is little or no incentive for the compliant firm to reduce emissions further. The next section discusses alternative approaches that offer improved incentives and flexibility, although the challenge of defining the ambient standards remains.

Incentive-Based Solutions

As an alternative to traditional command-and-control approaches, policymakers use incentive-based policy instruments to pursue the same efficiency goals from a different angle. The market's own engine of self-interest is teamed with influences designed to circumvent market failure. The added influence might be a subsidy or tax credit, a Pigovian pollution tax,[5] a deposit/refund program as with bottle bills, or one of the relatively new and innovative emissions trading programs. Earlier chapters have covered the influences of taxes, subsidies, and deposits; this section emphasizes the use of tradable emissions rights. As the next example shows, a virtue of incentive-based solutions is that they allow firms with differing circumstances to address environmental problems in different ways.

A Two-Firm Pollution Model with Tradable Emissions Rights

Firms value the right to emit pollution because it conveys the ability to produce goods and profits. Figure 12.1 illustrates the marginal value of emissions for each of two hypothetical firms. Firm 1 emissions increase from left to right; Firm 2 emissions increase from right to left. The curves indicate that Firm 2 receives less value from any given amount of emissions than Firm 1, perhaps because it is newer and operates with state-of-the-art emissions-control equipment. If each firm is restricted to the same emissions standard of half of the allowable emissions, the total value to Firm 1 is the sum of areas A and B, and the total value to Firm 2 is the sum of areas D, E, and F.

The efficient allocation equates the firms' marginal values from emissions. With the efficient allocation, the total value to Firm 1 is A + B + C + D and the total value to Firm 2 is E + F. Relative to the equal division of emissions rights, Firm 2 loses area D but Firm 1 gains areas D and E for a net societal gain of area C.

The efficiency gain in this example is attractive, but achieving it with government controls would require a great deal of information. As discussed in the previous sections, it is difficult to establish the optimal total amount of pollution, although meaningful targets are available. The next challenge is to determine the values placed on pollution by the various firms. If asked to report the benefits they receive from the ability to pollute, each firm would have an incentive to exaggerate in order to raise their perceived marginal value of emissions curve and increase what appears

5 Chapter 3 defines a Pigou tax as a tax that equals the marginal external cost of the behavior being taxed. Upon paying such a tax, the decision maker internalizes the full cost of his or her behavior.

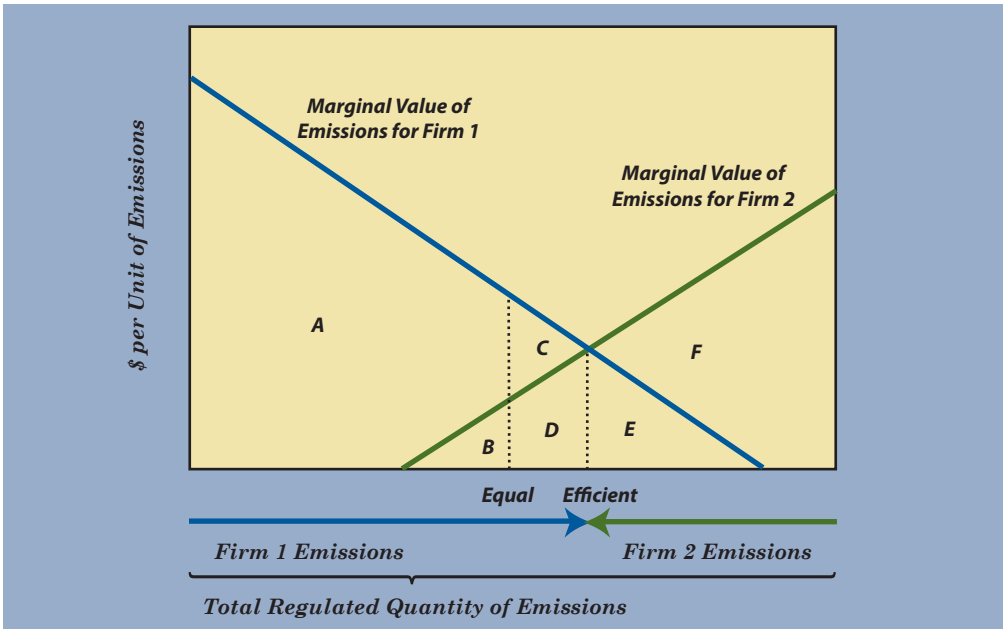
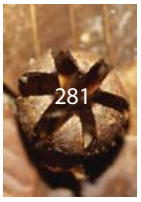


Figure 12.1
The Efficient Allocation of Pollution Rights

This diagram illustrates the marginal value of emissions for each of two firms. Firm 1 emissions increase from left to right, and Firm 2 emissions increase from right to left. As indicated by the lower marginal value curve, Firm 2 receives less value from any given amount of emissions than Firm 1. If each firm is permitted to emit the same volume of emissions, the total value to Firm 1 is the sum of areas A and B, and the total value to Firm 2 is the sum of areas D, E, and F. The efficient allocation is achieved where the firms' marginal values from emissions are equal. With the efficient allocation, the value to Firm 1 is A + B + C + D and the value to Firm 2 is E + F. The net gain from efficient allocation is area C.



to be their efficient share of the emissions allotment. It is with this challenge that tradable emissions permits work their magic.

Restricting emissions levels, dividing the rights to the permitted emissions among firms, and allowing the firms to buy and sell those rights, will theoretically result in efficient division. Given a market for emissions rights each firm faces a per-unit opportunity cost of emissions equal to the market price of emissions rights. Firms that do not have adequate emissions rights also have an incentive to find ways to reduce their emissions to minimize the need to purchase more rights. Even if a firm has more than enough rights to produce at their maximum capacity, it has an incentive to pollute less if emissions reductions cost less than the market price of emissions rights.

Consider the situation in Figure 12.1 in which each firm begins with the right to emit half of the allowed pollution. The firm that places the lowest value on pollution because it can reduce its emissions at the lowest cost (Firm 2) will end up selling rights to the other firm (Firm 1), for whom cleanup is relatively expensive and polluting is relatively valuable. This will occur until the efficient allocation of pollution is achieved, after which point the marginal value of another unit of emissions is higher for Firm 2 than for Firm 1. Then, the *most* Firm 1 would be willing to pay for

the ability to pollute some more is less than the *least* Firm 2 would accept for the transfer of the right to emit another unit, and trading will cease. During this process, each firm makes decisions based on its true marginal value of emissions—a value critical to the determination of efficient levels of emissions as indicated in Figure 12.1, but difficult to ascertain by any other means.

The initial distribution of rights affects the distribution of funds between the firms. The more rights a firm receives in the beginning, the more it can sell or the fewer it must buy. But this distribution has no influence on the efficiency of the final outcome. Whether rights are all given to Firm 1, or all to Firm 2, or there is some intermediate allotment, trades between the two firms are in each firm's best interest until the marginal value to each firm is the same and the efficient distribution is achieved. The same is true when there are many firms: Regardless of the initial allotment of pollution rights, trading will occur until the firms' marginal values of pollution are equal, thus marking the efficient distribution of rights.

Tradable Emissions Permits in Practice

Attractive in theory, the practice of emissions trading is also growing in popularity worldwide. A variant called cap-and-trade was first adopted in the United States in 1995 to address the acid rain problem, controlling SO_2 at the national level and NO_x in some regions. **Cap-and-trade** programs set a limit on the quantity of particular pollutants that can be released and allocate allowances for portions of that quantity among existing sources who can then trade them on the open market. The trading of pollution allowances is similar to that of stocks and commodities. Sulfur dioxide allowances are available from allowance brokers, environmental groups, and an annual EPA auction conducted by the Chicago Board of Trade.[6] Each allowance is for one ton of SO_2 emissions.

In the 2005 auction, the market-clearing price was $690 and 125,000 allowances were sold. Ameren Energy Generating Co. was the biggest buyer, purchasing 40,000 allowances. Among the other purchasers were the Acid Rain Retirement Fund, and environmental groups at Bates, Colby, Hobart, and William Smith Colleges and Cornell University. In 2001, before its financial scandals erupted, Enron North America spent almost $22 million to purchase 125,000 shares.

Articles 6, 12, and 17 of the 1997 Kyoto Protocol on Climate Change set forth greenhouse gas trading on a global scale.[7] In 1999 the World Bank's executive board approved the creation of a $130 million fund to help develop emissions-trading rules under the Kyoto Protocol, and to finance and monitor similar projects to reduce greenhouse gases. In the United States, the EPA is looking into effluent trading programs for National Pollutant Discharge Elimination System permit holders. The Clear Skies Act of 2003 would reduce greenhouse gas emissions by 18 percent over ten years and "cuts pollution further, faster, cheaper, and with more

6 Links to all of these allowance sources are available at http://www.epa.gov/airmarkets/trading/buying.html.

7 See http://unfcc.int/resource/docs/convkp/kpeng.html.

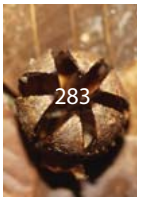
certainty, using a 'cap-and trade' program, replacing a cycle of endless litigation with rapid and certain improvements in air quality."[8]

There are three primary benefits from emissions trading programs:

1. **They allow flexibility and creativity.**
   Permissible emissions levels can be achieved via conservation, new technology, alternative energy sources, lower-sulfur coal, or the purchase of allowances—whichever is the most feasible and affordable to a particular pollution source.

2. **They allocate emissions rights to those who value them the most.**
   Newer, cleaner firms can sell their rights to firms for whom it would be much more difficult to reduce emissions levels.

3. **They provide incentives for reductions beyond the level stipulated by regulations.**
   When emissions can be cut for less than the going price for allowances, firms will do so and sell their extra allowances for a profit.



There are also caveats. Some worry that emissions trading at the international level will be less successful than trading within a nation due to monitoring difficulties. Others fear that focus on the development of new emissions trading systems will distract attention from more fundamental efforts to reduce consumption, conserve resources, and moderate behavior in the richest nations.[9] There is also concern that even effective policies enforcing emissions targets are only as good as the choice of those targets. The EPA and similar agencies in other countries face the contentious task of selecting the standards. As discussed in Chapter 2, cost-benefit analysis is an available but politically volatile tool for setting standards. Politics, morals, emotions, and imperfect information also become influential ingredients in real-world policymaking.[10]

Punishment and Deterrence

Deterrence via the Legal System

From 1986 to 1996, in violation of the Clean Water Act, Chemetco, Inc. allegedly discharged pollutants, including zinc, lead, and cadmium, into Long Lake, a tributary of the Mississippi River. Investigators say the toxic substances were released through a "secret pipe" from the company's copper smelting plant in southwestern Illinois. The case was investigated by the EPA's Criminal Investigation Division, the

8 See http://www.whitehouse.gov/news/releases/2002/02/20020214.html.

9 See, for example, http://www.oneworld.org/ips2/Dec98/07_14_005.html.

10 For perspectives on ethical and emotional arguments, see Chapter 16, Ott and Sachs (2000) and http://ecoethics.net/hsev/newscience/200012b-res.htm.

Market Incentives and the Endangered Species Act

In 2005 there were 1,830 species listed as *endangered* (in danger of extinction) or *threatened* (likely to become endangered in the foreseeable future) under the Endangered Species Act (ESA) of 1973. The United States Secretary of the Department of the Interior is responsible for approving domestic plants, wildlife, and inland fishes for the list and creating recovery plans for each species without regard to the cost. The Secretary of Commerce does the same for ocean-going fish and marine animals. When a species is listed, the Secretary must designate areas as protected "critical habitat" for the species. Private landowners are not compensated when the use of their land is limited by critical habitat designation.

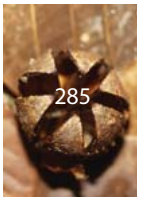
It would appear that the inflexibility of command-and-control policy is less of an issue when it comes to protecting endangered species—there aren't a lot of alternative ways to save these plants and creatures. Endangered species are often those that do not adapt well to substitute habitats and do not reproduce readily in captivity. Saving these species may come down to protecting their existing habitat.

This being the case, the influence of incentives remains critically important. Given the threat of land-use restrictions without compensation, the incentive for landowners is to preemptively destroy endangered species in order to avoid the burden of compliance. According to U.S. Representative Richard Pombo (R-California) and supported by economic research by Lueck and Michael (2002), landowners "frequently act to eliminate habitat, for fear of losing use of their property to federal government regulations" (see http://web.outsidemag.com/news/specialreport/esa/pomboedit2.html).

Pombo and his colleague Representative Don Young (R-Alaska) proposed the Endangered Species Conservation and Management Act, ostensibly to remedy problems stemming from poor incentives. The act would have compensated landowners whose property value decreased by more than 20 percent due to protective action, and provide tax incentives for property owners to promote species recovery. As with many bills, however, the fine print elicited detractors. The Sierra Club said the proposed act would "gut" the ESA by permitting the destruction of endangered species habitat, delaying the listing of species, and loosening other standards for protection. The National Wildlife Federation noted that the ESA already has virtually no restrictions on property use for landowners with endangered plants, and proposed its own set of incentives, including a conservation easement program that would provide tax breaks to landowners who preserve endangered species habitat. The general consensus is that even with command-and-control regulations, behavior hinges on incentives, and a policy will fail if the trail of incentives does not lead to the policy goal.

FBI, the U.S. Department of Transportation, the Illinois State Police, and the Illinois EPA. The U.S. District Court ordered a fine of $3,865,100 and $400,000 in restitution payments by the company. If convicted, the individuals accused of building or using the secret pipe face up to eight years in prison and up to $500,000 in fines. This case highlights both the risks that some people take to circumvent environmental policy and the many agencies that must devote resources to monitoring and enforcement.

Environmental policy loses its influence when enforcement mechanisms are weak. Some types of environmental abuses are difficult to police because toxic releases can happen anywhere at any time. The most vulnerable wilderness areas are often the most remote, meaning that watchful eyes are not upon them. These monitoring difficulties have implications on the best approaches to enforcement. This section outlines the theory of optimal deterrence and applies it to the special case of environmental policy.



We have seen that socially optimal behavior is expected when decision makers internalize the full costs and benefits of their contemplated actions. When illegal dumping or other deviations from policy guidelines are considered, the expected value of punishment weighs into the compliance decision. The **expected punishment cost** equals

(the probability of punishment) × (the punishment cost if imposed)

The probability of punishment is itself the product of the probabilities of apprehension, conviction given apprehension, and punishment given conviction. Thus, even if the chance of getting caught were 80 percent, if half of those apprehended were convicted and half of those convicted paid a $10,000 fine while the rest got a warning, the probability of punishment would be $0.80 \times 0.50 \times 0.50 = 0.20$, and the expected punishment cost would only be $0.20 \times \$10{,}000 = \$2{,}000$.

As described in Chapter 5, risk-averse people feel a burden from the uncertain outcomes of risky behavior. Environmental crimes constitute risky behavior, and the associated risk burden (or risk enjoyment felt by risk-loving individuals) is an added component of the expected punishment cost.

Socially efficient decisions are made when external marginal costs and benefits are internalized. When a firm or household receives all of the benefits from, say, illegal dumping, efficiency is achieved if the expected punishment cost equals the marginal external cost. This will cause decision makers to internalize the marginal external cost and only deviate from policy when the marginal benefit exceeds the social marginal cost. When monitoring is difficult, as is typically the case for environmental misconduct, the low probability of punishment can be made up for with a high punishment cost. Table 12.1 indicates several combinations of punishment probabilities and costs, all of which yield an expected punishment cost of $10,000 for a risk-neutral decision maker.

If the marginal external cost of dumping is $10,000, any of these combinations will result in the efficient amount of dumping. If monitoring is costly, however, *the solution that minimizes monitoring costs is that which imposes the highest possible punishment cost*. A fine of $10 billion coupled with the minimal monitoring efforts required to catch one in one-million criminals would have the same effect on risk-neutral criminals as

Table 12.1
Punishment Alternatives

Punishment Probability	*Punishment Cost*	*Expected Punishment Cost*
1	$10,000	$10,000
1/10	$100,000	$10,000
1/100	$1,000,000	$10,000
1/10,000	$100,000,000	$10,000
1/1,000,000	$10,000,000,000	$10,000

a certain fine of $10,000. The difference is that it would be prohibitively expensive to bring about certain detection. For risk-averse criminals, the burden of uncertain punishment means that some fine less than $10 billion (determined by their degree of risk aversion) with a one in one-million chance of apprehension would elicit the same behavior as a certain fine of $10,000. Monitoring cost minimization is one of the reasons why we see large jury awards in environmental crimes, as was the case for Chemetco.

In 1990 the EPA increased the penalties for hazardous waste violations under the Resource Conservation and Recovery Act (RCRA). Some fines were increased by 10 to 20 times their original size by the revised RCRA Civil Penalty Policy. Research by Sarah L. Stafford (2002, p. 294) found that within three years of this policy change, the number of violations per EPA inspection began a steady though less-than-hoped-for decline. Controlling for other influences, Stafford also found fewer violations in states where more citizens were members of environmental organizations. Apparently while incentives matter, so does attitude.

Activism and Vigilante Justice

Frustrated by what they perceive as insufficient policy standards, monitoring efforts, or punishments, some individuals and groups have decided to take matters into their own hands. Private ecoactivism ranging from letters to politicians to violent acts of ecoterrorism add to the landscape of incentives for socially responsible behavior. In grassroots efforts, consumers have voted with their pocketbooks against everything from Coke (due to allegedly insufficient recycling initiatives)[11] to U.S. coal (due to U.S. nonadherence to global environmental policy protocols.)[12] Some of the more successful efforts have led the fast food industry away from Styrofoam[13] and coaxed fashion retailers away from fur coats.[14] Greenpeace is famous for its peaceful but aggressive campaigns to influence policy on nuclear threats, whaling, toxic releases, deforestation, and global climate change, among their other concerns.[15]

Like litigation and prosecution, the threat of responses from activists poses a

11 See http://www.hotkey.net.au/~gargoyle/CDL/BoycottCocaCola/CokeSurveyResults.htm.

12 See http://www.spacedaily.com/news/010524134527.208biooq.html.

13 See http://www.mcspotlight.org/campaigns/countries/usa/usa_toxics.html.

14 See, among many examples, http://www.geocities.com/boycottthebay/.

15 See http://www.greenpeace.org/campaigns/.

Activists erected this display at Venice Beach, California, to raise public awareness about animal cruelty.

small risk of large costs, but with a vigilante twist. For example in 2001, the anti-urban-sprawl Earth Liberation Front (ELF) allegedly burned new homes using crude explosives, damaged bulldozing equipment, and scrawled "meat is murder" and "if you build it we will burn it" on a restaurant and a home. The *New York Times* quotes a 1997 Internet communiqué from ELF saying, "We take inspiration from the Luddites, Levellers, Diggers, the Autonome squatter movement, ALF, the Zapatistas, and the little people—those mischievous elves of lore."[16] Such groups have placed metal spikes in trees to make logging dangerous, destroyed labs where genetically engineered crops were developed, and released animals being kept to harvest for their fur.[17] While peaceful protests have influenced policy and practice, violent approaches are largely ineffectual. For governments to cater to criminal actions would be to invite more crime, and so the response to ecoterrorism has been limited almost exclusively to actions against the terrorists.

With ecoterrorism, activists are the judge and jury. Whether or not their determinations of right and wrong are less predictable than professional judges and formally selected juries, a strict adherence to the law provides no refuge from ecoterrorism. When ELF allegedly set fire to the Oregon offices of the Boise Cascade Corporation in 1999 for having "ravaged the forests of the Pacific Northwest" to manufacture paper, the corporation had broken no law. Defenders of both litigation and ecoterrorism claim that the uncertainty of punishments is a price we must pay for the necessary customization of penalties and prevention of wrongdoing.

16 See the *New York Times*, January 3, 2001, accessed online at http://www.nytimes.com/2001/01/03/nyregion/03EART.html.
17 See http://www.earthliberationfront.com.