

# Emerging ecosystem service markets: trends in a decade of entrepreneurial wetland banking

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Markets in ecosystem services are now commonly considered by policy makers to be effective ways of achieving the goals of federal environmental protection laws. However, little empirical data currently informs policy development around such markets. Can a market-like arrangement solve the problems of compensatory wetland replacement under the Clean Water Act? This research examines the dynamics of the Chicago, Illinois market in wetland credits over a 9-year period, and shows that, although successful in many ways, it is prone to regulatory turbulence and may not fully address losses of wetland function. Market-based approaches to environmental policy problems will proliferate as more policy makers become convinced of the power of markets to achieve effective environmental conservation. Due to the new challenges of standardized commodity measurement that are present in these markets, environmental scientists are likely to be increasingly drawn into policy development and evaluation. This article is intended to alert ecosystem scientists and the environmental policy community to issues involved in evaluating the success of ecosystem service markets in achieving environmental policy goals.

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The importance of wetlands to water quality, flood abatement, marine fisheries, and biodiversity is well known, and for nearly 30 years the Federal Government of the United States has required the replacement of wetlands lost to development under a policy now known as “no net loss of wetlands” (NWPF 1987; USEPA and USACE 1990). Individuals who wish to dredge or fill in wetlands must apply for a permit issued by the US Army Corps of Engineers (USACE, or Corps) under Section 404 of the Clean Water Act. These permits often require “compensatory mitigation” – usually, the restoration of former wetlands – to balance the effects of wetland loss. However, as the National Research Council (NRC) has reported, this replacement of lost wetlands has been plagued by lax compliance, inappropriate siting, and poor design (NRC 2001). Since 1991, regulators and entrepreneurs have collaborated in attempting to address these problems by creating regional wetland credit markets in the US, hoping that market-based incentives will produce better compensatory mitigation sites than direct regulatory compulsion has. The entrepreneurial providers of wetland credits, known as “wetland mitigation bankers”, have undertaken large wetland restoration projects. These projects are certified for sale as wetland credits by the Corps, and are then purchased by Section 404 permit holders.

Wetland bankers know that permit holders are generally happy to avoid the highly skilled and liability ridden task

of constructing their own wetland mitigation site. Some regulators and scientists are cautiously optimistic that wetland banking can resolve some of the characteristic problems of compensatory mitigation (NRC 2001; SWS 2005). Since the first entrepreneurial bank permit application was made (on August 29, 1991), the entrepreneurial wetland banking industry has grown to include over 300 banks, is led by a national lobbying organization, and boasts enthusiastic bipartisan support from policy makers (ELI 2002).

## ■ A market in wetland credits

Because wetland banking represents the oldest existing market in “ecosystem services” (such as habitat or biodiversity, ie commodities measured using ecological assessment techniques rather than metrics of weight or volume), banking may lead the way in answering a broad set of policy questions about the ability of markets to satisfy environmental regulatory requirements. Environmental economists have advocated the development of markets in ecosystem services on the grounds that the prices that customers pay for these services provide the most useful measure of the financial costs of environmental degradation (Coase 1960; Costanza *et al.* 1997; Balmford *et al.* 2002; Daily and Ellison 2002; Turner *et al.* 2003). Moreover, conventional economic theory holds that well-functioning markets automatically find the most efficient and lowest-cost way of meeting an environmental regulatory requirement. Pollution abatement efforts dictated by government bureaucracy, no matter how democratic, cannot achieve cost efficiency except by accident. Given an environmen-

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tal quality “target” established by regulation, people will buy the amount of environmental quality they require directly, rather than electing representatives who will pass legislation requiring bureaucrats to set policy that may eventually achieve the target environmental quality. People negotiating in a market for, say, water pollution allowances will automatically find the lowest cost at which successive units of water pollution abatement can be achieved until a regulatory standard is met. The hoped-for result is that the policy will produce exactly as much environmental improvement as is required, at the lowest cost.

This basic argument – usually articulated at a high level of abstraction – appears in various forms in many different forums: economic policy papers, federal agency briefs, newspaper op-ed pieces, and environmental management plans. Despite prominence in contemporary environmental policy rhetoric, however, very little empirical data on the dynamics of an operating ecosystem service credit market has appeared in the literature which informs these debates (Shabman *et al.* 1994; Fernandez and Karp 1998; Ruhl and Juge Gregg 2001; Bonds and Pompe 2003; Gardner and Pulley Radwan 2005; counter-examples are provided by Boyd and Wainger [2002] and Ruhl and Salzman [2006]). As the US Federal Government turns towards market-led strategies to meet the goals of major environmental protection laws, policy development must be based on information about how such markets behave in real regulatory environments.

### ■ Methods

The Chicago District of the US Army Corps of Engineers (comprising six Illinois counties around Chicago) was the first jurisdiction to develop federal interagency guidance (USACE 1994) on the rules and standards governing a wetland credit market. Most other Corps Districts use a system derived from Chicago's (USACE 1995). As one of the three oldest regional wetland credit markets in existence, trends seen here may be indicative of the future of other markets in wetland credits and other ecosystem services. The data presented here were produced through a complete census of all sales and credit approvals occurring at entrepreneurial wetland mitigation banks in the Chicago District, from the first transaction in 1994 through the end of 2002. Data were collected from entrepreneurial bankers in the Chicago District, individual permittees, and the Chicago District's regulatory database in July, August, and September of 2003. For each transaction, information was recorded on (1) purchaser type, (2) acreage of impact, (3) total required mitigation, (4) credits purchased, (5) date of permit issuance, (6) cost of purchase, (7) regulatory agency requiring mitigation, (8) regulatory permit number, and (9) location of impact.

The date of permit issuance must be used as a surrogate for the date of the transaction, since the latter was often unrecorded, even by the bankers. Cost data were provided by some bankers in the form of the actual price charged in

each transaction, and by others in the form of their per-credit pricing schedule as it changed over time (in which case cost was derived by multiplying cost per credit by credits purchased). With the exception of cost, these data are all publicly available; however, Corps records for some permits were incomplete and the compilation of a complete census required a substantial amount of additional investigation. This study is not a “paper assessment” (a common criticism of studies which assess mitigation success by examining only Corps permit files, and which assume the existence of the required sites), since all bank sites were visited by regulatory staff in the course of this research, and were certified as meeting regulatory standards.

### ■ Results and discussion

Over the study period, there were 15 individual wetland bank sites in the Chicago District with approved credits for sale, owned by eight entrepreneurial interests (Figure 1). Credits at these sites are certified for sale by the Corps, using techniques that measure ecological function; however, for simplicity, one acre of certified wetland restoration at a bank site is considered to represent one credit. One acre of certified upland buffer or the enhancement of one acre of existing wetland may represent smaller increments of one credit. The industry has generated a gross income of \$16 379 555 on the sale of 318.61 credits in 199 transactions, at an average credit price of \$51 474.

Three trends in the development of the wetland credit market are suggested by this research, but they must be interpreted with caution. While the wetland banking market is mature in comparison with all other ecosystem service markets, it still experiences fundamental instabilities of regulation and measurement; it is too early to determine if the trends discussed here are ephemeral or persistent, and comparative work will be necessary to broaden the applicability of these findings.

#### ***Supply is dominated by “unfinished” credits***

At the time of bank establishment, the banker and regulatory authorities agree on a schedule for releasing credits for sale. In Chicago, a bank's eventual credit total is released for sale in phases linked to the achievement of certain performance standards:

- Phase 1: 30% of a bank's credits are released upon the acquisition, bonding, and protection of the site.
- Phase 2: 20% of the credits are released upon the establishment of wetland hydrology.
- Phase 3: an additional 20% of the credits are released upon the planting of approved vegetation.
- Phase 4: the final 30% of the credits are released when the site meets all ecological performance criteria.

Although this necessarily means that Phase 1 credits can be sold to permittees requiring compensation credits

before physical work at the site has begun, this constitutes a major advance over the practices associated with permittee-built compensation sites, in that bank sites are acquired and protected well in advance of the impacts for which they will compensate. The large up-front capital costs involved in bank establishment mean that entrepreneurial banking would not be economically viable without phased credit release. Unlike public entities, ecosystem service entrepreneurs require disciplined profit-realization timelines, and cannot wait out the slow process of site maturation before achieving a return on investment.

Phase 1 credits represented 60.3% of all credits for sale during the study period, while fully functional (Phase 4) credits comprised 8.4%, and did not constitute a significant percentage of supply until late in the study period (Figure 2). While this dominance by Phase 1 credits may be an ephemeral feature of an immature market, some percentage of “unfinished” wetlands in the overall supply of credits may be a necessary condition of the market-led approach. This is important because wetland banking, as a policy, has frequently been advocated on the grounds that it provides compensation in advance of impacts to wetlands (USACE 1994, 1995; ELI 2002). While entrepreneurial banking may provide greater assurances of success through the performance-based, phased release of wetland credits for sale, there is no compensation method that eliminates the temporal loss of wetland functions that occurs between a wetland impact and the full development of wetland functions at the compensation site.

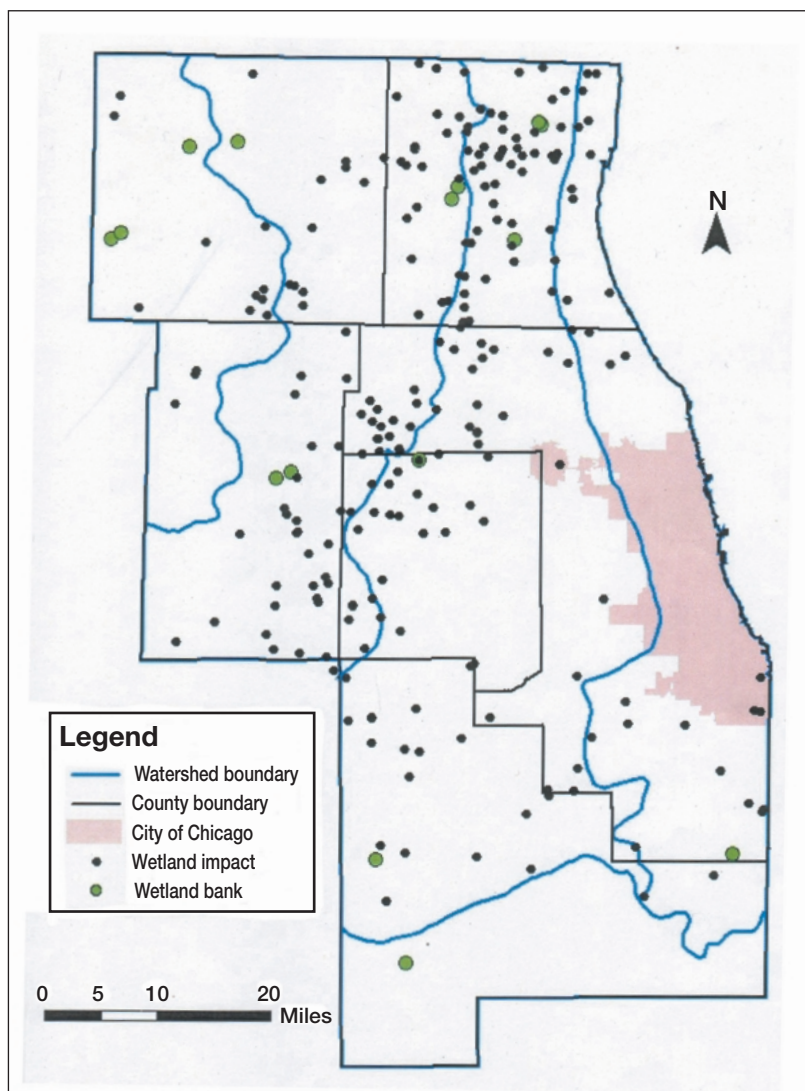
### Regulatory shifts have dramatic but ambivalent consequences

The banking industry experienced considerable disruption following the January 9, 2001, US Supreme Court decision *Solid Waste Agency of Northern Cook County vs US Army Corps of Engineers* (SWANCC; 531 US 159). This decision restricted the Corps’ jurisdiction over hydrologically isolated wetlands, a type of wetland particularly common in the Chicago area. Many of these wetlands are now impacted without a permit or mitigation requirements.

The direct effect of SWANCC was to produce a gross income decline of 46.1% among Chicago bankers between 2000 and 2001 (Figure 3). Despite this, SWANCC caused no entrepreneurial bankers who had made credit sales to leave the market through default or

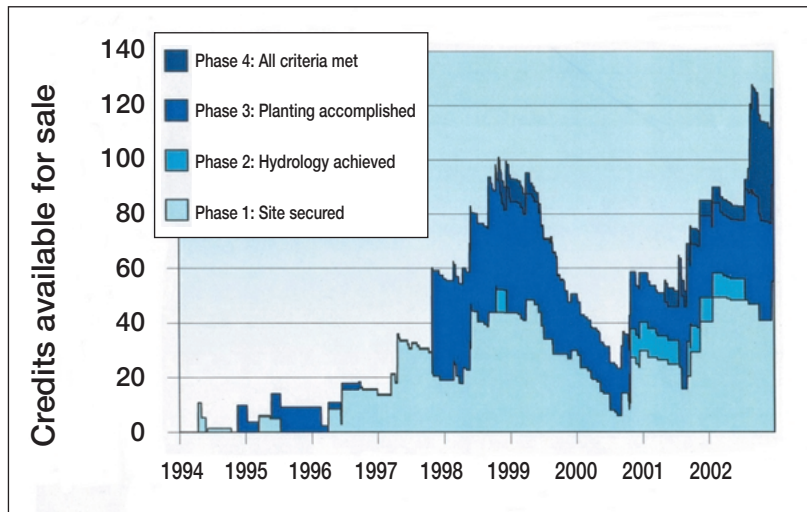
bankruptcy. This represents a remarkable persistence on the part of these bankers, which can be traced to the adoption of relatively strict ecological and administrative performance standards (USACE 1994). These high standards discouraged less able or innovative entrepreneurs from entering the market, leaving only those agile enough to survive powerful disruptions (King and Kuch 2003).

The indirect effect of SWANCC has been to initiate a nationwide cascade of state and local regulation of wetlands to “fill the gaps” in federal wetland protection (Christie and Hausmann 2003). In Illinois, county level ordinances requiring mitigation for wetland impacts have proliferated to create an uneven geographic patchwork of revived demand for wetland credits, and public sector entities are now required by state statute to perform mitigation for all wetland impacts. This regulatory turbulence is reflected in the fact that bankers’ gross income from private-sector clients dropped by 70.4% in the year after SWANCC, while income from public sector clients actually grew by 20.7% (the latter group remained as customers



**Figure 1.** Wetland bank sites and banked wetland impacts in the Chicago District.

Courtesy of N Hayden



**Figure 2.** Composition of credits available for sale on the Chicago District market, 1994–2002.

because of the Illinois state statute). It is tempting to dismiss this regulatory turbulence as a consequence of the youth of the market, but the specific developments in question originate outside the market and may be expected to continue, regardless of the presence or absence of wetland credit markets. Such forces – “exogenous” in the language of conventional economics – are analogous to weather: a building can be designed to withstand or resist violent weather, but the weather cannot be eliminated. It is much the same with market institutions and the external forces they face, and there are still large uncertainties about the exogenous climate in which ecosystem service markets are being erected. Where diverse local laws regulate wetland impacts, we may expect to see rapid shifts in the sector and geography of demand – who is purchasing credits and where they are located – similar to those that have occurred in Chicago. This may require swift changes in entrepreneurial strategy; in Chicago, SWANCC caused a sudden devaluation of the network of relationships that have traditionally connected bankers with private-sector credit purchasers. There is no apparent way to prevent the normal course of regulatory and judicial activity at all scales from interfering with demand for wetland credits, even as it simultaneously creates that same demand. It is possible that this effect may be more pronounced in markets for ecosystem service commodities (such as some wetland services) that are frequently the objects of long-standing local regulations concerning public health, safety, and utilities.

### **Price appears unresponsive to changes in demand**

In any ecosystem service market, the price of the commodity is critically important in assessing the health of the market and its responsiveness to changes in demand. In the Chicago market, price per credit has remained relatively stable during a time of extreme fluctuation in demand (Figure 4), averaging \$51 474 over the study period. The average price per credit showed no response

to the dramatic drop in demand associated with the SWANCC decision, and only a minor response to the spatial location and set of choices available to individual customers. This is of potential significance in the design of ecosystem service market policies, because where price is unresponsive to the situation of the purchaser, it no longer plays its expected role of facilitating the most cost-efficient compliance with regulatory directives. In general, when market demand falls steeply, as it did following SWANCC, economists expect a concomitant decline in commodity price. This is not observed in the Chicago wetlands credit market. The post-SWANCC stability in price strongly suggests that non-market factors are influencing bankers’ pricing decisions. It is possible that these factors may

prevent the dynamics of supply and demand from “discovering” the market-clearing price – which is the promised source of cost efficiency in market-based environmental policy. Furthermore, while Chicago-area bankers claim to offer volume discounts frequently, and it is economically rational to do so, the census of transactions reveals only a slight negative correlation between purchase volume and cost per credit ( $r = -0.12$ ,  $n = 197$ ; no  $P$ -values are given as the calculation was performed on data from a census).

In wetland banking, “option cost” refers to the difference between the bank credit price and the next most expensive mitigation option available to the purchaser (typically, the construction of a compensation site on or close to the development project site). Theoretically, the market price of the commodity in a well-functioning market should be influenced by changes in the costs (including lost profit) associated with other available options that satisfy the same need. In suburban Chicago, this may include the cost of on-site construction of a wetland compensation site, as well as the cost of the land on which the wetland is constructed. It may also include the lost profit on the houses that could have been constructed instead. A bank customer who builds houses on very expensive land should therefore be willing to pay more for credits than a bank customer building houses on inexpensive land.

Does the cost of wetland credits behave in this way? A rough test can be performed by correlating mitigation cost per credit with distance from downtown Chicago. In the area where bank-compensated impacts are concentrated (see Figure 1), it is reasonable to assume that real estate value decreases with distance from downtown Chicago. If purchasers’ option to compensate on-site figured strongly in bank credit prices, one would expect a negative correlation between credit price and distance from Chicago (ie credit price should drop as one moves away from the high-value real estate area). Indeed, there was a small but clear negative correlation between credit price and distance from the Sears Tower in downtown Chicago ( $r = -0.22$ ,  $n = 236$ ;

WebFigure 1). However, the regression indicates that bank credit price is only a few thousand dollars higher nearer to downtown, while over the same distance the option cost associated with real estate prices may have increased several times over. Thus, credit price appears weakly responsive to purchaser option cost, a finding that offers only tepid support for the ability of the price mechanism in the wetland credit market to reflect the relevant costs to society. To be sure, there are almost certainly countervailing influences not captured in this dataset; for example, it is possible that some permit holders are skilled at finding nearby non-bank compensation options that have much lower option costs than the general spatial pattern of real estate values would suggest. More data on the costs of compensation performed by permittees themselves is required to fully interpret this result. While such unresponsiveness in price is a common imperfection in many markets, in ecosystem service markets the consequences bear directly on environmental quality and compliance with regulatory requirements.

Further important departures from conventional market principles can be observed, and have been noted by other researchers (ELI 1993, 2002; King and Kuch 2003; Ruhl and Salzman 2006). First, a regulatory third party creates all supply and demand: the Corps certifies the supply of wetland credits and it is Corps permits that stimulate the demand for them. Secondly, bankers and independent observers in this market believe that price is primarily influenced not by supply and demand, but by an informal consensus among the small community of bankers. They express concern that fragile alliances with repeat buyers may be disrupted by a quixotic search for profits. This concern is exacerbated in an unpredictable regulatory environment (Robertson 2004).

In short, economic theories developed to describe mature free markets in traditional commodities may be poor guides to the fundamental character of supply, demand, and price in nascent regulatory ecosystem service markets. It is not uncommon, in fact, to hear wetland economists claim that the word "market" may not truly describe the trade in wetland credits; they point out that fundamental characteristics of the wetland credit market are directly responsive to government-imposed regulatory requirements and the maintenance of extra-market social relations, rather than being responsive to innate human wants and needs (the traditional source of demand in economic analysis; Shabman *et al.* 1994; Scodari and Shabman 1995; Oates 2006; King and Herbert 1997). These economists generally do not construe this as problematic for market-based policy, arguing that markets can satisfy human needs which have been imposed by regu-

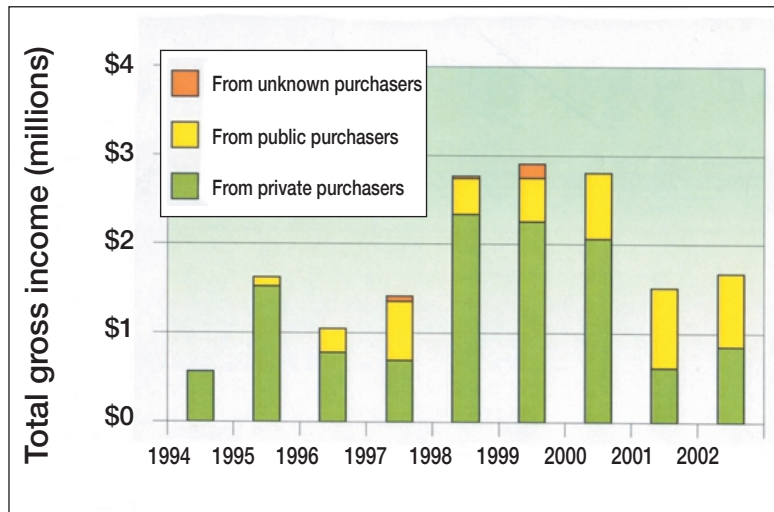


Figure 3. Gross income of private entrepreneurial bankers, subdivided by the class of client making purchases, 1994–2002.

latory directive as cost efficiently as they can satisfy innate human needs. The data presented here, however, call into question whether the dynamics of exchange in ecosystem service credits are interpretable with conventional market analytic tools. Interpreted broadly, these data present an empirical challenge to the promise that market-based environmental policy will optimize social welfare through cost-efficiency. At the very least, the data highlight a strong disconnect between the integral role of regulation in wetland trading on the one hand and the conceptual foundations of market-based policy on the other, as well as the deregulatory rhetoric that pervades policy discussions of ecosystem service markets.

### Conclusions

It is federal policy to achieve the goals of the Clean Water Act and other environmental legislation through

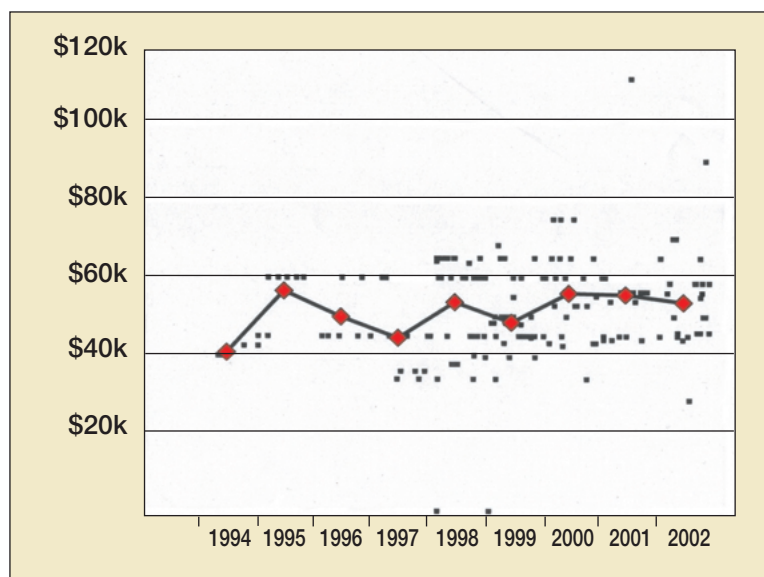


Figure 4. Price per credit with yearly average, 1994–2002.

ecosystem service markets (eg US EPA 2003; USDA 2005). Chicago's arrangement is a success in many ways: institutions for trading wetland credits have been populated by skilled entrepreneurs and competent regulators, wetland compensation sites are reliably held to relatively strict performance standards, and the market is seemingly able to survive considerable external shocks. On the other hand, the market has experienced chronic regulatory turbulence, failed to fully address temporal losses of wetlands, and has not generated easily interpretable price signals.

These features call into question the applicability of conventional economic pronouncements on supply, demand, and price to market-like environmental policy tools. While such markets are often framed as alternatives to regulation, non-economic interpersonal and regulatory influences appear to be simultaneously essential to market functions and fundamentally destabilizing in a way that economic analysis rarely captures. Unless economists are able to characterize the influence of these factors in designing environmental policy prescriptions, their work may produce misleading or unintelligible guidance for environmental policy. Entrepreneurial banking appears successfully to address several problems that have long been associated with compensatory wetland replacement; policymakers should understand, however, that at this early stage it remains unclear whether it is the adherence to – or the departure from – general market-economic principles that has produced these outcomes.

### ■ Acknowledgements

Views represented in this paper are those of the author and do not necessarily represent those of the Environmental Protection Agency.

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## Towards paper-free publications

The increasing rate at which publications are appearing makes the work involved in writing reviews or syntheses greater. Also, space constraints, even in review journals, mean that articles cannot be comprehensive. Even if they were, in these times of environmental awareness, it is hard to justify many pages of references, which are only repeated in the next synthesis.

An internet site, such as the Diving Database (<http://polaris.nipr.ac.jp/~penguin/penguiness/>), which documents the diving capacities of air-breathing animals, offers a possible solution to this problem. Those wishing to examine general trends in diving capacities, such as Schreer and Kovacs (1997) or more recently, Halsey *et al.* (2006), have only to consult this site before presenting and analyzing data that can be traced to its original source at any time by simply citing the weblink. Using this approach, the aforementioned work, for example, would ultimately save about three pages, or 72% of reference text (Schreer and Kovacs 1997).

The only stipulation must be that such sites be accessible forever. Similar sites could deal with a multitude of issues, ranging from species masses to the times of bird migrations and would offer a service that could be updated by approved scientists, providing a way out of the publication reference quandary.

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Halsey LG, Butler PJ, and Blackburn TM. 2006. A phylogenetic analysis of the allometry of diving. *Am Nat* **167**: 276–87.

## War of the roses: the author replies

McMahon (*Front Ecol Environ* **4**(5): 237) and I both acknowledge human responsibility for invasive species, but he further argues that militarization is sometimes appropriate towards them (also see Clergeau and Nuñez 2006). My original article (*Front Ecol Environ* **3**(9): 495–500) did not intend to deny that eradication and perhaps even militarism can be useful in the management of *some* invasive species. I primarily sought to redress our knee-jerk militaristic response to them, encouraging the search for alternatives that nonetheless “promot[e] conservation action”. Hence, I heartily agree with his wish that “both philosophies should be integrated”.

Nonetheless, McMahon provides only a weak example of his proposed “holistic view”. Marion Island is largely uninhabited, except for a scientific research station (<http://marion.sanap.org.za/index2.html>), so his “success story” about the eradication of feral cats skirts social dimensions. A holistic example would incorporate these dimensions along with measures of success in terms of biodiversity. Simberloff (2006) also discounts these dimensions in his focus on how the metaphor of an invasional meltdown – which he associates with militarism – has encouraged scientific investigation. As emphasized in my paper, however, a militaristic approach will be most problematic when it occurs within a complex social setting. I provided the case of Portola, CA, where protesters against a fish eradication project carried a banner that read “Stop Fish & Game [Department] from poisoning Lake Davis – Save our children”. While McMahon demonstrates that militaristic planning can work in a rarefied setting, it will be more challenging to include it within holistic management that incorporates multiple stakeholders.

Both McMahon and the earlier letter by Liebhold (*Front Ecol Environ* **4**(2): 66) argue that eradication sometimes works, but neither of them consider its future. A successful eradica-



tion is not necessarily forever, and measures to prevent future reintroductions appear moderate at best. It remains to be seen whether society will pay for the inevitable re-eradications. It took nearly 15 years to eradicate the cats from Marion Island.

Finally, a critical question is whether successful eradication – such as the one McMahon describes – really depends on a “militaristic approach”. We can undertake a “staged process” to quickly eliminate an invasive species without being militaristic. Perhaps a hallmark of this approach would be an appreciation for the success of these organisms that we have spread – a more realistic and humane view of them rather than managerial enmity.

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## Erratum

Editorial. *Front Ecol Environ* **4**(6): 283. Fourth paragraph, 2nd sentence should read: “Apparently 80% of the journals in the Thomson Scientific database have a self citation rate ranging from zero to 20%”.

Robertson MM. *Front Ecol Environ* 2006; **4**(6): 297–302. Page 299, 2nd paragraph, first line should read, “Phase 1 credits represented 49.7% of all credits for sale during the study period, while fully functional (Phase 4) credits comprised 6.1%...” This does not change the analysis or overall conclusions.