FRESHWATER SYSTEMS

Working for Water, Working for Human Welfare in South Africa

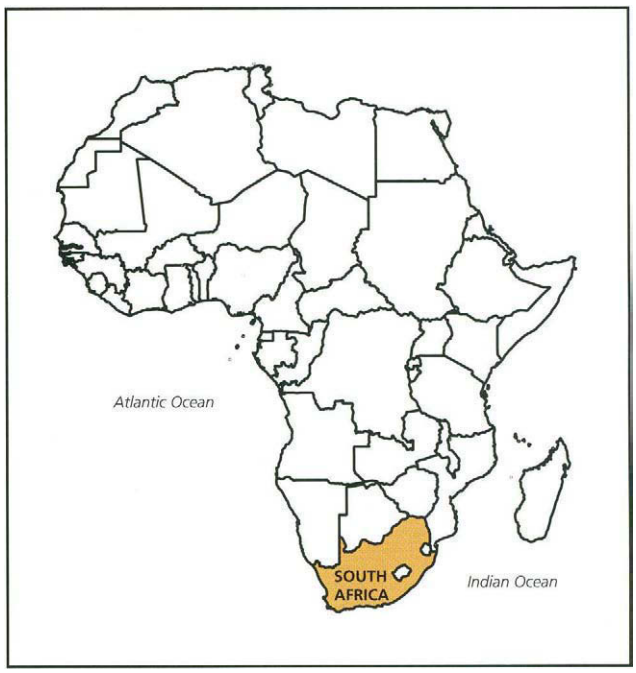
South Africa is waging a new sort of turf battle. Beginning at dawn each day, thousands of citizens wield scythes, axes, and pesticides against a rapidly advancing and thirsty enemy: the alien trees, shrubs, and aquatic plants that thrive in South Africa's mountain watersheds, drainage basins, and riparian zones. These invading nonnative plants are literally drinking the water that people desperately need in this semiarid country.

Imported for aesthetic and economic reasons and unchecked by natural enemies, alien plants have infested 10 Mha, or 8 percent of the country (Versveld et al. 1998:32). Their noxious spread creates a chain reaction of ecological and economic disasters. In addition to depriving South Africans of needed water, these plants obstruct rivers, exacerbate the risk and damage of wildfires and floods, and reduce biodiversity by crowding out native vegetation.

Destroying trees and aquatic plants may seem counterintuitive to basic concepts of watershed protection and ecosystem management. Watershed conservation is most often associated with the prevention of deforestation. But South Africa is a country naturally dominated by grasslands and fire-prone fynbos shrub vegetation that, because of its low biomass, requires little water–unlike an infestation of large alien trees and woody weed species.

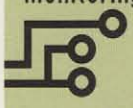
Common invader species such as wattle (*Acacia*), silky hakea (*Hakea sericea*), and pine (*Pinus*) increase the aboveground biomass of fynbos ecosystems by 50–1,000 percent. The invaders dramatically decrease runoff from watersheds

(continues on p. 196)



Box 3.12 Overview: South Africa's Invasives

Nonnative plants have invaded 10 Mha of South Africa. Though they provide valuable timber and other benefits, invasive plants deprive the country of precious water, reduce biodiversity, obstruct rivers, and increase risk and damage of wildfires and floods. South Africa's response, a multiagency effort called the Working for Water Programme, has hired thousands of poor, disadvantaged citizens to remove invasive species while acquiring a living wage and new skills.

Ecosystem Issues	
Freshwater 	Since the invasion of South Africa by nonnative plants, the water quantity provided by the country's freshwater ecosystems to downstream areas has dramatically decreased—by as much as 82 percent in some watersheds.
Forests 	Converting grasslands and native forests to nonnative plantations made it possible for South Africa to increase fiber production. Today, timber contributes R1.8 billion to the national economy and forest-based industries another R10 billion. The trade-off: the nonnative trees drink almost 7 percent of water that would otherwise flow into rivers—far more than native species.
Grasslands 	Already one-third of South Africa's Cape Floral Kingdom, a grassland and fynbos shrubland ecosystem, has been lost to urbanization, agriculture, and forestry. Invasives now threaten biodiversity in the remaining 90,000 km^2 of fynbos, home to 45 percent of the subcontinent's plant species. Invasives also increase soil erosion after wildfires and floods.
Agriculture 	Conversion of lands to agriculture and habitat disturbance from road building and other developments promotes the spread of nonnative plants.
Management Challenges	
Equity and Tenurial Rights 	The end of apartheid began to return a voice to black citizens, whose control over land and water had previously been drastically limited. This era also brought a new commitment to supplying sufficient water to all. If that commitment is sustained, it provides impetus for the Working for Water Programme and other restoration efforts that promise to provide more water at minimal cost.
Economics 	Once almost free, the government now charges citizens for water to discourage overuse and waste. Charges for other major water consumers like the forestry and agriculture sectors are critically needed, too, but hotly contested.
Stakeholders 	The Working for Water Programme has found some common ground with stakeholders, but more difficult policy negotiations are ahead. For private landowners and commercial foresters, many invasives are valuable crops or decorative elements of yards; controlling them brings higher costs than benefits.
Information and Monitoring 	Research on the impacts of invasives on water supply helped generate interest in today's integrated invasive plant control effort. More economic studies that illustrate the impacts of invaders and the financial benefits of control are essential to help justify the increasingly large-scale funding that the Working for Water Programme requires.

Timeline

c. 1000 Traders and nomads introduce plant and animal species to Southern Africa, but none significantly impact native vegetation.

1652 The Dutch colonize South Africa's Cape. They soon import more than 50 crop plants from Europe, Asia, and South America; some are present-day invaders.

1820–1870 A large influx of settlers from around the world introduces 11 of the 12 invasive species that now cause the greatest problems in fynbos.

1880s–1890s Botanists begin to note the spread of nonnative plants over mountain slopes and losses of endemic species in Cape fynbos vegetation. At the same time, foresters promote mountain plantations of nonnative trees.

1920s Controversy about effects of forest plantations on water supplies begins, even as demand for commercial timber and related products drives high rates of afforestation with nonnative hardwoods that continue for the next 60 years.

1930s Rapid spread of prickly pear (*Opuntia aurantiaca*) in the succulant Karoo sparks awareness of the threat invasives pose in arid areas as well as fynbos. Threats to biodiversity in grasslands and savanna are not fully understood for another 50 years.

1934 The South African parliament appoints an interdepartmental committee to assess water preservation options.

1937 The Weeds Act is passed, one of the first major legislative attempts to deal with invasives, but a lack of field staff and resources makes it difficult to enforce.

1940s–1970s Hydrological studies show that plantations have a negative effect on streamflow. Efforts to control invasives are launched, but they are uncoordinated, erratic, and hampered by limited follow-up after clearing.

1948 Apartheid designates 83 percent of South African land "whites only." Rural land and water laws in ensuing decades mainly serve white interests. Blacks are denied access to the political process.

1970 The Mountain Catchment Act gives the Department of Forestry management responsibility for high-lying areas; invasives there are tackled in earnest, with plants cleared from tens of thousands of hectares. The Plant Research Institute conducts vital research on biological controls for invasive plants.

1983 Conservation of Agricultural Resources Act grants government wider power to control invasive species and introduces the idea that landowners are obliged to manage their land sustainably.

1986 International program on biological invasions focuses attention and research on plant invasions in South Africa. A review of catchment experiments provides unequivocal evidence of the detrimental effect of nonnative plants on stream flow.

Late 1980s Responsibility for management of mountain catchments is passed from the Department of Forestry to the provinces; lack of funding ends momentum for integrated invasive plant control programs. Plants re-invade cleared areas.

1989 International SCOPE program on biological invasions focuses attention and research on South African plant invasions. A review of catchment experiments provides unequivocal evidence of the effect of nonnative plants on streamflow.

1993 Further government-sponsored research determines that clearing invasive vegetation can improve runoff from catchments.

1994 Apartheid ends. South Africa becomes a constitutional democracy.

1995 The Working for Water Programme is founded by South Africa's Minister of Water Affairs and Forestry, hires 7,000 people, and clears 33,000 ha in its first 8 months.

1998 The National Water Act recognizes water as a common resource; commits to protecting its quantity, quality, and reliability; and grants each South African a right of access to 25 l of water per day. Meeting that commitment to 14 million people without access to sufficient water is a daunting challenge.

2000 The Working for Water Programme employs tens of thousands of people and has successfully cleared more than 450,000 ha of land of invasive species, yet millions of hectares still require attention.

through greater water uptake from soil and subsequent transpiration (van Wilgen et al. 1996:186, citing Versfeld and van Wilgen 1986). Currently, invasive species in South Africa consume about 3.3 billion m^3 of water each year, almost 7 percent of the water that would otherwise flow into rivers (Versveld et al. 1998:iv). That's nearly as much water as is used by people and industries in South Africa's major urban and industrial centers (Basson 1997:10).

South Africa's response to the invasion may be the largest and most expensive program of alien-plant control ever undertaken. It is also an effort to address the impoverishment of black South Africans–poverty being one of the legacies of apartheid, the system of white rule that ended in 1994. Through a multiagency effort called the Working for Water Programme, the government has hired thousands of citizens to hack away the thirsty invasive plants and to turn the by-products of their labors into saleable goods such as fuelwood, furniture, and toys. Since its inception in 1995, the Programme has offered men and women opportunities to acquire a living wage and new skills. In some project areas, the Programme provides childcare, community centers, and health and national water conservation education.

By uniting social goals with ecosystem restoration, and by capitalizing on public pressure to provide more water to millions of people, Working for Water has mustered political will, public support, and funding at a time of fierce competition among the many social welfare projects visualized by South Africa's new democratic government. Still, success is far from assured and the stakes are high. If the Programme fails, many pervasive invaders could double in extent over the next 10–20 years (Versveld et al. 1998:vi), jeopardizing the water supply to cities, industries, and agriculture. The Programme's high cost, conflicts of interest with landowners, and management and safety problems cannot be ignored. But the multiple dividends that Working for Water pays are substantial: a healthier ecosystem, more water at less cost, and employment for thousands in a country where opportunities to escape poverty are rare.

The Plant Invaders

Today, invasive plants and animals are considered one of the gravest threats to the biodiversity of natural ecosystems worldwide. That awareness, however, has come relatively recently. For centuries alien plants were seen as desirable; their cultivation offered immediate economic returns and social benefits, although their costs were usually slower to manifest. Alien plants can spend decades living innocuously in nonnative settings before some subtle adaptation or shift in ecological dynamics triggers an invasion. Even after years of study, it is not always clear which organisms will aggressively invade new ranges, where invasions will occur, when, or why.

A ribbon of invasive alien pines *(Pinus pinaster)* on the horizon; these pines spread from a plantation just over the mountain. They radically alter the structure of the fynbos and reduce streamflow from rivers.

IMPORTING THE INVADERS

Nonnative plants certainly seemed harmless to the Dutch, who introduced more than 50 plants within the first few years of their settlement at South Africa's Cape in 1652 (Wells et al. 1986:29). For the next 150 years, colonists from all over the world continued to import species that would provide firewood, timber, food, and shade, and would stabilize sand drifts, enhance gardens, and remind them of home.

In total, about 8,750 plant species have been introduced into South Africa. Fortunately, only 2 percent have become seriously invasive, mainly trees and shrubs that mature quickly, multiply prolifically, spread easily, and fare well in disturbed conditions (van Wilgen and van Wyk 1999:566). Species imported from southern continents and other fire-prone ecosystems, like Australia, took hold particularly readily in the fynbos, where fires trigger seed release and create conditions conducive to germination.

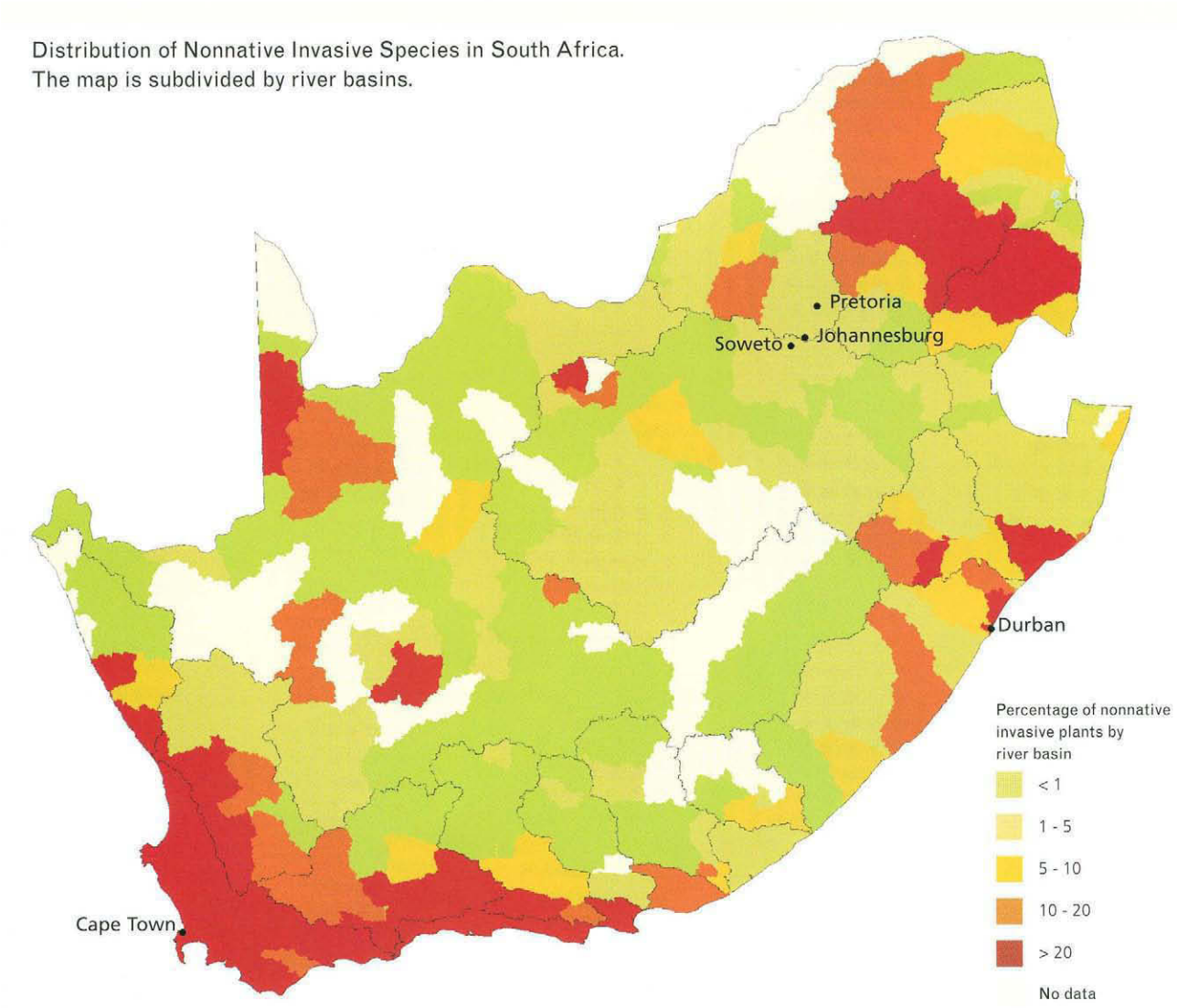
Some of the most problematic species took root in the late 19th century when forest authorities began to promote afforestation of the mountains around Cape Town. Imported pines, eucalyptus, and wattles were promoted to supply tannin and timber, since the extent of South Africa's natural forests is limited by climate and the fire regime. Officials believed also that alien plants would increase the water supply and provide aesthetic relief; they called the naturally bare and stony slopes of the Cape's mountains "a reproach and an eyesore." Government foresters provided private growers with free seeds and transplants of the alien species and awarded prizes for the best plantations (Shaughnessy 1986:41).

The nonnative trees proved fast growing and able to take root on all kinds of marginal lands. South Africa soon trans-

Box 3.13 Most Widespread Plant Invaders in South Africa

Species	Origin	Reason for Introduction	Approx. Area and System Invaded	Water Use (millions of cubic meters)
Syringa *(Melia azedarach)*	Asia	Ornamental, shade	3 Mha; savanna, along riverbanks, disturbed areas, roadsides, urban open spaces	165
Pines *(Pinus species)*	North America and Europe	Timber, poles, firewood, shade, ornamental	3 Mha; widespread in mountain catchments, forest fringes, grasslands, fynbos	232
Black wattle *(Acacia mearnsii)*	Australia	Shelter, tanbark, shade, firewood	2.5 Mha; widespread, except in arid areas	577
Lantana *(Lantana camara)*	Central and South America	Ornamental, hedging	2.2 Mha; forest and plantation margins, water courses, savanna	97

Sources: Versveld et al. 1998:75; Working for Water Programme n.d.:4.



Sources: Versfeld et al. 1998; USGS 1997.

formed grasslands and scrub-brushland habitats–largely unsuitable for agriculture and grazing though very rich in native biodiversity–into state-owned and private plantations to feed the burgeoning timber industry and pulp and paper mills. Today, plantations of alien trees cover 1.52 Mha. Natural forests cover less than 7,177 km^2–about 0.25 percent of South Africa (Le Maitre et al. Forthcoming).

Unfortunately, in riparian zones fast-growing aliens drink almost twice the amount of water that the same trees consume in areas away from rivers (van Wilgen and van Wyk 1999:567). And, plantations can only grow in the higher rainfall areas, like South Africa's mountain catchments. There they garner "first take" on some of the key water supplies for South Africa's lowlands. Although mountain catchments encompass just 8 percent of the land surface, they provide 49 percent of the total annual freshwater runoff for the country (van der Zel 1981:76).

LOSING WATER, GAINING AWARENESS

As early as the 1800s, South African botanists expressed concern that introduced plants might suppress and replace natural vegetation, eventually turning the species-rich fynbos into a biological desert. But among land managers and policy makers, there was little interest in alien plant control for almost another 100 years.

The threat of water shortages–more than the potential loss of biodiversity–is what eventually motivated a reevaluation of South Africa's land management practices. Suspicions that the proliferation of alien plants might be linked to water supply problems arose in the 1920s when farmers' associations petitioned the government to investigate why South Africa's rivers were drying up. The government initiated a series of experiments to assess the impact of commercial forestry on water resources in mountain areas. In study catchments, fynbos shrublands and grasslands were heavily planted with alien pines and eucalyptus, and the impact on stream flow was monitored and compared to untreated control catchments. In the following decades, researchers found stream flow sensitive even to small changes in catchment vegetation cover. In KwaZulu-Natal Drakensberg, for example, there was an 82 percent reduction in stream flow in grassland catchments 20 years after planting with pines, a 55 percent reduction in fynbos catchments in the Western Cape 23 years after planting with pines, and a total drying up of streams in Mpumalanga Province 6–12 years after completely replacing grassland catchments with pines and eucalyptus (van Wilgen and van Wyk 1999:x). Despite these findings, until the 1990s, efforts to protect watersheds and combat the spread of invasive plants were small and sporadic, petering out when funding waned.

Finally ecologists were able to galvanize support for change with a critical body of evidence that water losses to unchecked invasives could be economically disastrous. Advances in technology enabled the development of computer models that simulated the growth, spread, and water use of alien plants in a fire-prone landscape. The results were eye-opening. Even sparsely infested areas are likely to become dense with invasives over the next half century, resulting in reductions in streamflow of 30–60 percent (van Wilgen et al. 1997:406). During the dry months when water needs are greatest, runoff in some invaded catchments could be reduced to zero, converting perennial streams to seasonal ones.

Unchecked alien plants would have dire implications for the Cape region's native wildflower, foliage, and dried flower harvests and for the 1.3 Mha of irrigated croplands that produce 25 percent of the country's agricultural output (IWMI 1999:4). The Western Cape's harvests of apples, peaches, and pears, for example, depend entirely on water derived from adjoining mountain catchments; and the deciduous fruit industry generated gross export earnings of more than US$560 million and employment for 250,000 people in 1993 (van Wilgen et al. 1996:185).

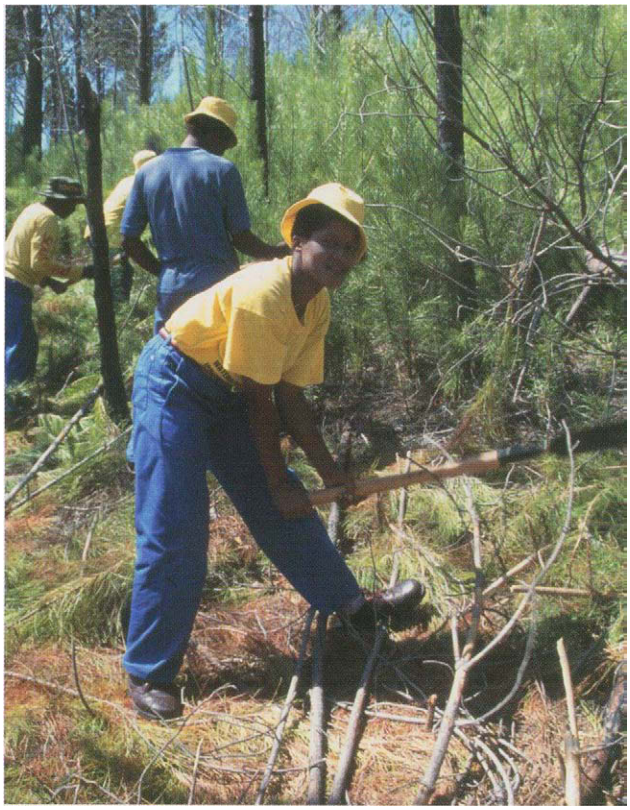
The impetus for invasives control gained further momentum from a political transformation–the end of apartheid in 1994. A democratically elected government brought a new national focus to equitable water access, a radical departure from a history in which water was seen as the property of the person whose land it ran through, usually white farmers. Now, under South Africa's 1998 Water Law, all water is a common resource. Each South African has a right of access to sufficient water for basic needs, an amount provisionally set at 25 l/person/day.

Since 14 million South Africans have inadequate or no water supplies (Koch 1996:12), translating this new "right" into practice will make prior water shortages seem trivial. South Africa is already water stressed, and rapid population expansion in metropolitan areas like Cape Town threaten to create regional water crises. Studies have predicted that in parts of the Cape, water demand in the year 2010 could be 70–106 percent higher than in 1990 (Marais 1998:2, citing Spies and Barriage 1991).

A New Kind of Turf Battle

Watershed protection and poverty alleviation are dual goals paired effectively in South Africa's Working for Water Programme. In 1995 Kader Asmal, Minister of Water Affairs and Forestry, was convinced by the arguments of scientists and conservationists that clearing invading plants could supply water and other ecological benefits. He proposed that the government use Poverty Relief funds to hire disadvantaged citizens to remove invasive trees, shrubs, and aquatic plants.

The first year of the plant-clearing effort had a budget of R25 million and employed more than 6,100 people (van Wilgen 1999). Now in its fifth year, Working for Water's 1999-2000 budget is eight times larger–R202 million (van Wilgen 1999)



A Working for Water team clears a dense stand of *Pinus pinaster* in the mountains above the coastal town of Kleinmond, about 120 km east of Cape Town.

and funding 240 projects in eight heavily infested provinces. At times, employment has risen to 42,000 people, many of whom have never been employed before or only labored as migrant workers (Working for Water 1998, 1999). Priority is given to clearing invasives from riparian zones and areas with the greatest number of disadvantaged citizens.

PROTECTING THE WATERSHEDS

The Programme has cleared in excess of 450,000 ha of infested land. In some places streams have flowed again for the first time in decades (van Wilgen 1999). The clearing of a dense stand of pines and wattles from 500 m of river bank in Mpumalanga Province, for example, soon resulted in a 120-percent increase in stream flow. Removing pines for 30 m on either side of a stream (just 10 percent of the catchment) in the Western Cape resulted in a 44-percent increase in stream flow a year later–more than 11,000 m^3 of water gained per cleared hectare (Scott 1999:1151-1155; Dye and Poulter 1995:27-30).

Twelve to 18 months after clearing an area, workers must eliminate alien seedlings with herbicide treatments or burning and replant the land with indigenous species. Follow-up also may require the use of biological controls such as species-specific insects and diseases from the alien plant's home country. Examples include the tiny gall wasp that prevents the long-leafed wattle from flowering and producing seeds, or leaf-feeding insect species that damage the leaves and stems of lantana, another aggressive invader. In most cases, biological methods cannot control alien plant species on their own–they cannot remove existing established stands of trees, for example–but they can provide a cost-effective means of minimizing the invaders' future spread and an alternative to herbicide applications near water.

ALLEVIATING POVERTY

Working for Water's momentum comes as much from the jobs it creates as the water that flows anew from project areas. Employment is a powerful lever for change in a country with 37 percent unemployment (in 1997) (UNEP 1999, citing South African Institute for Race Relations 1998); 50 percent of all households are classified as "poor," earning less than R353/ adult/month (May 1998). In many project areas, citizens lack reliable sources of clean water, electricity, and permanent homes. Few have the education or skills to take on available jobs, especially those in an increasingly technological labor market.

Programme workers are paid a daily wage of R22-R55–on par with local wages for similar jobs (Marais 1999). Most workers spend the day removing invasives with scythes and chain saws. Some employees trained in mountaineering start the week with a helicopter flight to parts of Mpumalanga and Western Cape provinces that are inaccessible by foot. There they clear alien vegetation from peaks and gorges, camping until a return flight home on Friday.

The Programme's social welfare benefits are expanding along with the water supply. By supporting child daycare centers, Working for Water has built a workforce that is more than 50 percent female, including many single mothers. The Programme also strives to create jobs for youths, rural residents, and the disabled. Worker training and education, provided in collaboration with government agencies, schools, and nonprofit organizations, complements hiring programs. Topics include environmental awareness and health education–from first aid, to family planning, to HIV/AIDS prevention.

TEMPERING THE TAP

While striving to restore the mountain watersheds to a state of uninvaded abundance, the Working for Water Programme serves to awaken citizens to a new appreciation of the limits of South Africa's precious water resources. A combination of incentives is spurring the adoption of conservation measures and providing Programme income.

A major impetus comes from South Africa's new Water Law, which explicitly recognizes the need to protect "the quantity, quality, and reliability of water required to maintain the ecological functions on which humans depend" (see next page). Some municipalities where Working for Water operates

(continues on p. 202)

Box 3.14 South Africa's New Water Law: Managing Water for Equity, Economic Growth, and Ecosystem Resilience

Reforming the way water is managed is central to South Africa's economic and political reconstruction. Since the democratic elections of 1994, the nation has crafted a suite of water policies, including the Water Services Act of 1997 and the National Water Act of 1998 (NWA), to redress past inefficiencies, inequities, and environmental degradation. These new policies are considered among the most progressive in the world.

Like other countries, South Africa's has crafted water-sector reforms that emphasize a decentralized approach to water management, encourage local participation in decision making, and use innovative water pricing practices (Saleth and Dinar 1999:iii). What sets South Africa's approach apart are its far-sighted and ecologically grounded commitments to manage water efficiently, while ensuring equity of access and the sustainability of the resource. These goals have required radical departures from the nation's old practices.

Protecting Ecosystem Integrity

South Africa's new water policy is based on the principle that the nation must maintain the natural ecosystems that underpin its water resources if it expects to meet its ambitious water provision goals. To this end, the NWA requires that the country maintain an environmental "reserve"—the amount of water that its freshwater ecosystems require to remain robust (NWA No. 36, Chap. 3, Parts 2 and 3). The law also encourages an integrated, watershed-based approach to water management; actions that could fall under the law's purview include modifications of land-use practices along stream corridors, the clearing of nonnative vegetation, and measures to reduce the production of pollutants.

Water Allocations to Satisfy Basic Needs

The NWA establishes a "basic needs reserve" for humans, too—an allocation of water for drinking, food preparation, and personal hygiene. This reserve, provisionally targeted at 25 l/person/day, is guaranteed as each citizen's right (DWAF 1994:15; Water Services Act No. 108). To ensure that everyone has access to the reserve, the law directs the Department of Water Affairs and Forestry (DWAF) to oversee the provision of water and sanitation across the provinces.

After a supply of water to meet basic human needs and the environmental reserve is assured, South African law requires that remaining water be allocated so that: (a) all people have equitable access to the resource for productive purposes, especially within the agricultural sector; and (b) all people have equitable access to the benefits that flow from water use, such as jobs. For example, under law, the country would seek to remedy such inequities as the distribution of irrigation water; currently, irrigation accounts for more than half the water used in South Africa, but black farmers have access to less than 10 percent. The NWA also specifies that the government can implement water charges (described below) for certain regions or groups to further the goal of equitable access.

Water as Public Property

The 1998 law makes all water public property, repealing the previous statute that assigned water rights based on property ownership (NWA No. 36, Ch.4). For example, a landowner now needs permission to make large-scale water withdrawals from water that crosses his or her property. Other regulated water uses include storing water, impeding or diverting the flow of water in a watercourse, engaging in activities that can reduce stream flows such as plantation forestry, irrigating land with waste water, or altering the banks of a watercourse.

Individuals who want to use water beyond reasonable amounts for domestic use, livestock, emergencies, and recreation must apply for temporary licenses (NWA No. 36, Chap. 4, Part 1 and Schedule 1). Water authorities grant licenses for specific uses, like irrigation, and for specific periods of time. The maximum grant of water rights is 40 years, but all licenses of any length are subject to review at least every 5 years to ensure equitable distribution in a watershed. Reviews are conducted to maintain water quality, to redress situations where water has been over-allocated, or to address situations in which socioeconomic demands have changed. Licenses can be traded or auctioned.

New Governance Structures

The scope for local participation in water management in South Africa has been vastly broadened while the capacity to coherently plan and integrate water management at national and watershed levels has been retained.

At the national level, DWAF is charged with establishing the details of the national water strategy, making decisions about water transfers among watersheds, meeting the terms of international agreements in shared river basins, and determining water quality standards. But the responsibility for actually allocating water to users within an individual watershed rests with local "Catchment Management Agencies" (CMAs) (NWA No. 36, Chap. 7, Part 1). The CMAs and other institutions are expected to operate with broad participation from all interested parties—for example, they must make all applications for water licenses public and judge all water users' responses.

It is also worth noting that South Africa's water laws are among the first in the world to grant water rights to a person who farms a given piece of land, whether the person is the formal owner or merely the user of the plot. This arrangement is substantial help to holders of communal land (International Water Management Institute 1999:8).

Water Fees for Equity and Efficiency

The NWA relies on water fees as the main tool for financing the provision of water and encouraging efficient use (NWA No. 98, Chap. 5, Part 1). The law requires the DWAF to develop water pricing strategies and gives the agency considerable discretion in varying water prices by location, depending on circumstances. For example, the agency can apply a given water charge on a national or regional basis, or simply within a specific water management area. The DWAF can use three types of water fees:

- A charge to cover the full financial costs of providing access to water, including the costs of developing, operating, and maintaining the water infrastructure.
- A watershed management charge, which can apply to the use of rivers and other water bodies for waste disposal as well as to water consumption. Funds generated can be used to support water management, conservation, and research.
- A resource conservation charge that can be applied where a particular water use significantly affects others in the watershed. These charges are intended to reflect the scarcity value of water in a water-stressed area.

Implementation Challenges

South Africa's water reforms are lauded internationally, and people across South Africa recognize the merits of the changes outlined in the new water policies. Nevertheless, implementing the new policies is challenging. Weak management and inadequate training have plagued many water delivery projects in the past 5 years, and some communities have resisted paying the new water charges. These early experiences demonstrate that, no matter how lofty the goals, instituting profound changes in the management of a resource as basic as water takes time, both to build support among the wide array of water users and to build the capacity and professionalism of local water institutions.

An equally great challenge posed by the new water policies is the need for the South African government to take a multidisciplinary approach to water management issues. Hydrological and engineering considerations—for decades, the water department's focus—now are merely pieces of a larger management framework that gives equal consideration to economic, social, and ecosystem issues.

use water conservation campaigns to help implement that law. Prepaid meters encourage citizens to pace their water use and "save" water. Citizens use "grey water" (wastewater) in the garden, water-efficient toilets, and low-flow showerheads. They refrain from irrigation between 11 a.m. and 2 p.m., when 60 percent of the water applied evaporates.

Another conservation incentive is an increase in what had been some of the cheapest water prices in the world. Sliding scales for household water use make the first 5 m^3 of water just R0.007 each, but each additional cubic meter has a higher price–as much as R0.14/kl for use of more than 60 kl/household/month (van Wilgen 2000).

The results are striking. In Hermanus, for example, water use decreased by 25 percent, while revenue from the sale of water increased by 20 percent, helping to fund a local Working for Water project. Conservation measures have allowed Hermanus can delay building expensive additional water supply capacity–like a new dam (Working for Water 1998:17).

CALCULATING THE BOTTOM LINE

Currently, Working for Water is spending R200–R250 million/year, mainly on worker wages. Financial support comes principally from the government's Reconstruction and Development Programme and Poverty Relief funds, and about 40 percent from water tariffs (van Wilgen 1999). Substantial training, materials, and staff for the social welfare programs are provided by many partner agencies. In Walker Bay near Hermanus, landowners are paying half the clearing costs and the full maintenance costs. In Cwili-Kei Mouth/Komga on the Eastern Cape, farmers are paying 60 percent of the cost to clear their land (Marais 2000; Working for Water 1998:17). Programme leaders hope to replicate these models.

Yet at current rates of work and efficiency, the plants are still spreading faster than the Programme is removing them. Assuming an alien expansion rate of 5 percent/year, watershed restoration and plant control will require about 20 years of work–an annual investment of about R600 million. That's a total cost of about R5.4 billion, plus long-term maintenance of about R30 million/year (Versveld et al. 1998:iv–vi).

Still, put in the context of other water supply options, plant-clearing programs and watershed protection may be the best buy. One study suggests that the additional water generated by clearing aliens from catchments in the Western Cape would cost just over R0.06/m^3. By comparison, it would cost, per cubic meter, R5.70 to secure water from the best dam option in the Western Cape, R1.50 for treating sewage water, and R4.80 cents for desalination (van Wilgen et al. 1997:409; van Wilgen 2000). The studies also showed that early investment in clearing is financially prudent. The spatial cover of invasives in fynbos regions appears to spread and intensify from light to dense within four to six fire cycles (50–80 years). To clear lightly infested areas costs about R825/ha compared to R5,875/ha to clear a densely invaded area (Versveld et al. 1998:vi).

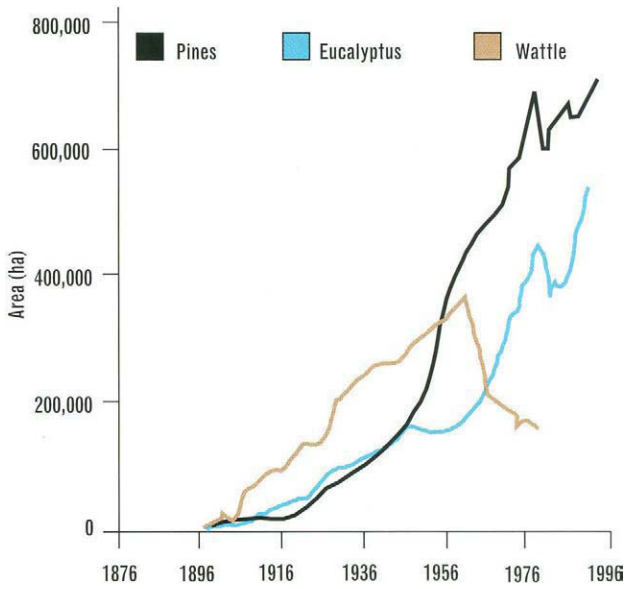
WINNERS AND LOSERS

Not only does the government face steep plant-clearing and weed-control costs, so do private companies and landowners. Many of the species targeted as "pests" sustain one of the country's fastest growing economic sectors: plantation forestry contributes 2 percent to South Africa's GDP, about R1.8 billion/year; and products from pines, eucalyptus, and wattles contribute another R10 billion/year. Yet forestry is a major source of invaders. Thirty-eight percent of South Africa's invaded areas are occupied by nonnative species used in commercial forestry, and nearly 80 percent of invasive pines occur within 30 km of plantation forestry (Nel et al. 1999:i,1,19). Many rural landowners are reluctant to finance the restoration of invaded areas for which they are responsible–areas where species like wattle and eucalyptus have escaped from intended use on farms as windbreaks, shade trees, and wood lots. Plant nurseries, too, have been targeted for tighter regulations on sales of invasive plants.

Private landowners and Working for Water have found some common ground. Working for Water proponents do not propose banning the use of invasives on plantations, and many landowners are eager to control weeds like lantana, bugweed, and chromolaena, which obstruct plantation operations and increase the fire hazard. The forest industry has committed to a code of conduct that requires riparian zones and nonafforested areas in their estates to be kept clear of alien plants. Some forestry companies have helped plant-control efforts by clearing weeds and commercial species from riverine areas or assisting with planning, mapping, vehicle donations, and worker training.

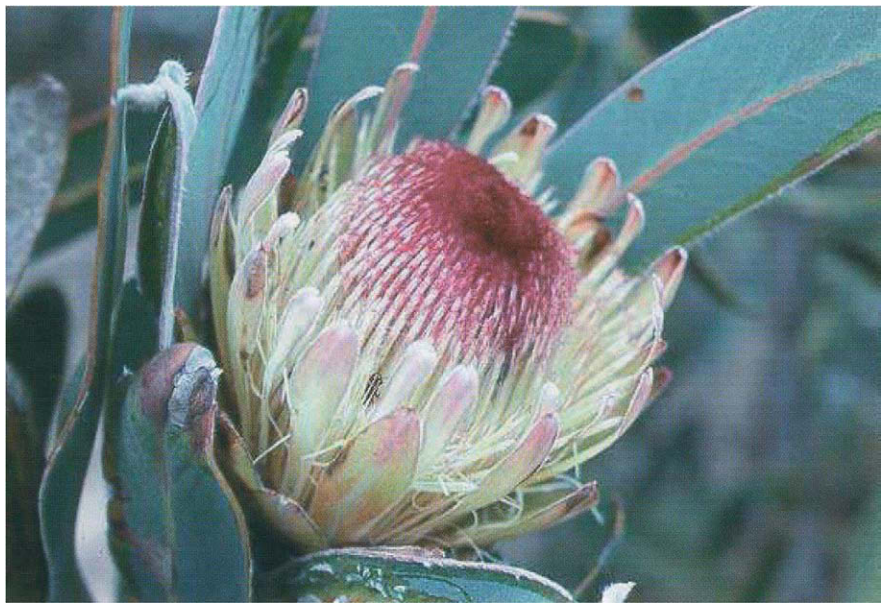
But broader consensus on the financial responsibility of the forest companies and the thousands of small independent farmers for clearing and controlling invasives is elusive. Not all agree

The Expansion of Forestry over the Past Century



Source: Nel et al. 1999: 20.

Box 3.15 Valuing a Fynbos Ecosystem



The ability to estimate the value of South Africa's ecosystems with and without invasives has proved key to securing support for clearing programs. For example, a 1997 analysis valued a hypothetical 4-km^2 fynbos mountain ecosystem at R19 million with no management of alien plants and at R300 million with effective management of alien plants. The analysis was based on the value of just six major goods and services provided by the ecosystem: water production, wildflower harvest, hiker and ecotourist visitation, endemic species, and genetic storage (Higgins et al. 1997:165). The authors also determined that the cost of clearing alien plants was just 0.6–5 percent of the value of mountain fynbos ecosystems. That may be a very conservative estimate, given the extraordinary species richness and endemism in South Africa's eight biomes and the fact that invading plants threaten to eliminate about 1,900 species (van Wilgen and van Wyk 1999, citing Hilton-Taylor 1996).

In fact, South Africa's biodiversity is perhaps the strongest long-term justification for limiting the extent of invasives, but the most difficult ecosystem service to value. It is possible, for example, to estimate a "market worth" for fynbos plants when developed as food and medicines or horticultural crops. However, it is more difficult to put a value on a species like the Cape Sugarbird, whose habitat is endangered by invasions in the Western Cape, or the oribi antelope, threatened by invaders that disrupt grasslands habitats.

Benefits and Costs Associated with the Black Wattle *(Acacia mearnsii)* in South Africa

The black wattle, an aggressive invader, provides significant commercial benefits and is an important resource for rural communities. But one recent analysis suggests that its costs may be more than twice as high as its benefits.

Wattle Benefits	Net 1998 Value (R6 = US$1)	Wattle Costs and Negative Impacts	Net 1998 Value (R6 = US$1)
Timber and other commercial wood by-products, including tannins, pulp, woodchips	$363 million	Reduction of surface streamflow estimated at 577 million cm^3 of water annually	$1,425 million
Firewood	$143 million	Loss of biodiversity	Unknown, but believed to be significant
Building materials	$22 million	Increases in the fire hazard	$1 million
Carbon sequestration	$24 million	Increase in erosion	Unknown
Nitrogen fixation	Unknown	Destabilization of river banks	Unknown
Medicinal products	Unknown	Loss of recreation opportunities and aesthetic costs	Unknown
Combating erosion	Unknown		
Total	>$552 million		>$1,426 million

Source: de Wit et al. Forthcoming.

with proponents of Working for Water who advocate more clearing near and downstream from plantations and fines for illegal plantings within 20–30 m of riparian zones. Plus, the Programme advocates a polluter-pays approach to seed pollution, which would hold those who use invasives responsible for the costs if the plants spread. Private landowners question the practicality of trying to measure seed pollution. They fear being blamed for impacts caused by others, including the backlog of removal to be done in riverine areas–at least some of which were likely infested by the government before plantation forestry was privatized. Unless these disputes are overcome and the stakeholders work cooperatively, Working for Water's efforts will be crippled.

Foresters also oppose Working for Water's advocacy of water tariffs on "stream flow reduction activities"–effectively, a tax on the water consumed by their trees to help fund the clearing of alien-infested catchments. These tariffs will force the forest industry to come to grips with a system in which water is no longer a free service; the industry fears that such water controls will inhibit its global competitiveness. Singling out the forest industry for user fees complicates the dispute. Sectors like agriculture and mining pump more water from rivers than forestry but are not likely to be charged for several years. Detailed knowledge of their impact on water use lags far behind that of forestry, making it difficult to issue permits and bills.

Working for Water also poses problems for the many rural communities that depend on invasive plants for firewood, shelter, and food such as honey, prickly pears, and guava. So far, the Programme has avoided clearing where invasive plants are a major fuel source for impoverished communities, or has sold or donated felled species as firewood, charcoal, or barbecue wood. Eventually, though, it may be necessary to develop locally managed woodlots of species with minimum invasive potential or of fast-growing indigenous species.

The Programme's Future

Securing the buy-in and support of landowners is only one of a gamut of daunting obstacles faced by Working for Water. Living up to its promise of creating empowerment and alleviating poverty for local communities may prove harder than plant removal. The scope for employment in catchment clearing is massive if Programme funding is sustained, but it is less clear whether the Programme can provide meaningful and sustainable livelihoods for a significant number of people.

Success may depend on the Programme's ambitious aim of shifting many of the 92 percent of its participants who currently remove plants into higher-paying, permanent jobs in fire management, ecotourism, and "secondary" industries (Fynbos Working for Water Allied Industries 1998:4). Secondary industries are businesses that turn cleared invasives into profitable products like firewood, treated processed timbers, and crafts. Through a partnership between the Green Charcoal Company and Working for Water, for example, a factory is manufacturing charcoal processed from harvests of invasive alien trees. This partnership lowers the Programme's clearing costs and simplifies follow-up treatment of the cleared areas by removing the felled wood. In Mpumalanga Province, the Programme is producing wood chips that can be mixed with cement to create panels for inexpensive, insulated home construction. A possible partner is the Homeless People's Federation, a network of savings and credit collectives that help disadvantaged citizens secure loans to build homes or start businesses. Perhaps the most poignant example of the secondary industry concept is the mills that Working for Water is building to produce, from invasive biomass, low-cost coffins. There is no shortage of buyers. The devastating spread of HIV/AIDS in South Africa has forced thousands of impoverished families to spend precious funds to bury relatives in expensive coffins.

But running a successful secondary industry requires management and business acumen and a labor force with solid technical skills. That is one reason why Working for Water seeks to sign contracts with established businesses–to gain managerial, marketing, and product development experience for workers and establish outlets for the felled wood or finished products. Programme workers also gain critically needed training. An assessment of Working for Water found that about 70 percent of laborers lack the skills for furniture building, saw-milling, industrial woodworking, or ecotourism (Fynbos Working for Water Allied Industries 1998:8). That relegates the bulk of untrained laborers to lower-paying firewood, bark, and chip industries.

The management deficit identified in the secondary industries also hinders Working for Water as a whole. The idea and vision for the Programme were implemented quickly by Programme founders eager to begin "doing" rather than "planning." The rapid Programme expansion appears to have short-changed worker training. Thirty-six percent of the Western Cape projects reported problems, such as removal of the wrong species, use of the wrong extraction methods, or failure to carry out the required follow-up prescriptions (Raddock 1999). Some projects are led by managers who lack experience, training, mentoring, and supervisory skills. Worker productivity flags under the daily-pay system, and poor management exacerbates the problem.

To improve quality control and productivity, Working for Water is shifting from the daily wage to a contract system. The best workers are promoted to "contractors" who identify people with initiative and form a labor team. After training, the contractors can bid on plant removal and restoration jobs that fall under the auspices of the Programme and can contract with private industries to clear invasives from railway and utility easements or other large land holdings. In test contract system areas, productivity is up 30–50 percent, and in some places more than 65 percent of the clearing is achieved by self-employed teams (Marais 1999; Botha 1999).

Fynbos vegetation is a shrubland characterized by a mixture of three main growth forms: proteoids, ericoids, and restioids.

The environmental goals of the Programme present challenges as well. Some allege that Working for Water is too politically driven, leading to an emphasis on labor initiatives rather than research, monitoring, and conservation practices such as careful rehabilitation of cleared areas. The return of a full complement of ecosystem services in cleared areas mandates that topsoil be replaced followed by mulching and plantings of indigenous vegetation to prevent soil erosion; that nutrient cycling be initiated; and that the provision of a clean water supply be promoted. If felled trees are not removed, wildfires can burn very hot (invaded grassland and shrubland sites have 10 times more fuel than non-invaded ecosystems), killing indigenous seed banks and causing soil to become water repellent. In subsequent rainfalls, sheet and gully erosion may result. Prevention of further invasions through careful management of primary infestation routes and sources–roads, railways, rivers, and actions of private landowners–requires more attention, too.

Programme success also depends on overcoming financial problems. Until the government's recent commitment to provide funding in 3-year cycles, varying levels of income meant labor contracts could be as short as 1 month. Also, the timing of cash flows does not always correspond with optimal seasonal work plans. For example, the ideal time to cut wattles is in the winter when cold temperatures would help kill trees, but funding has sometimes only been available in the summer when regrowth is strongest. Another problem is that sudden infusions of cash from the Poverty Relief Fund might necessitate surges in hiring and clearing efforts without adequate management.

A Complex Fabric of Solutions

Without its tangible social welfare benefits, few democratic governments would embrace an investment of public resources on the scale of the Working for Water Programme. In a country with poverty as widespread as in South Africa, it would be hard to convince public leaders that limiting the spread of alien plants–even with compelling evidence that biodiversity or water is at risk–outweighs the need to provide a living wage.

But Working for Water relates ecosystem protection to local residents' lives, viewing social context not as a static background but as a promising avenue for ecosystem restoration. Rather than cordoning off one problem from another, the Programme weaves a solution around all of them. A surplus of unemployed citizens is tailored into a resource, not a drawback. Felled wood is an input, an opportunity for entrepreneurs, and a source of Programme funding, not waste. Clearing trees in a community offers a chance to provide education programs.

Many hands weave Working for Water's complex fabric of solutions. The Programme benefits immeasurably from a savvy public relations campaign and the support of myriad government agencies. Programme promoters have garnered international recognition and R23 million in foreign aid (Gelderblom 2000). Programme managers capitalize on marketing opportunities, such as outfitting workers in bright-colored T-shirts printed with the Programme logo and the names of financial sponsors. Partnerships with government agencies, nonprofit organizations, and the private sector yield management advice, research, ideas, and staff and materials. Perhaps most important, the tacit buy-in of those many partners has transformed Working for Water from an idea to a multimillion-dollar project in just 5 years. The high levels of recognition that the Programme has gained among national and international publics and policy makers also offers insurance against cutbacks in tough budgetary times.

Whether Working for Water can grapple comprehensively and cogently with invasive plants, water conservation, poverty, and even worker health remains to be seen. There is the strong possibility that the Programme will fall short of its goals. Controlling invasives completely may not be possible, but partial success will still warrant acclaim. Even if invasives' spread continues to outpace Working for Water's efforts, the Programme's expenditures have already translated into more water. The Programme's social welfare strategies have brought about greater public understanding of the value of ecosystem services, better health education, and worker skills training. These investments cannot be lost.

Persistence is critical to what must be an ongoing process of watershed restoration and biodiversity protection in South Africa. Sustaining the necessary public and political interest, sufficient to ensure millions in annual funding, is no small task. But the need for water–mandated for all by law and essential for economic growth–plus the need for jobs may be the ultimate insurance that the Working for Water Programme will succeed.

Managing the Mekong River: Will a Regional Approach Work?

The Mekong River represents a last chance of sorts–the last chance to tap a large, relatively pristine river basin's potential to supply energy and water without destroying its environmental integrity. The Mekong is the world's 12th longest river, stretching 4,880 km from its source on the Tibetan plateau to its outlet on the coast of Vietnam. It is the 8th largest river in terms of annual runoff and perhaps the world's least exploited major waterway in terms of dams and water diversions. But the Mekong's 795,000 km^2 watershed includes six of Southeast Asia's richest and poorest nations–Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam. All these governments are eager to promote economic development using the Mekong's water resources (MRC 1997:14-15).

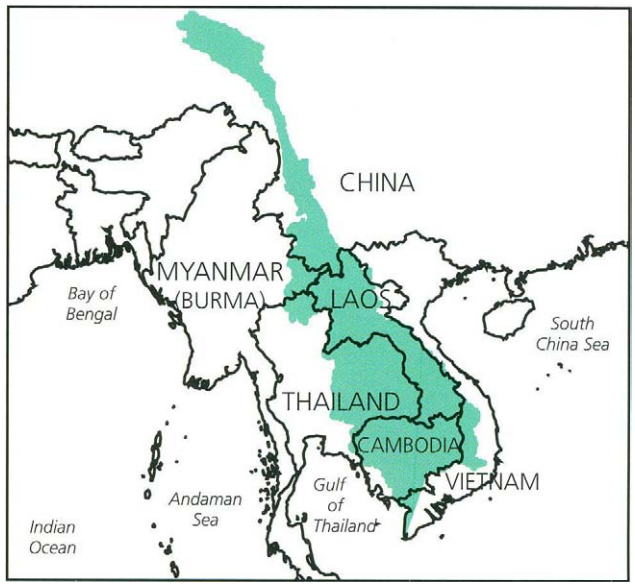
The drive to dam and divert the Mekong threatens the traditional uses of the river–as a source of fish and a barrier to salt water penetration into the rich Mekong delta soils. Ideally, a new model of coordinated regional water management will preserve those benefits while sharing new ones. The Mekong River Commission (MRC), originally known as the Mekong Committee, was established among the basin countries in 1957 to address potential conflict over hydropower development. The MRC provides a vehicle for joint management of the river and for the coordination of development strategies for the lower Mekong basin. In 1995, after almost 4 decades of political turmoil had hampered the Commission's effectiveness, the basin countries reaffirmed their interest in working together. Cambodia, Lao PDR, Thailand, and Vietnam signed the Agreement on Cooperation for the Sustainable Development of the Mekong River basin, which acknowledges the need for regional action. China and Myanmar have observer status.

Yet the MRC lacks any real power to develop or enforce a unified vision of sustainable water use in the basin, and each of the riparian countries is pursuing its ambitious development plans largely independently at this time. Can a truly regional approach to Mekong management evolve in time to influence the basin's environmental future?

Damming the Mekong

The Mekong River and its tributaries have a potential hydroelectricity generating capacity of 30,000–58,000 MW (MRC 1997:5-19). Although plans to construct major hydroelectric dams have been afoot for years, as of 1997 less than 5 percent of this potential had been exploited.

Now, however, scores of large dams are under serious consideration in response to both the growing regional demand



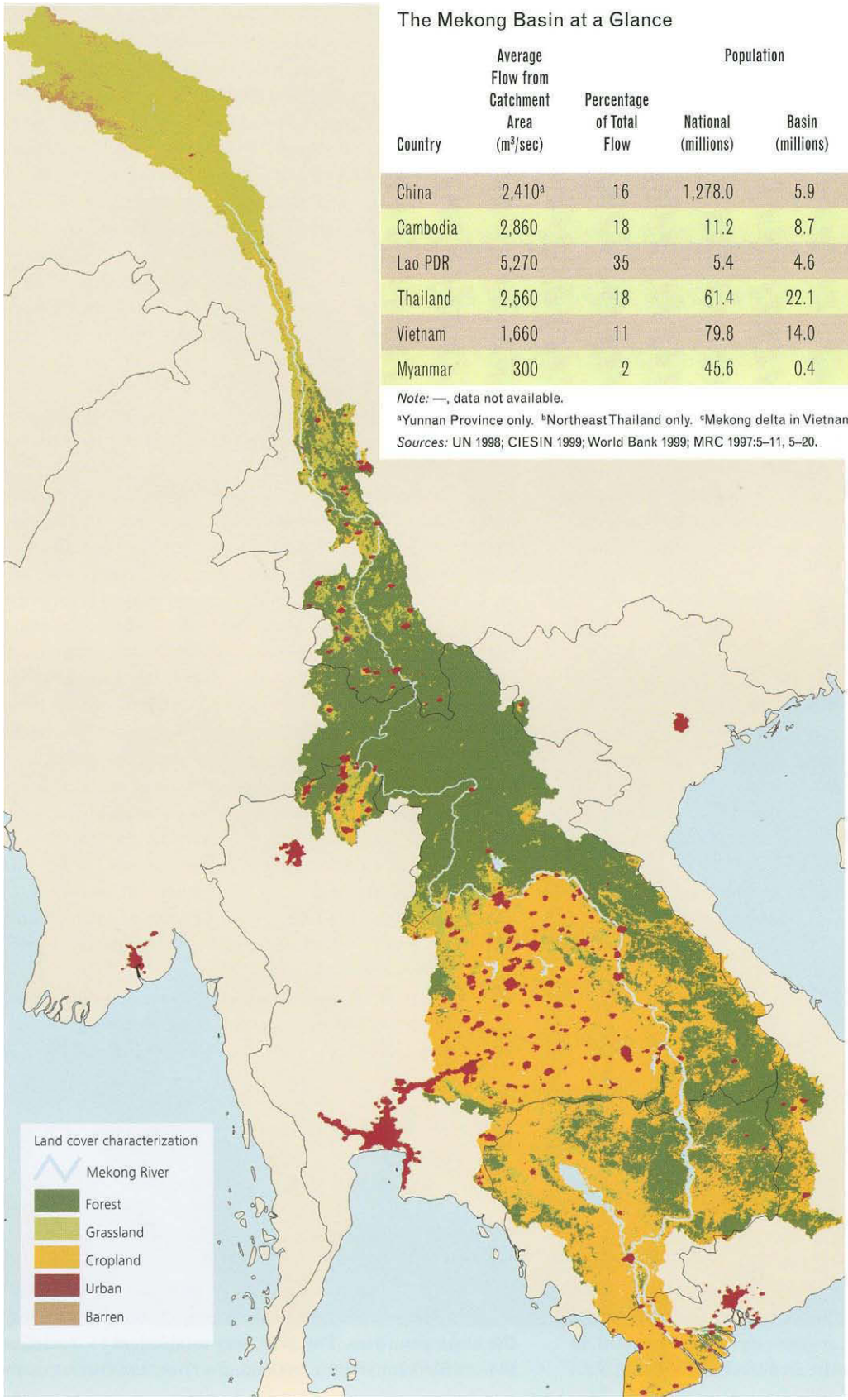
for electricity and the desire of the nations in the basin to earn foreign exchange from international sales of hydropower. The financial crisis that erupted in Asia in 1997 shook Thailand's economy particularly hard, slowing electricity consumption and delaying power purchase agreements and dam start-ups, but energy demand is expected to pick up again quickly as the recession recedes (EIA 1999). By 2020, electricity demand in the Mekong region could be six times greater than in 1993 (MRC 1997:5-9).

Hydropower potential varies greatly among the riparian nations. Highland countries like China and Lao PDR possess the greatest share, while countries like Vietnam and Cambodia–along the slower-moving, lower reaches of the Mekong–possess relatively little. Currently, major pressures on the Mekong include:

- China's Yunnan province at the top of the watershed is planning a cascade of up to 14 dams on the upper Mekong–known locally as the Lancang River. These dams would have a total installed capacity of 7,700 MW, equivalent to 20 percent of China's current energy consumption. Because of Yunnan's remoteness from China's more developed areas and the chance to earn export dollars, Yunnan authorities are likely to export electricity to Thailand. China has also proposed plans to divert water from the Mekong into the Yellow River to meet Northeast China's growing demand for water.

- Many of the tributaries feeding the Mekong in Thailand have already been dammed to provide power and irrigation water to its arid eastern provinces. However, Thailand has

Box 3.16 How the Mekong's Hydropower Resources Are Divided



The Mekong Basin at a Glance

Country	Average Flow from Catchment Area (m^3/sec)	Percentage of Total Flow	Population: National (millions)	Population: Basin (millions)	GDP ($ billions)	Consumption: Electricity (KWh/ person/yr)	Consumption: Fish (kg/ person/yr)
China	2,410[a]	16	1,278.0	5.9	902.0	260[a]	—
Cambodia	2,860	18	11.2	8.7	3.0	55	13
Lao PDR	5,270	35	5.4	4.6	1.8	55	7
Thailand	2,560	18	61.4	22.1	153.9	900	15–27[b]
Vietnam	1,660	11	79.8	14.0	24.8	140	21–30[c]
Myanmar	300	2	45.6	0.4	—	60	—

Note: —, data not available.

[a]Yunnan Province only. [b]Northeast Thailand only. [c]Mekong delta in Vietnam only.

Sources: UN 1998; CIESIN 1999; World Bank 1999; MRC 1997:5–11, 5–20.

long-standing plans to divert water from the Mekong into the water-scarce Chao Phyra River, the main source of water for Thailand's economic heartland.

- One-third of the total flow of the Mekong originates in Lao PDR. Given its abundant rainfall and rugged topography, estimates of the country's hydropower potential reach 7,000 MW, of which only a fraction is currently exploited. Laos has prepared plans to construct as many as 17 new dams during the next decade to reduce the country's poverty. Most of the hydroelectricity will be sold to Thailand and Vietnam. Thailand already buys electricity from Lao PDR's Nam Ngum dam and is negotiating to buy power from the planned Nam Theun II dam.

Not all the proposed projects will be developed, however. Only a handful are both technically feasible and economically viable, and public and NGO outcry against some–like Nam Theun II–may stall construction. For those hydropower plans that do hold economic promise, the private sector stands ready to invest. Often the funding comes through "build-own-operate-transfer" (BOOT) projects, in which foreign investors finance, construct, and operate a dam, recouping their investment and sharing risk during a concession period, then transfer ownership of the project to the government.

Vulnerability Downstream

Although dams and diversion projects dominate the official development discourse, the Mekong has long provided many other environmental benefits to the basin's 55 million inhabitants. Approximately 30 percent of households in the Mekong delta are below the poverty line and most of the rural population depends on the river and its tributaries for their survival (MRC 1997:4-6).

For example, the fish caught in the Mekong are the source of 40–60 percent of the animal protein consumed by the population of the lower basin, and fish sustain an even higher percentage of people in much of Cambodia (Institute for Development Anthropology 1998:87-88). The 900,000 tons of fish harvested annually (Friederich 2000) and the Mekong's extraordinary fish species richness are threatened by dams, which interfere with spawning cycles by preventing fish migrations.

Dams also reduce the seasonal floods that sustain fish spawning and nursery grounds in the wetlands upstream and the delta region. The flood cycle, keyed to the monsoon rains, is a critical factor in the life cycle of many of the area's aquatic species. Even slight changes in peak flood flow could threaten the region's fish production and food security (MRC 1997:3-8). Impacts observed at dams already constructed on Mekong tributaries illustrate the area's vulnerability. At Nam Pong reservoir in Northeast Thailand, the number of fish species found in the river dropped from 75 to 55 after impoundment. Fishermen upstream of Thai dams at Tuk Thla and Kompol Tuol saw their catches decline from 5–10 kg/day to 1–2 kg/day after the dams were built (MRC 1997:5-14).

Altering the annual flood cycle, reducing the silt load of the water, or diverting the Mekong's flow could also have serious impacts on agriculture in the Mekong delta. Flood waters deposit 1–3 cm of fertile silt each year on the lowland floodplains in Vietnam and Cambodia, sustaining these intensively farmed areas (MRC 1997:2-17). In addition, river flows during the dry season are important for controlling salinity penetration into interior areas from the coast. According to the Vietnam Water Resources Sector Review, seawater penetrates up to 70 km inland during the dry season. If current trends in water abstraction in the delta continue, the area affected by salinity could increase from 1.7 to 2.2 Mha (Xie 1995:10). Increased salinity was cited as the primary cause of rice yield declines of 50–90 percent in Tra Vinh province over the last 30 years (Nguyen 1998:4).

The dangers that dams could pose to the biodiversity of the Mekong must also be considered in the context of the environmental degradation that the region has already suffered. A combination of deforestation, increasing conversion to intensive, chemical-dependent agriculture, continued population growth, and mangrove clearance for shrimp aquaculture in the delta region has compromised the basin's environmental health. Vietnam, for example, has already lost approximately 85–90 percent of its forest cover, largely because of decades of war and reconstruction. In Thailand, perhaps 55–65 percent of forests has been cleared for agriculture and tree plantations (WCMC 1994:106-107). Some of the highest rates of deforestation in the world continue to plague the riparian countries (FAO 1999:132). Many remaining forests are of poor quality, affecting water retention in the basin and promoting land degradation and soil loss in the uplands (MRC 1997:3-5). Disrupting flood cycles or decreasing base flows during dry times through water diversions could add significantly to these existing stresses.

Furthermore, where will countries resettle the thousands of people who will be displaced by dams? Just the nine proposed mainstream dam projects could displace 60,000 people (MRC 1997: 5-24).

Conflict Brewing?

With all its mighty waters, the Mekong ecosystem is finite and fragile. The array of current demands and future plans for the river has already led to increasing competition among the basin countries. The MRC was established to minimize the conflicts inherent in managing a river that crosses many

international borders, but its efforts at regional coordination have been largely unsuccessful (China Environment Series 1998). Although it collects hydrological data from the basin, the MRC has done little to analyze the data, promote debate among the partners on the cumulative effects of their water developments, or craft a common vision of how water should be shared. As a result, the governments of Cambodia, Vietnam, Lao PDR, and Thailand are competing for international funding for their dam-building projects and have "... adopted a rhetoric of cooperation and sustainable development to mask underlying conflicts and competition" (China Environment Series 1998).

Complicating the equation is the fact that China is not a member of the MRC, although it controls the upper reaches of the river and has an ambitious dam-building program in place. China is reluctant to join the MRC until water-use rules are clarified and it is assured that restrictions on dam building and water diversions will not interfere with its upper Mekong development plans. The agreement specifies that the watershed nations have neither the right to veto the use nor the unilateral right to use the water of the Mekong. This implies that dam construction on the river's mainstream would only proceed by consensus, a system unacceptable to China.

In reality, compromise will be difficult for all the basin countries, whose negotiating powers vary greatly as a function of their location within the river basin and their wealth. Based on the size of its economy, China has by far the greatest capacity to mobilize funding and technology to exploit its "share" of the Mekong. Because its portion of the river runs through sparsely populated territory, China also has a relatively small population that depends on the river for irrigation and fish production. China, therefore, has much to gain and little to lose from dam construction. Cambodia and Vietnam, on the other hand, are extremely vulnerable because of their downstream location, relative poverty, and the large number of people that depend directly on the Mekong for their livelihoods. Lao PDR, one of the poorest nations in the world, is desperate to develop its hydropower resources to spur economic growth. Thailand is in an intermediate position. It has the largest within-basin population among the riparian countries, but has the economic and human resources to withstand potentially negative changes in the river upstream.

A Regional Vision

Despite the current imbalance of power among the riparian countries and the potential for conflict, the benefits of a regional approach are compelling. Development of a regional electricity transmission grid, for example, would benefit from a coordinated plan to develop the basin's hydropower potential. A regional grid would facilitate China's ability to market hydropower to other energy users in the region, offering advantages all around. In addition, a regional growth plan that helps expand the economies of the lower Mekong basin countries and promotes open markets in the region provides a longer-term inducement for Thailand and China to cooperate.

A basin-wide approach to water management would also offer clear environmental advantages. It would, by definition, force the riparian countries to examine how dams on the upper reaches of the river would affect flow conditions downstream. Currently, upstream countries can pursue water withdrawals and hydropower production while ignoring repercussons such as salt water intrusion, decreased catches for subsistence fishing, and soil depletion.

Since the governments in the region unanimously favor developing the region's hydropower potential, a regional approach to water management would not necessarily mean less power generation, but it would offer a chance to distinguish between environmentally "good" dams and "bad" dams. The challenge is to select dams that meet strict environmental and economic standards. Some have argued, for instance, that dams on the Lancang and in the uplands of Lao PDR are "good" because they generate a lot of power without displacing many people and flooding large areas. Thus, the social and environmental costs are relatively small. It is also possible that dams could actually benefit the local environment in some ways. Planners of Lao PDR's Nam Theun II dam have proposed earmarking a portion of the hydropower revenue for forest conservation in the surrounding watershed. Protecting forests around dams is desirable because it reduces sedimentation, lowers maintenance costs, and prolongs dam life.

But capitalizing on the benefits of a regional approach to water development and use in the Mekong region will take quick action, given the rapid changes under way. Water experts warn that now is the time to rethink basin-wide water management, not after the dams and diversion schemes have been built and the environmental and geopolitical repercussions are felt.

The MRC has a critical role to play in promoting regional cooperation. It has been criticized for failing to seriously address the potential negative environmental impacts of proposed dams and diversion schemes, and it has failed to build the predictive modeling capacity that is needed to assess the trade-offs between river basin development options. But the MRC reaffirmed its commitment to environmental analysis and assessment in 1995 and to serving as a regional information center on environment and development in the Mekong River basin. These developments could help basin nations to better visualize the benefits of a regional approach to managing the Mekong watershed and to quantify the damage–environmental and social–that may occur if they pursue an uncoordinated approach.

New York City's Watershed Protection Plan

To safeguard the city's drinking water, in 1997 New York City chose to launch an ambitious environmental protection plan, rather than build an expensive water filtration plant. By protecting its watershed the city would employ nature's ability to purify water while preserving open space and saving money. But as this widely heralded example of watershed protection is implemented, many question whether it will, in fact, deliver all that it promises.

For more than a century, New York City residents have enjoyed drinking water of such purity that it has been dubbed "the champagne of tap water." That water–about 1.3 billion gallons per day–flows from an upstate watershed that encompasses 1,970 mi^2 and three reservoir systems: the Croton, Catskill, and Delaware (NRC 1999:3, 17). Until relatively recently, undisturbed soil, trees, and wetlands provided natural filtration as the water traveled through the Catskill Mountains and the Hudson River Valley before reaching 9 million residents of the city and its suburbs. The only regular treatment needed was standard chlorination to control waterborne diseases such as cholera and typhoid.

But in the last several decades, development has brought increasing numbers of people and pollutants to the watershed, straining the land's buffering and filtering capacities. More than 30,000 on-site sewage treatment and disposal systems and 41 centralized wastewater treatment plants discharge wastewater into the upstate watersheds (NRC 1999:358). Runoff from roads, dairy farms, lawns, and golf courses contains fertilizers, herbicides, pesticides, motor oils, and road salts.

The need to attend to the development-pressured upstate watershed became clear in 1990. The U.S. Environmental Protection Agency (EPA) put New York City on notice: protect the source for the Catskill and Delaware reservoirs–the watershed, nature's own treatment plant–or construct and operate a water filtration system. Filtration would cost $3–$8 billion, according to various estimates, potentially doubling the average family residential water bill (Ryan 1998). By comparison, the City determined that the price tag for watershed protection would be just $1.5 billion, increasing the average water bill of a New York City resident by about 1–2 percent, or $7 per year (Revkin 1995, State of New York 1998).

The EPA's warning was compelled by the 1989 Surface Water Treatment Rule, which requires that surface water supplies for public water systems be filtered unless stringent public health criteria are met and extensive watershed protection strategies minimize risks to the water supply. The rising levels of bacteria and nutrients in the watershed, plus the risks posed by antiquated sewage treatment plants and failing septic systems, put New York City's Catskill and Delaware supplies in danger of violating the Rule. The Croton supplies

east of the Hudson River were in bigger trouble already: because of that area's greater pollution pressures, filtration was mandated. Even though the Croton system supplies just 10 percent of the City's water, compared to the 90 percent that flows from the Delaware and Catskill systems, the cost to build and maintain that plant is still expected to be at least $700 million (Gratz 1999).

The cost savings from protecting the Delaware and Catskill supplies were clear, but crafting and implementing a major ecosystem protection plan is no small undertaking. Nationwide, less than 2 percent of municipalities whose drinking water systems are supplied by surface water have demonstrated to the EPA that they can avoid filtration by instituting aggressive watershed protection programs (Gratz 1999). The vast majority are far smaller than New York, less populated, and own substantially more of the critical watershed lands. When the protection agreement was crafted, New York City owned just 85,000 acres of the watershed, less than 7 percent of the total critical area, including the land beneath the reservoirs (Ryan 1998); another 20 percent was owned by the state (NRC 1999).

With so little watershed land under its direct control, but millions of water users dependent on it, New York City needed to obtain the support of upstate landowners for open-space conservation and stronger land-use protection. But from the perspective of upstate communities, watershed restrictions such as land acquisitions, limits on where roads and parking lots can be constructed, and strict standards for sewage treatment systems amounted to outsiders threatening local taxpayers' economic viability. Still, after years of

contentious negotiations, city, state, and federal officials, some environmentalists, and a coalition of upstate towns, villages, and counties forged a 1997 watershed management agreement that convinced the EPA to extend its filtration waiver until 2002.

Perhaps the most crucial element of the program is the state's approval of New York City's plan to spend $250 million to acquire and preserve land in the watershed, with priority given to water-quality sensitive areas (NRC 1999:213). A local consultation process helps protect the interests of watershed communities. Other plan elements include new watershed regulations, direct city investments in upgrades to wastewater treatment plants to minimize contamination, city funding of voluntary farmer efforts to reduce runoff, and payments to upstate communities to subsidize sound environmental development (State of New York 1998).

In addition to economic savings, the ecosystem protection program offers some additional advantages that filtration cannot. It lowers health risks that are present even with filtration–for example, the risk that a sewage plant will malfunction or an incidence of the disinfectant-resistant pathogen *Cryptosporidium* will occur. Land acquisition and development controls also mean more land for parks, recreation, and wildlife habitat.

Ownership of Critical Watersheds

Only a handful of major U.S. cities have unfiltered water supply systems—mostly those that can ensure long-term water protection because significant portions of the critical watershed lands are owned by the water utility or are designated as protected open space under state or federal ownership and management. New York City is an exception—and accordingly, it must rely heavily on the cooperation of private upstate landowners to help protect its drinking water.

City	Ownership (percent) Public	Private	Watershed Area (acres)	Population Served (millions)
Seattle, WA	100	0	103,885	1.2
Portland, OR	100	0	65,280	0.8
New York, NY	26	74	1,279,995	9.0
Boston, MA	52	48	228,100	2.4
San Francisco, CA	100	0	475,000[a]	2.3

[a]Supplies 85 percent of the city's water; 15 percent is filtered and comes from other publicly owned watersheds.

Sources: NRC 1999; personal communications.

But whether this dramatic effort will prove to be a bargain remains to be seen. Among the unknowns are the effectiveness of voluntary pollution protection commitments by farmers, and still-evolving knowledge of best management practices to control roadway, lawn, farm, and other runoff. Environmental organizations are concerned that the negotiated settlement contains serious loopholes in the watershed rules and land-buying requirements. For example, the agreement provides no limits on the number of new sewage treatment plants that can be built in the City's cleanest reservoir basins.

Nor does the agreement specify an absolute acreage requirement that the city must purchase in the watershed, only that the city must *solicit* the purchase of 350,000 acres. The City projects that this approach could lead to its acquisition of about 120,000 acres, allowing it to increase its holdings to 17 percent of the critical land area in the next 10 years (Gratz 1999). However, the City's solicitation efforts might yield far less land, since the plan relies on the cooperation of upstate residents–and even 17 percent ownership gives the City limited watershed control. Another problem is that the plan sets criteria for types of land to be acquired but no assurance that the "best" lands from the perspective of water quality will be purchased, since land is obtained on a willing buyer/seller basis. From the perspective of the Natural Resources Defense Council, the plan may allow too much development to take place on sensitive watershed lands and the scientific aspects of water management were given insufficient attention by negotiators under pressure to craft a politically acceptable plan (Izeman 1999, Revkin 1997). Other concerns include inadequate requirements for buffers–zones of vegetation where discharge of pollutants, and development, cannot take place (NRC 1999:14)–and the agreement's failure to emphasize pollution prevention as much as pollution control.

Only years of extensive water quality monitoring will prove whether the watershed protection program is sufficient to protect public health. At the moment, the water is still deemed safe to drink, but some still think filtration ultimately will be required.

Shortcomings aside, the agreement is laudable. It formally acknowledges the interests of watershed residents and stresses the need to implement watershed protection plans fairly and equitably. Elements of the New York City watershed agreement may serve as a model for other communities. There is a growing recognition that filtration, by itself, is no panacea. It can reduce the threat of waterborne pathogens, but it cannot completely eliminate the threat, especially if the source water is poor. Watershed protection offers a cost-effective approach to clean drinking water, and benefits the environment as a whole. The challenge in the case of New York City is the need to compel many people and communities to work together, putting aside self-interest, toward the twin goals of saving the watershed and saving money.