mitigation banks are organized by watershed, reflecting federal guidelines, and these 31 banks contain more than half of the total acreage in banks (Table 2—Service Area Definition). However, 60% of the acreage in these banks is projected loss, accounting for 68% of the 21,328 acres of projected loss across the 68 banks. Among other types of service area definitions, counties are the second largest by number (16), while statewide banks are the second largest by area (25%) and acreage of projected loss (4125).

Mitigation ratios range from 0.3 to 6, with a mean of 1.36, or 1.41 when weighted by acreage. The majority of banks use a 1:1 ratio, accounting for 73% of all the acreage in banks and 83% of the projected net acreage loss.

Spatial Analysis

National scale. The geography of mitigation banking at a national scale reveals the spatial interaction between naturally occurring wetlands and ongoing land-use change (Figure 1). By number, size, and wetland type (Figure 1A), two clusters of banks occur—13 small, primarily estuarine wetland banks in coastal southern California, and eight small, primarily palustrine forested banks in the Gulf coast of peninsular Florida. Broader groupings occur with 13 primarily palustrine forested banks in the lower Mississippi Valley and western Gulf coast that include most of the largest banks in the country, and 13 banks of mixed size and

Table 1. Wetland mitigation banks of the United States through 1 January 1996[a]

Year est.	Bank name	Location	Acreage	Service area	Comp. method	Comp. ratio	Projected acreage gain (loss)
Lacustrine							
1984	Port of Los Angeles	Orange Co., CA	18	Cst. pl.	creation	1:1	0
Estuarine							
1984	Goose Creek Tidal	Isle of Wight Co., VA	11	Cst. pl.	creation	2:1	6
1984	Cabrillo Marina	Orange Co., CA	18	Cst. pl.	rest.	1:1	0
1984	Port of Long Beach, Pier A	Orange Co., CA	29	Cst. pl.	rest.	1.5:1	10
1985	Pac Tex, Batiquitos Lagoon	San Diego Co, CA	383	Cst. pl.	rest.	1.5:1	128
1986	Sea World Eelgrass	San Diego Co, CA	1	W'shed	rest.	1.2:1	0.2
1986	Anaheim Bay Project	Orange Co. CA	120	Cst. pl.	rest.	1.32:1	29
1986	Naval Amphibious Base	San Diego Co., CA	10	Cst. pl.	rest.	1:1	0
1986	SMAP-Port of Pascagoula	Jackson Co. MS	4675	W'shed	preserv.	1:1	(4675)
1988	Huntingdon Restoration	Orange Co., CA	25	W'shed	rest.	1:1	0
Palustrine emergent							
1975	Rogers & Drayton Interch.	Pembina Co., ND	175	W'shed	rest.	1:1	0
1980	Bracut Marsh	Humboldt Co., CA	6	County	rest.	3:1	4
1984	Henderson Marsh	Coos Co. OR	420	W'shed	creation	1:1	0
1984	Fina LaTerre	Terrebonne Parish, LA	7014	W'shed	enhance	2:1	(3507)
1987	Astoria Airport	Clatsop Co., OR	33	County	rest.	1:1	0
1987	Minn. Wetland Habitat	Minnesota (40 sites)	1750	DOT	creation	1:1	0
1987	North Dakota State Hwy.	ND (numerous sites)	5000	State	rest.	1:1	0
1987	West Eugene	Lane Co. OR	980	County	enhance	1:1	(980)
1988	Wetlands Acct. Systems	Kingsbury Co. SD	25	W'shed	rest.	1:1	0
1988	San Joaquin Marsh	Orange Co., CA	18	County	enhance	1:1	(18)
1988	Mid City Ranch	Humboldt Co, CA	8	County	rest.	1:1	0
1988	Washoe Lake	Washoe Co., NV	89	W'shed	enhance	0.3:1	(208)
1988	Patrick Lake	Dane Co., WI	165	COE	rest.	1:1	0
1988	Mud Lake	Jefferson Co. ID	125	W'shed	enhance	1:1	(125)
1989	Old Beaver	Clark Co., ID	16	W'shed	rest.	1:1	0
1989	Montana DOT	Montana (3 sites)	289	W'shed	rest.	1:1	0
1991	Acequia	Minidoka Co., ID	28	W'shed	creation	1:1	0
1991	Southeast Mitigation	Hillsborough Co., FL	31	W'shed	enhance	1:1	(31)
1993	Maryland State Highway	Prince George Co., MD	170	W'shed	rest.	1:1	0
1993	Mission-Viejo-ACWHEP	Orange Co., CA	35	W'shed	enhance	3:1	(12)
1994	Land & Water Resources	Kane Co., IL	48	W'shed	rest.	1:1	0
1994	Blue Elbow Swamp	Orange Co. TX	3343	W'shed	preserv.	1:1	(3343)
1994	City of Virginia Beach	Vir. Beach Co., VA	80	W'shed	rest.	1:1	0
1995	San Marcos Creek	San Marcos Co, CA	57	W'shed	creation	1:1	0
1995	Santa Ana River	Riverside Co, CA	1500	W'shed	creation	1:1	0
1995	Mystice Lake	Riverside Co., CA	135	County	creation	1:1	0
1995	Florida Wetlandsbank	Broward Co., FL	358	W'shed	rest.	1.2:1	60
1995	Ferson Creek	Kane County, IL	82	W'shed	rest.	1:1	0
1995	Wetland Research, Inc.	Lake Co., IL	118	W'shed	rest.	1.5:1	39
1995	Greens Bayou	Harris Co., TX	1450	County	preserv.	1:1	(1450)
Palustrine forested							
1982	Louisiana Dept. of Trans.	Grant, LaSalle P., LA	2944	State	preserv.	1:1	(2944)
1985	Company Swamp	Bertie Co., NC	1031	State	preserv.	1:1	(1031)
1987	Pridgen Flats	Sampson Co. NC	127	DOT	rest.	1:1	0
1987	Georgia Dept. of Trans.	Georgia	250	W'shed	rest.	2:1	125
1988	Dahomey NWR	Bolivar Co. MS	162	COE	enhance	1:1	(162)
1988	Malmaison Wildlife Area	Grenada Co., MS	318	COE	preserv.	1:1	(318)
1988	Pitcher Plant Bog	Greene Co., MS	360	COE	rest.	1:1	0
1989	Weisenfeld-Meadow	Orange Co., FL	235	W'shed	preserv.	6:1	(39)
1990	Millhaven, Inc.	Burke, Screven Co. GA	350	County	rest.	1:1	0
1990	Otterdam Swamp	Greensville Co., VA	14	COE	creation	2:1	7
1990	Polk Parkway	Polk County, FL	3	County	creation	2.5:1	2
1990	Hillsborough County	Hillsborough Co., FL	13	County	creation	1:1	0
1990	Northlakes Park	Hillsborough Co., FL	11	County	rest.	2.5:1	7

Table 1. (Continued)

Year est.	Bank name	Location	Acreage	Service area	Comp. method	Comp. ratio	Projected acreage gain (loss)
1991	Cheval Players Club	Hillsborough Co., FL	27	County	creation	1:1	0
1991	Turner Citrus, Inc.	Desota Co., FL	47	W'shed	rest.	2:1	24
1992	Pine Flatwood	Cameron Co. LA	150	State	enhance	1:1	(150)
1992	Geist Reservoir	Marion Co., IN	25	County	rest.	1:1	0
1992	Morse Reservoir	Hamilton Co. IN	15	County	rest.	1:1	0
1993	Delta Land Trust	Warren Co., MS	100	W'shed	rest.	1:1	0
1993	Cabin Creek	Prince George Co, VA	9	DOT	creation	2:1	5
1993	Fort Lee	Prince George Co, VA	34	DOT	creation	2:1	17
1993	Faulkbern Tract	Sumter Co. SC	1709	W'shed	enhance	3:1	(570)
1993	State Highway Bank	Williamsbury Co., SC	1000	State	rest.	1:1	0
1994	Anderson Tract	Smith Co. TX	2473	W'shed	preserv.	1:1	(2473)
1995	T.L. James & Co.	Louisiana	200	W'shed	rest.	1:1	0
1995	West Tennessee	Shelby Co., TN	389	W'shed	creation	2:1	195
1995	White Cedar LLC	Suffolk Co. VA	100	County	creation	2:1	50

[a]Cst. pl. = Coastal plain; DOT = Department of Transportation; COE = Corps of Engineers; rest. = restoration; preserv. = preservation.

type along the south Atlantic coast from Maryland to Florida. Remaining banks are mainly palustrine emergent and are found in the Pacific Northwest (11) and Midwest (10), of which by far the largest is the North Dakota State Highway bank that services small wetland conversions statewide. Banks occur in 21 of the 50 states and are absent from the Northeast and Appalachians and a broad region stretching from Iowa to Arizona.

Geographical patterns of compensation method are similar to patterns of net gain and loss (Figure 1B and C). Banks using the preservation method are overwhelmingly concentrated in the lower Mississippi Valley–western Gulf coast area, which accounts for the concentration of wetland loss due to mitigation banking in that region of the country. In other regions, a mixed pattern of compensation methods and acreage gains and losses are evident.

Within-bank spatial patterns. The six maps shown as Figure 2 reveal differing patterns of geographic relocation of wetlands. Except for the Cheval Players Club and Pac Tex-Baquitos Lagoon banks, where a single impact site is mitigated in another location in the county or the same region of the state, mitigation banking has concentrated dispersed wetland conversions into a single banking site. In the case of Patrick Marsh, the bank is centrally located among converted wetlands, but in the case of Company Swamp, Pitcher Plant Bog, and Blue Elbow Swamp, the bank is in a more coastal location than converted wetland sites, which lie as much as 300 km further inland. Some credit withdrawal also has occurred outside the stipulated geographic service area of the authorizing instruments.

Discussion

We project wetland mitigation banking will lead to a substantial net loss of wetland acreage as already credited wetland acreages are converted to other uses. While most wetland mitigation banks are using appropriate compensation methods and ratios, several of the largest banks use preservation or enhancement. Most banks using the former have minimum mitigation ratios of 1:1. Ten of these banks account for over 99% of projected net wetland acreage loss due to mitigation banking (Table 3). While there is no discernible temporal trend in the establishment of these acreage-losing banks, or a focus on a particular wetland type, there is a clear geographical concentration in the western Gulf coastal region (Mississippi, Louisiana, Texas). Other regions of the country are experiencing modest net gains or have only one important acreage-losing bank. These results bring into question the extensive use of enhancement, and especially preservation, as a compensation method, because these methods are to be used only in exceptional circumstances when avoidance of impacts, minimization of impacts, and restoration and creation options have been eliminated. The negative impact of these banks on wetland acreage is amplified by the large size of several of the banks using these methods and the low mitigation ratios employed. Weighted by bank acreage, banks using the enhancement and preservation methods of compensation have average minimum mitigation ratios of 2.01 and 1.05, respectively.

In interpreting these results from an ecosystem

Table 2. Composition of wetland banks by year established, size, compensation method, wetland type, service area definition, mitigation ratio, and projected net gain or loss

	No. of banks (%)	Acreage (%)	Projected net gain (loss), acres (%)		% of projected net loss attributable
Total	68 (100)	40,964 (100)	(21,328)	(52)	100
Net gaining and losing banks					
Gaining	18 (26)	2,010 (5)	708		
Neutral	32 (47)	12,172 (30)	0		
Losing	18 (26)	26,782 (65)	(22,036)		
Year established					
1975	1	175 (0.4)	0	(0)	0
1980	1	6 (0)	4	(67 gain)	−0.02
1982	1	2,944 (7)	(2,944)	(100)	14
1984	6	7,510 (18)	(3,491)	(46)	16
1985	2	1,414 (3)	(903)	(64)	4
1986	4	4,806 (12)	(4,646)	(97)	22
1987	6	8,140 (20)	(855)	(11)	4
1988	10	1,295 (3)	(831)	(64)	4
1989	3	540 (1)	(39)	(7)	0.2
1990	5	391 (1)	16	(4 gain)	−0.07
1991	5	157 (0.4)	(7)	(4)	0.03
1992	3	190 (0.5)	(15)	(8)	0.07
1993	7	3,057 (7)	(560)	(18)	3
1994	4	5,914 (14)	(5,816)	(98)	27
1995	10	4,398 (11)	(1,106)	(25)	5
Size (acres)					
Small: 1–99	32 (47)	890 (2)	(187)	(21)	1
Medium: 100–999	24 (35)	6,179 (15)	(1,148)	(19)	5
Large: 1000–7014	12 (16)	33,889 (83)	(19,993)	(59)	94
Compensation method					
Restoration	33 (49)	9,641 (24)	426	(4 gain)	−2
Creation	17 (25)	4,541 (11)	282	(6 gain)	−1
Enhancement	10 (15)	10,313 (25)	(5,763)	(56)	27
Preservation	8 (12)	16,469 (40)	(16,273)	(99)	76
Wetland type					
Estuarine/lacustrine	10 (15)	5,279 (13)	(4,502)	(85)	21
Palustrine emergent	30 (44)	23,548 (57)	(9,571)	(41)	45
Palustrine forested	28 (41)	12,137 (30)	(7,255)	(60)	34
Service area definition					
Watershed	31 (46)	24,116 (59)	(14,540)	(60)	68
County	16 (24)	3,195 (8)	(2,385)	(75)	11
Coastal plain	7 (10)	589 (1)	173	(29)	−1
State	5 (7)	10,125 (25)	(4,125)	(41)	19
Corps district	5 (7)	1,019 (2)	(473)	(46)	3
DOT district	4 (6)	1,920 (5)	22	(1)	−0.1
Mitigation ratio					
0.3:1	1 (1)	89 (0.2)	(208)	(234)	1
1:1	46 (68)	29,999 (73)	(17,700)	(59)	83
1.2–2:1	15 (22)	8,877 (22)	(2,812)	(32)	13
2.5–3:1	5 (9)	1,764 (4)	(569)	(32)	3
6:1	1 (1)	235 (0.6)	(39)	(17)	0.2

function point of view, other important considerations emerge. It is possible, especially for cases of enhancement, that acreage losses and mitigation ratios are justified on a functional or value basis. Determining this is beyond the scope of this study. However, given that preservation is a recommended compensation method only under ''exceptional circumstances,'' these functions and values must be demonstrated, and larger mitigation ratios must be used if mitigation banking is to become consistent with a policy goal of no-net-loss by function and value. The 1995 federal guidelines emphasize that preservation should only be used if the func-

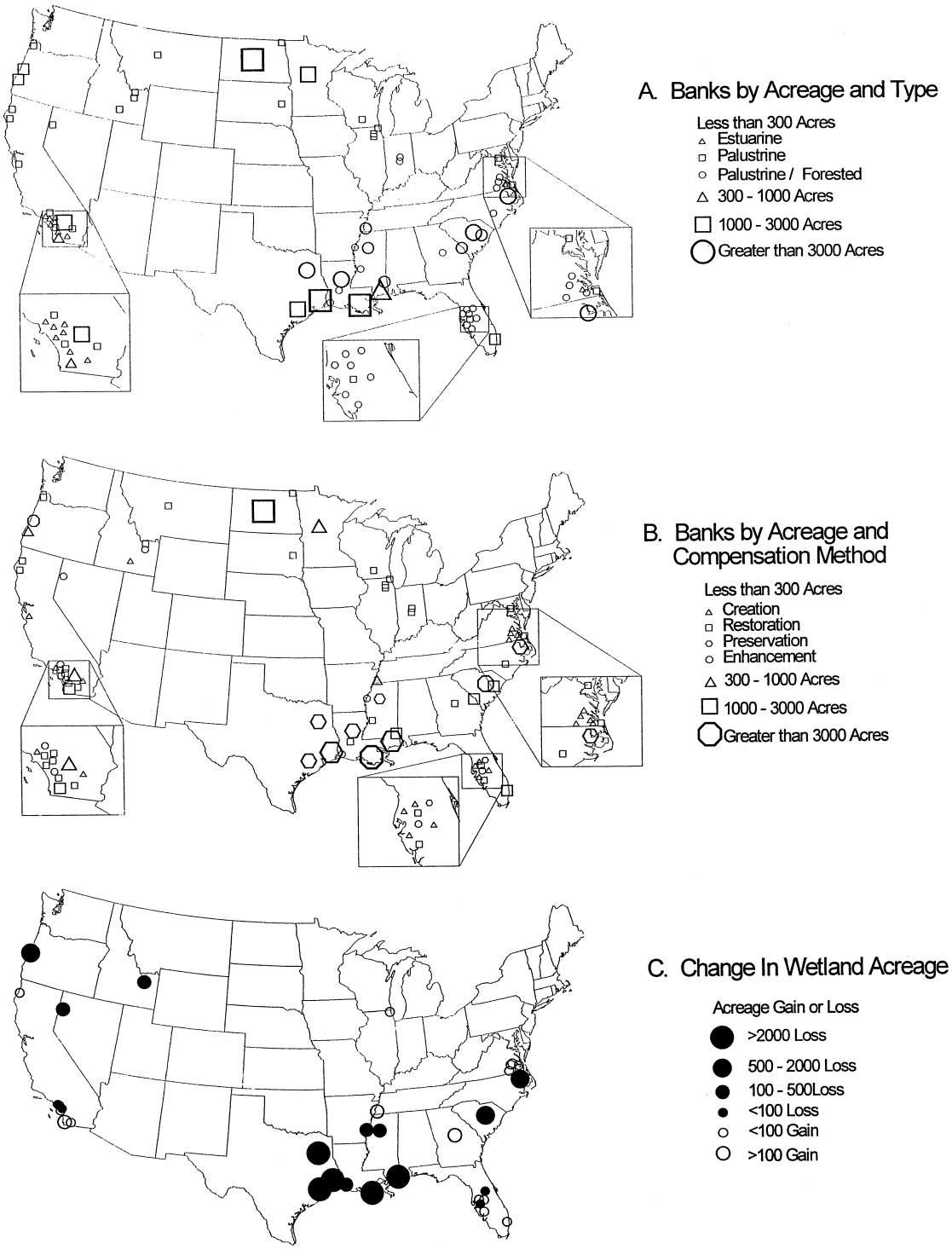

Figure 1. (**A**) Wetland mitigation banks of the United States by acreage and wetland type. (**B**) Wetland mitigation banks of the United States by acreage and compensation method. **C:** Wetland mitigation banks of the United States by acreage gained and lost.

tions performed by the wetlands are important to the region and the wetlands are under "demonstrable threat of loss or substantial degradation due to human activities that might not otherwise be expected to be restricted," the latter to be determined based upon "clear evidence of destructive land use changes which are consistent with local and regional land use trends" (Federal Register 1995). We were not able to determine

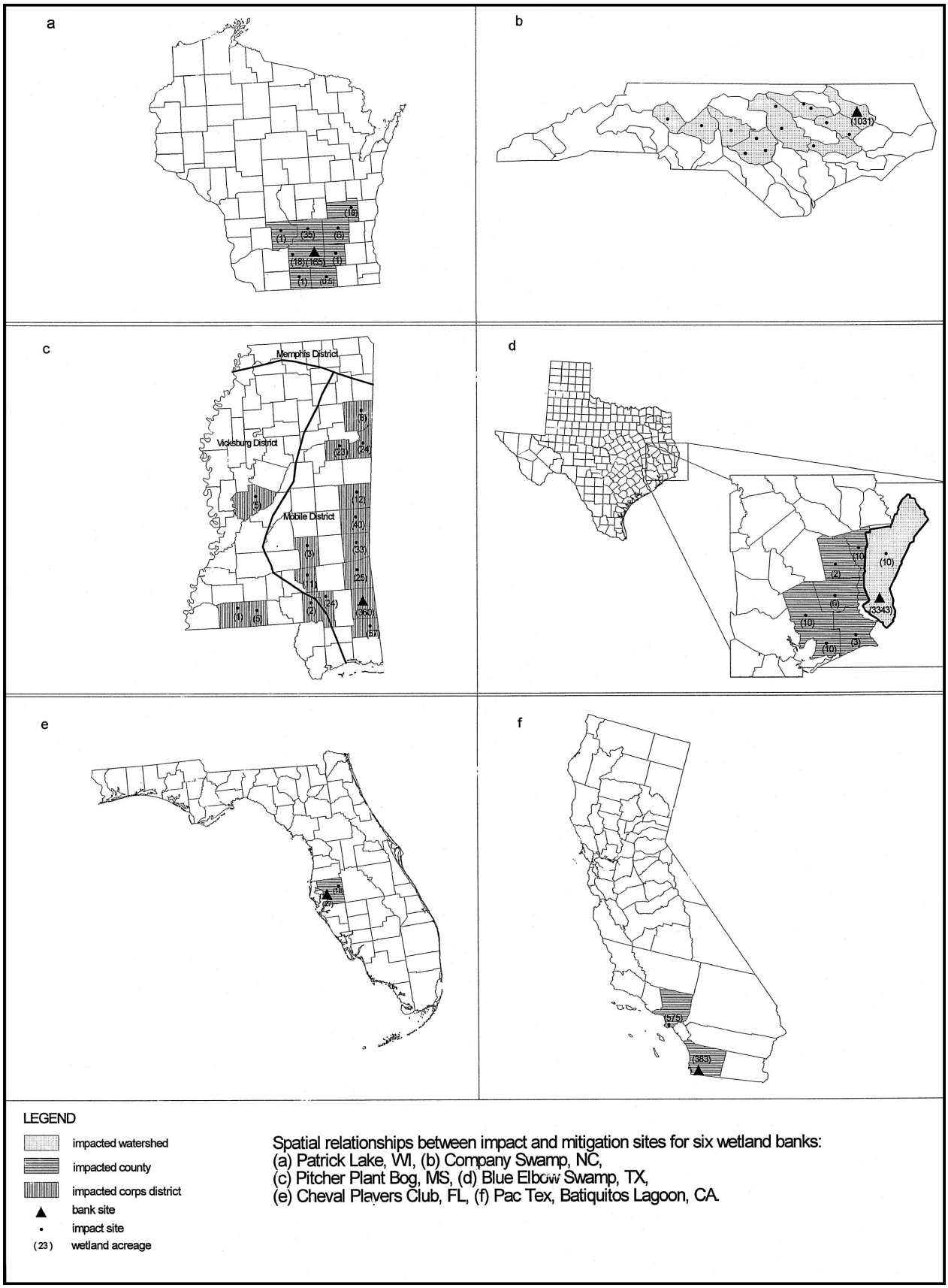

Figure 2. Spatial relationship among areas of wetland loss and areas of wetland gain for banks in (**a**) Wisconsin, (**b**) North Carolina, (**c**) Mississippi, (**d**) Texas, (**e**) Florida, (**f**) California.

Table 3. Mitigation banks accounting for projected net losses of wetland acreage

Rank	Year est.	Bank name	Location	Projected net loss (acres)	% of projected net loss attributable
1	1986	SMAP-Port of Pascagoula	Jackson Co., MS	4675	22
2	1984	Fina LaTerre	Terrebonne Parish, LA	3507	16
3	1994	Blue Elbow Swamp	Orange Co., TX	3343	16
4	1982	Louisiana Dept. of Trans.	Grant, LaSalle P., LA	2944	14
5	1994	Anderson Tract	Smith Co., TX	2473	12
6	1995	Greens Bayou	Harris Co., TX	1450	7
7	1985	Company Swamp	Bertie Co., NC	1031	5
8	1987	West Eugene	Lane Co., OR	980	5
9	1993	Faulkbern Tract	Sumter Co., SC	570	3
10	1988	Malmaison Wildlife Area	Grenada Co., MS	318	1.5
		Other 58 Banks		89	0.4

if this was the case in the eight existing banks using preservation as the primary compensation method. The guidelines also cite that mitigation ratios should be higher for banks using preservation than other compensation methods, while we calculated a mean of 1.05. Whether projected losses can still be reduced in those banks is a difficult issue; on the one hand only a minority of the credits for these banks have been used to date, but on the other, the 1995 federal guidelines are not intended to ''be retroactive for mitigation banks that have already received agency approval.''

Secondly, while there is a net gain of wetland acreage nationally where restoration or creation is used as the compensation method, the ability to replicate characteristics exhibited by natural wetlands remains problematic (Kusler and Kentula 1990). For example, the retention qualities of developed hydric soils and hydrophytic vegetation can take many years to replicate (Kentula and others 1992). Forested wetlands are particularly difficult to create or restore in time spans of a few or even several years. Reproducing the fluctuating hydrologic regimes that many wetlands require is often not possible on confined mitigation sites.

Shabman and others (1996) argue that mitigation difficulties experienced to date are due as much to institutional failures, which are inherently correctable, as to lack of scientific understanding. For example, under current practice, financial assurances are only guaranteed through the construction phase with a standard 5- to 10-year monitoring period. As such, the spatial relocation of wetlands or period of time required for constructed wetlands to replicate the functions of the converted wetlands may result in at least a temporary loss of wetland function. Additionally, eight banks have failed to provide designated functions and four have allowed less compensation of acreage than the amount converted. As of early 1996, four of the eight banks in fail status were being redesigned or reconstructed, and two of the four banks that have more acreage impacted than mitigated were attempting to provide additional compensation.

The November 1995 federal guidelines recommended that, with the exception of linear projects (usually associated with highways), the service area of banks should reflect USGS hydrologic units or ecological regions. Sufficient evidence exists from studies of wetland ecosystems that protection of wetland functions requires consideration of their location throughout the landscape (Bedford and Preston 1988). The values wetlands provide often are dependent upon their location in the landscape, such as their position relative to one another, to adjacent waters, and to the human population that would benefit from the services provided. To our knowledge there are no studies into either the hydrologic or ecologic impacts of the changed geographic distribution of wetlands that are associated with banking. Thus, an interpretation of the effect of the change in the spatial distribution of wetlands that is inherent in mitigation banking must be made with reference to watershed hydrology (Black 1996), island biogeography (MacArthur and Wilson 1967), and landscape ecology theory (Forman and Godron 1986).

The trend among the six banks for which detailed data were obtainable is that mitigation banking results in a more concentrated distribution of wetland acreage, with a tendency for this concentration to be in a more downstream or coastal location (Figure 2). The spatial relationship between the delivery of wetland functions and the demand for those ecosystem services is the critical issue here. For example, Ogawa and Male (1986) determined that the flood control services provided by wetlands decrease as one proceeds in a downstream direction. Thus, if a bank concentrates wetlands directly upstream of a floodplain settlement, this is a positive redistribution of wetlands. The ability of wetlands to filter nonpoint source pollutants is depen-

dent on their position between pollution sources and waterways, as determined with respect to surface and shallow groundwater flows (Peterjohn and Correll 1984). It is likely that a concentration of wetlands will reduce the overall interface between upland, wetland, and waterways, thus reducing this filtering effect. Because of the complexity and site-specific nature of these issues, wetland banks are best managed in the context of a watershed plan, as recommended by the 1995 federal guidelines.

From a conservation biology perspective, island biogeography theory hypothesizes that larger contiguous habitats yield greater numbers of species than the same acreage of habitat in a more dispersed spatial distribution (MacArthur and Wilson 1967). Thus banking could have a positive effect for wetland-dependent species, but the effect could just as easily be negative for species whose habitat requirements include both upland and wetland, or both open water and wetland, given that the concentration of wetlands resulting from banking has the effect of reducing the total interface among these habitat types. Similarly, a concentration of wetlands could reduce landscape connectivity, especially if the wetlands being converted had formed riparian corridors. For example, Gosselink and others (1990) have documented the fragmentation of wetland forest in the Tensas River basin of northeastern Louisiana as a result of cumulative conversion to agricultural use.

Finally, from a social point-of-view, the redistribution or concentration of wetlands raises issues of equity. Inevitably, if the geographic distribution of wetlands is changed, some individuals and communities will lose the ecosystem services they provided and others will gain the services provided by mitigation wetlands.

Conclusions

Wetland mitigation banking is projected to lead to a net loss of wetland acreage as credits are utilized in several large banks in the western Gulf coast region that combine preservation as the primary compensation method with minimum mitigation ratios of 1:1. The Lower Mississippi Valley and the western Gulf region have been the national focus of wetland loss since the 1940s, and so the continued loss of wetlands there through the operation of mitigation banks is part of a regional trend, where forested wetlands from southern Illinois to central Louisiana have been converted, primarily to agriculture, and coastal marshes have been lost due to oil and gas development and sediment starvation (Tiner 1984). Nevertheless, the continued loss of wetlands in this region through mitigation banks stands out nationally, and, in effect, becomes the location where wetland mitigation banking policies are tested as a national policy.

Nationally, projected net loss amounts to over 20,000 acres and over 50% of the acreage of wetlands now in banks. This acreage loss probably also results in a loss of wetland functions and is therefore inconsistent with federal guidelines issued in 1995. This cumulative loss of wetlands should be compared to the estimated 79,300 acres of annual net loss in the United States in the period 1982–1992 (Weibe and others 1996) and the 300,000 acres enrolled in the Wetland Reserve Program (WRP) in 1992–1995 (Weibe and others 1995). It should be mentioned that mitigation banks can be established in conjunction with or supplemental to WRP projects, thus taking advantage of the large potential for cost-effective wetland restoration on willingly supplied, often dispersed farmland, especially on lands for which WRP easements have been offered, but not accepted by the US Department of Agriculture.

While most mitigation banks are now organized by watershed, 68% of the projected net loss of wetland acreage due to banking is taking place in those banks. Thus, it is only after the overall impact of banking on wetland acreage and function is adequately addressed that the definition of the service area becomes important. The concentration of wetlands that is occurring with mitigation banking is a complex issue that needs to be addressed on a bank-by-bank basis with reference to the functions that wetlands can provide in different positions on the landscape and the value of these functions as they provide ecosystem services to a site-specific human population.

Wetland mitigation banking as an environmental planning tool has a number of unresolved problems, including biological and hydrological difficulties in restoring wetland functions and values, legal or institutional difficulties in creating appropriate mechanisms for credit exchanges and long-term assurance (Marsh and others 1996), and, as demonstrated here, difficulties in achieving no-net-loss of acreage through appropriate use of mitigation ratios and compensation methods. Nevertheless, the concept of wetland mitigation banking is a sound one, so long as it is recognized that a spatial redistribution of wetlands, and therefore wetland functions and ecosystem service values, is inevitable through the operation of banks. This is inherent in the concept of no-net-loss of wetlands, whether by acreage or function. Mitigation banking, as a market-oriented environmental policy tool, has the potential to exploit opportunities where low value wetlands on high-value real estate can be converted while high-value wetlands on lower-value real estate are restored, created, or enhanced. This same potential to be simultaneously cost-effective and environmentally beneficial applies to mitigation banking for land categories other than wetlands, such as forest, groundwater recharge

zones, urban parks or parking areas, or even low-cost housing. Thus, it is a planning tool with considerable potential, especially when integrated with overall planning activities such as watershed planning.

Literature Cited

Adamus, P. R. 1983. A method for wetland functional assessment, Vol. 2, FHWA assessment method. Rpt. No. FHWA-IP-82-24. Washington, DC, US Department of Transportation, Federal Highway Administration, 134 pp.

Bedford, B. L., and E. M. Preston. 1988. Developing the scientific basis to assess cumulative effects of wetland loss and degradation on landscape functions: Status, perspectives, and prospects. *Environmental Management* 12(5):751–771.

Black, P. E. 1996. Watershed hydrology, 2nd. ed. Ann Arbor Press, Chelsea, Michigan.

Brumbaugh, R., and R. Reppert. 1994. National wetland mitigation banking study: First phase report. Institute for Water Resources, Water Resources Support Center, US Army Corps of Engineers, Alexandria, Virginia.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van der Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.

Dahl, T., and C. Johnson. 1991. Wetlands: Status and trends in the conterminous United States. US Fish and Wildlife Service, US Department of Interior, Washington, DC.

Dennison, M. S., and J. A. Schmid. 1996. Wetland mitigation: Mitigation banking and other strategies for development and compliance. Government Institutes, Rockville, Maryland.

Federal Register. 1995. Federal guidance for the establishment, use and operation of mitigation banks, 60 Fed. Reg. 58605 (28 November 1995).

Forman, R. T. T., and M. Gordon. 1986. Landscape ecology. Wiley, New York.

Gosselink, J. G., G. P. Shaffer, L. C. Lee, D. M. Burdick, D. L. Childers, N. C. Leibowitz, S. C. Hamilton, R. Boumans, D. Cushman, S. Fields, M. Koch, and J. M. Visser. 1990. Landscape conservation in a forested wetland watershed. *Bioscience* 40(8):588–600.

Graves, G. 1995. Pursuing excellence in water planning and policy analysis: A history of the institute for water resources USACE. Institute for Water Resources. Water Resources Support Center, US Army Corps of Engineers, Alexandria, Virginia.

Hart, M. J. 1995. What you should know about mitigation banking. *Rock Products* 98(3):34–39.

Hays, C. A. 1997. Any comments? An analysis of the factors influencing participation of organized interests in the federal rule-making process. Unpublished PhD dissertation. Department of Political Science, Southern Illinois University-Carbondale.

Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, and J. C. Sifneus. 1992. Wetlands: An approach to improving decision making in wetland restoration and creation. Island Press, Washington, DC.

Kruczynski, W. L. 1990. Mitigation and the section 404 program: A perspective. *In* J. A. Kusler, and M. E. Kentula (eds.), Wetland creation and restoration: The status of the science. Island Press, Washington, DC.

Kusler, J. A., and M. E. Kentula (eds.). 1990. Wetland creation and restoration: The status of the science. Island Press, Washington, DC.

Lant, C. L., and R. S. Roberts. 1990. Greenbelts in the Cornbelt: Riparian wetlands, intrinsic values, and market failure. *Environment and Planning A* 22:1375–1388.

Lewis, W. 1995. Wetlands: Characteristics and boundaries. National Research Council, National Academy Press, Washington, DC, 307 pp.

MacAuthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

Marsh, L. L., D. R. Porter, and D. A. Salvesen (eds.). 1996. Mitigation banking: Theory and practice. Island Press, Covelo, California, 289 pp.

MOA. 1990. Memorandum of Agreement Between the Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1)Guidelines, 6 February 1990.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands, 2nd ed. Van Nostrand Reinhold, New York, 699 pp.

National Research Council. 1995. Wetlands: Characteristics and boundaries. National Academy Press, Washington, DC.

National Wetlands Policy Forum. 1988. Protecting America's wetlands: An action agenda. Conservation Foundation, Washington, DC, 69 pp.

Ogawa, H., and J. W. Male. 1986. Simulating the flood mitigation role of wetlands. *Journal of Water Resource Planning and Management* 112:114–128.

Peterjohn, W. T., and D. L. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. *Ecology* 65:1466–1475.

Reppert, R. 1992. National wetland mitigation banking study: Wetlands mitigation banking concepts. Institute for Water Resources, Water Resources Support Center, US Army Corps of Engineers, Alexandria, Virginia.

Salvesen, D. 1995. Banking on wetlands. *Planning* 61:11–15.

Shabman, L., P. Scodari, and D. King, 1996. Wetland mitigation banking markets, Pages 109–138 *In* L. L. Marsh, D. R. Porter, and D. A. Salvesen (eds.). Mitigation banking: Theory and practice. Island Press, Covelo, California.

Tiner, R. W., Jr. 1984. Wetlands of the United States: Current status and recent trends. US Fish Wildlife Service, 59 pp.

Weibe, K. D., A. Tegene, and B. Kuhn. 1995. Property rights, partial interests, and the evolving federal role in wetlands conversion and conservation. *Journal of Soil and Water Conservation* 50(6):627–629.

Wiebe, K. D., R. E. Heimlich, and R. Claassen. 1996. Wetlands potentially exempted and converted under proposed delineation changes. *Journal of Soil and Water Conservation* 51(5): 403–407.