New Hope for Desert Lands

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Large as they are (Ed. note: should have been!, the work was not carried out*), these expenditures are only a part of the price which must be paid for the wasteful use and destruction of a great natural resource. Still another part of the price is the time over which the reconstruction effort must continue.*

The Western Range. Secretary of Agriculture 1936.

Dry lands and deserts all over the world are being damaged and made less productive by historic or current mismanagement. The causes include: tenure problems, over-pumping of groundwater, over-grazing; over-cutting timber and fuel wood; inappropriate farming; excessive water diversion; poor irrigation management leading to salinity or alkalinity problems; mining; transportation; pipeline and utility corridors; military operations, air pollution and the introduction of exotic animals and plants (Warren and Agnew, 1988; UNEP, 1991; Bainbridge, 1997; Lovich and Bainbridge, 1999). Although the extent of desertification is understood, the causal factors and processes are still imperfectly understood, making restoration more challenging (Grainger, 1982; Schlesinger et al., 1990). Developing environmental histories for disturbed sites can help clarify causes and symptoms, making treatment more effective (Fontana, 1976; Blaikie and Brookfield, 1987; Bainbridge, 1998).

Repairing this damage will require more extensive research, cooperation, funding, education, and demonstration (Allen, 1996; Bainbridge, 1988; Chambers et al., 1991). This immense challenge can be seen as an opportunity, as well as a crisis, particularly in the American Southwest where degradation is less often caused by pastoralists, farmers and ranchers fighting for their lives.

Dry land restoration is needed in virtually every place humans have been active past the gatherer-hunter stage (Bainbridge, 1985a; Lean and Hinrichsen, 1992). This includes most of the semi-arid and arid areas of the world, about 35% of the global land area with 15% of the World's population. In 1980, only 450 million people suffered from degraded dry lands, today they affect the daily lives of more than 850 million people and every year another 6 million hectares are completely lost to production through desertification (Lean and Hinrichsen, 1992), table 1.

Table 1. Areas affected by severe or very severe desertification (percent)

	Rangeland		Rainfed cropland		Irrigated cropland	
	Very Severe	Severe	Very Severe	Severe	Very Severe	Severe
Africa	0.4	53.3	0.7	6.5	--	1.2
Asia	0.7	44.0	1.4	8.5	1.8	6.3
Europe	1.1	46.0	0.4	14.6	0.9	3.9
Australia	4.4	8.4	<0.1	1.0	1.1	7.0
North America	2.1	59.0	0.2	1.0	1.0	3.5
South America	3.9	47.2	0.6	2.6	0.7	3.7

Source: UNEP (1991).

Globally more than 60% of the rangeland, 60% of rainfed croplands and 30% of irrigated croplands are at risk of further degradation (Lean and Hinrichsen, 1992). Poor resource use has limited the ability of dry land residents to make a living, reduced their quality of life, destroyed communities, created environmental refugees, led to conflicts over land and water, reduced health and life expectancy and severely affected natural systems and biodiversity. Degradation of dry lands in one area can affect others through increased flooding, reduced water supply and dust and sand deposition.

Sadly many of the drylands of the western United States still illustrate the effects of severe overgrazing and land mismanagement, largely from the turn of the century (Sheridan, 1981; Sabadell et al., 1982). As Costello and Turner (1941) wrote almost sixty years ago, *"The most widespread and cataclysmic change in the desert (of the United States) in modern times has resulted from unrestricted grazing... The desert in many places is one-tenth as productive for wildlife as when white men first came on the scene".*

Extreme temperatures, intense sun, high winds, limited moisture and the low fertility of desert soils limit natural recovery. Conditions suitable for plant establishment occur only infrequently and irregularly, and it may take hundreds of years for full recovery to take place without active intervention. Studies in the Mojave Desert suggest that without intervention it may take 100-200 years for reasonable recovery of species diversity on non-compacted soils (Prose and Metzger, 1985; Lovich and Bainbridge, 1999). Estimates for recovery periods in more disturbed areas reach several thousand years. Unless we are willing to wait many generations for recovery we need to actively participate in restoration.

Desertification is exacerbated by problems of uncertain or weak land tenure. A small farmer, rancher, or herder will not invest in environmental repair without secure tenure and the belief that long term benefits will accrue from current actions. Tenure problems are severe in many areas of the world where the deserts are spreading (Bruce, 1998: Burley, 1982; Chambers et al., 1991). Tenure is an issue even in the American Southwest where many of the arid and semi-arid lands are owned by the public and leased to private users. In effect this often becomes a classic problem of open access or unowned resources, where perverse economic incentives exist to misuse the land (Kahn, 1997). These problems are compounded by uncertain futures related to environmental litigation and limited lease supervision as a result of inadequate funding and political pressure.

In the last 15 years a growing recognition of the importance of financial pressure and market forces has reframed the discussion of land degradation (see for example Hallsworth,1987; Blaikie and Brookfield, 1987; Trudgill, 1991). They clearly describe the complex interactions leading to resource deterioration: they are not just physical/technical but more critically economic and social. Until the economic and cultural forces that lead to poor land management are better understood and incorporated in planning for restoration, treating the symptoms will continue to be ineffective and frustrating (Bainbridge, 1985b; Blaikie and Brookfield, 1987). The growing literature on the value of Nature's Services and Natural Capital is also helping reframe the discussion of land management (Daily, 1997; Hawken et al., 1999).

The economic and biological impacts tend to have positive feedback. As grazing reduces plant cover it increases surface soil temperatures and decreases water infiltration into the soil. The higher surface temperatures reduce the accumulation of organic nitrogen, which is often a limiting factor in dry land ecosystems. The reduced soil moisture and soil nitrogen lead to a decline in vegetation, which increases grazing pressure, which further reduces productivity until grazing must be abandoned. Large increases in arid lands from degradation may lead to regional changes in ecosystem function. The degradation of arid lands may also increase denitrification, adding to the problems of ozone destruction and global warming (Schlesinger et al., 1990).

The economic effects of degradation can also develop positive feedback, accelerating destruction. As grazing declines the pressure becomes greater to get more benefit from the little browse remaining, this increased grazing eliminates the few remaining pockets of desirable browse. The first response is usually to switch grazing animals, from cattle to sheep. This continues the destruction of the remaining browse until only goats or camels can survive. If pressure remains high a barren gravel plain will develop.

One of the best methods for assessing the economic cost of degradation is calculating the cost of restoration, this increases rapidly with the severity of damage. For modest restoration it may be $1,000 acre, more complex and intensive restoration may cost $10, $20 or even $50,000 per acre. In most cases the cost of restoration will exceed the economic return over the history of use, but restoration can return hope and empower people (Jordan, 1990). It will always remain an important activity for protecting Nature's Services, beauty and biodiversity. Restoration also provides invaluable opportunities for testing theory and knowledge about how ecosystems function.

Restoration is possible

The good news is that research has demonstrated that despite many possibilities for failure, desert restoration is possible (Aronson et al., 1993; Cox et al., 1982; Bainbridge, 1990; Bainbridge and Virginia, 1990; Bainbridge et al., 1995; Bainbridge, 2004; Dreesen et al., 2001; Jackson et al., 1991). Both restoration and improved management are essential to reverse the process of dry land degradation and desertification. Efforts to recreate structure and function similar to an undisturbed site is commonly called ecological restoration. It is the deliberate attempt to speed recovery of damaged areas, including a wide range of possible interventions, from soil amendments, tillage, weed removal, seeding, planting, and aftercare. It ranges from practical and economic attempts to simply restore some productivity to degraded grazing lands, to the attempt to return full ecosystem function and structure in a “natural” protected ecosystem. Restoration is desirable for biological, economic, social, and aesthetic reasons, but it rarely can be justified under current economic accounting.

Successful restoration requires a multidisciplinary approach, ranging from the soil to the economic incentives of the people who manage it. It benefits from a clear understanding of environmental history, current conditions, the decision making environment, planning, and funding and undertaking project implementation, maintenance, and monitoring.

The most appropriate restoration approach for a site depends on the type of disturbance, the degree of disturbance, the causes of the disturbance, the available budget of time and labor, and the desired goals and speed of recovery desired. The effort should always include issues of both structure and function. Traditionally function has often been ignored in favor of structure--but repairing function is more important and can hasten recovery and ensure that the environment continues to improve. Restoration requires a systematic, holistic view of the interactions between humans and the environment.

For restoration to succeed everything has to be done correctly at the right time, and some supplemental water usually has to be provided for initial establishment. As investments increase the speed of recovery will increase; but even large expenditures are no guarantee of success in these extreme environments. And for lands with a value of a few hundred dollars an acre or less, restoration must be very economical.

The magnitude of the task globally can be calculated the area of land needing treatment and the cost of restoration. A modest restoration program for just 10% of the desertified rangelands of the U.S. each year would cost $36 billion, about 12% of the current budget for the Department of Defense. To treat 10% of the global rangelands each year would cost about $254 billion dollars, about 4% of the total GDP of the United States, but less than 1% of the world GNP. Contrasted with the looming war with Iraq, estimated to cost the U.S. from $100 billion to $2 trillion dollars. The countries worst affected are least able to pay, with many struggling to pay immense debt services on loans from the United States and other developed countries, many with total external debts more than 2.75 times total foreign exchange earnings. The developed countries will have to participate in the restoration work, because these high debt service requirements often drive mismanagement of resources.

Restoration planning

Active intervention is necessary in degraded arid and semi-arid areas because natural recover may take centuries to recover without active intervention and restoration (Lovich and Bainbridge, 1999). This is not surprising as establishment and succession of any kind in this severe environment is naturally slow and disturbance makes these conditions much worse (Bainbridge and Virginia, 1990). The uncertainty of the climate and the extreme conditions make restoration challenging even if adequate resources are available for restoration. When resources are limited, as they commonly are, careful planning must be done to make success more likely.

Although much has been learned about the functioning of desert ecosystems in the last 80 years, much remains to be learned about virtually every aspect of the ecology of these fragile lands. This is particularly true for the complex interactions involved in plant establishment and soil restoration. A good goal is to become less ignorant with each project, by testing a range of options that previous research has suggested are "best bets". The results of this work will help fine tune treatments and improve the rate of recovery on future projects.

1. First priority

The adverse effects of disturbance should first minimized by limiting access or reducing the level of impact. This may be by moving watering points, rotation of pastures, mixed grazing, or limitation of grazing during the dry season for a few years. It may also involve restrict recreational areas for OHVs, mountianbikes, horses and pedestrians.

Seed collection should be given priority in the beginning and throughout most projects, because seed production in desert species is erratic and seeds of a particular species are not often unavailable from wild stocks when needed. Seed quality is highly variable from year to year and should be evaluated before collecting large quantities of seed. If the seed quality is very low it may not be worthwhile collecting seed, table 2. If the seed quality is very high it may be worth setting up a large scale collection program. Seed quality can be assessed by non-destructive X-ray analysis, dissection, and germination tests (Lippitt and Bainbridge, 1993).

Table 2. Bladderpod seed viability (*Cleome isomeris)* from Red Rock Canyon State Park

	Percent good seed	
Year	*dark seeds*	*light seeds*
1992	62	4
1991	0	0
1990	97	45

Source: Lippitt et al., 1994.

For most restoration projects, it is desirable to harvest seeds from a diverse population; at least 50 plants over a large area should be utilized. To further encourage genetic variation, plants should be selected from different stands in a range of comparable sites, as provenance may affect germination and growth characteristics. If seed is not collected across a broad genetic base, inbreeding will occur and this can result in reduced diversity and inferior progeny. Once a stand has been selected, the timing of seed collection can be crucial. For some species, ripe seed is available for several weeks or months, in others it may be for only a few days. Seeds that ripen and fall quickly can sometimes be collected by early placement of the seed head in a section of nylon stocking or netting.

To improve seed purity and decrease the percent of empty or less viable seed, weed seeds, the seeds of other plants, and empty seed must be removed. Seeds can be sorted and cleaned using an air separator, which utilizes the movement of air to divide materials according to their terminal velocities (see SeedTech). A seed's size, shape, surface texture, and density are factors that contribute to it's terminal velocity. When fed into a rising airstream, seeds and debris of different terminal velocities will separate from each other. The velocity of the airstream can be manipulated to capitalize on the differences between the seeds or trash being sorted.

2. Second Priority – Restore process and function

Repairing soil damage is often a critical step in restoration of ecosystem processes in arid lands (Bainbridge, 1997; Whisenant, 1999; Allen et al., 1999). The nutrients are often concentrated near the surface and even minor erosion can severely limit fertility. Restoring soil characteristics can be essential to initiate recovery (Allen, 1988). Surface shaping may be needed to capture and retain moisture.

Soil is often compacted by equipment operation, animals and human activity. Compacted soil can slow or halt root growth and prevent seedling establishment. recovers very slowly, in arid areas (Bainbridge, 1993). Compacted soils may be aided by breaking up the soil as deep as possible with a ripping shanks or chisels. This should be done without inverting the soil layers to maintain a natural fertility gradient. Deep ripping improved tree survival and growth in western Australia (Schuster, 1979). Cross ripping and planting at the intersections was very effective in rehabilitating Australian drylands.

If budgets are limited, simply roughening the soil surface may be worthwhile. Deep ripping can dramatically improve infiltration. It is most effective on compacted soils with poor structure. Soil pitting can be done with a variety of different machines or by hand using a shovel, hoe or McLeod (Bainbridge, 1999). Pitting machines leave a number of discontinuous pits in the soil which concentrate water and improve infiltration. Vegetation often establishes well in these pits and by increasing surface roughness the pits also reduce wind speed and facilitate sand, seed, and deposition of beneficial root fungus inoculum. This could be done economically over very large areas with disk pitters.

Imprinting desert soils with a shaped toothed roller has been very effective in increasing infiltration. The imprinter produces a pattern of pits and catchment areas that concentrate water and also trap blowing silt and seed (Dixon, 1988). Unfortunate the heavy roller and equipment can also compact the soil. While compacting the seeds and soils can improve germination in some cases by improving moisture contact with the seed it is often more effective for grasses and less helpful for deep rooted shrubs.

Mulches often improve plant survival and establishment. They can provide a number of benefits: wind protection, reduced evaporation, increased infiltration, rainwater retention, reduced erosion, and improved plant microclimate. Mulches used in the desert must be wind resistant. Rice straw is preferred as it is very durable and less likely to contain weeds. Bundles of rice straw set vertically into the soil have worked well in restoration efforts, probably by limiting wind erosion and increasing infiltration (Bainbridge, 1996). Fiber nets over long stemmed straw have been effective for erosion control. This method can also provide seeds if native grasses are used as the mulch. Cut brush also works well in initiating site recovery (Ludwig and Tongway, 1996). But mulch is a gamble, it can reduce water infiltration and plant survival in very dry years (Bainbridge, 2001a).

Gully and erosion control is difficult in any environment and particularly hard in the desert (Bainbridge, 1994a;1998; MacAller et al., 1998). High intensity rains, rapid runoff from denuded areas, and steep slopes make it very challenging. Many tons of soil material can be quickly lost and difficult to replace. Stabilization methods include check dams (rock, brush), spreader dams, and contoured berms or terraces. Reestablishing shrubs on slopes can also help reduce erosion and runoff.

3. Transplanting and maintaining plants

Vegetation restoration in arid lands usually requires transplanting to reestablish plants, although in some cases direct seeding can work. Revegetation should be done with seed collected on or near the site. Inoculation with proper microorganisms may improve survival and growth although the linear nature of much of the disturbance makes it less likely than on large areas with more remote sources of inoculum.

A. Nursery transplant preparation and procedures

The dominant desert shrubs are generally easy to grow in a nursery or maintained landscape setting but can be challenging to establish in the field in a low- or no-maintenance situation (Bainbridge and Virginia, 1990; Bainbridge et al., 1995; Grantz et al., 1998). Multi-stemmed shrubs and trees such as creosote bush and mesquite are especially good candidates for revegetation and restoration efforts. Once they are established they will improve site conditions for other plants by trapping fine soil, organic matter, and symbiont propagules, by increasing infiltration and water storage in the soil, and providing protection from the sun and wind. The shrub mounds that develop under these multi-stemmed shrubs improve nutrient and water supply for the shrub itself, and provide the unique microhabitat required by many desert annuals.

Concentrating resources to create resource islands may provide greater benefits than less intensive treatments over a larger area. These islands can provide seed and inoculum for surrounding areas. These resource islands apparently play a major role in the development of these desert ecosystems. Transplanting clumps of shrubs into the center of barren areas is a low cost method of promoting resource island formation.

A wide variety of containers have been used for transplants for desert revegetation, ranging from the small supercells up to meter tall 15 cm diameter tubes with costs ranging from 75¢ up to more than $15 per plant. No ideal system has been developed and the choice will depend on site control, budget, timing, access, and irrigation and project goals (Bainbridge, 1994; 2004). Generally the money spent on plants will improve survival if roots are given priority. Plant containers effective for desert restoration include:

Plant bands--2x2x14 inches -- many other sizes available from Pacific Western Container and Monarch Manufacturing. These are plastic or foil coated cardstock square tubes with no bottom. They are readily available, inexpensive, and effective. With loose soil mix they can be slipped up over the root system and shoot after it is placed in the soil, minimizing damage and plant stress.

4-6 inch PVC pipe x 16 inches. Open ended plastic pipes are relatively easy to work with. They provide a very stable environment for the plants, are easy to remove after placing the plant in the planting hole.

6 inch PVC pipe x 32-36 inches. These large pipe containers are heavy and awkward to move. They provide a very stable environment for plant root development and are excellent for long term grow out. They require hard work to plant, but plastic tube can be pulled out after backfilling. (developed at Joshua Tree National Monument in California).

Seedling inoculation may be essential on extremely disturbed large sites. It can be done with native soil taken from under healthy plants of the same or closely related species or with commercial inoculum. Native inoculum is preferred for restoration work. The most important symbiotic partners are rhizobia, which enable many leguminous plants to fix nitrogen, and mycorrhizal fungi which improve root characteristics and phosphorus uptake. Double inoculation of leguminous plants with both rhizobia and mycorrhizae may be important if field populations of microsymbionts are severely depleted or absent. Some of the more prominent nitrogen fixing plants are not very specific in their requirements for rhizobial inoculum. Most perennial desert plants depend on mycorrhizal fungi for successful establishment and growth in soils with low phosphorus levels. Lack of needed symbionts is often revealed by plant failure after initial growth following germination.

Protection from microclimatic extremes and herbivory is often essential. This can involve tree shelters, rocks, brush or other protective devices (Bainbridge, 1994; Bainbridge and MacAller, 1996).

B. direct seeding

Direct seeding is relatively inexpensive (cost commonly ranging from $100 to more than $1,500 per acre depending on the seed mix). Direct seeding is extremely vulnerable to drought and seed harvesters (ants and rodents) and often fails completely (Bainbridge and Virginia, 1986). Experiments in the Sonoran and Chihuahuan Deserts beginning in 1890 and involving 83 species and 400 sites suggest direct seeding can be expected to succeed only in one of ten years, mainly due to insufficient water in years with normal precipitation (Cox et al., 1982). Ideally direct seeding should be done when forecasts say precipitation is very likely or the soil is already moist. If forecasts are very clear seeds might be pre-imbibed by soaking in water and then spread during a gentle rain. Pits or imprinting can improve germination and survival.

C. Protecting natural volunteers

Protecting naturally established plants can be one of the most inexpensive options for improving vegetation. Protective shelters or screening and supplemental water for volunteer plants may be one of the most cost effective options available for restoration.

D. Transplants from the wild

Transplanting from the wild is also relatively easy in a maintained setting. Some species may benefit from pruning to improve root; shoot ratio. Damaged roots should be cleaned up. Clay pot irrigation of transplants for a recovery period in nursery of field may improve survival. Transplanting from the wild is most suited for construction activities like pipelines or mines, when plants can be removed and replanted quickly (Franson and Bainbridge, 1993).

4. Providing supplemental water

Water is often the critical factor limiting growth and establishment in the desert (Bainbridge, 2002). Many viable seeds may be available in the soil seed bank, but they cannot grow without water. Changes in surface soils (compaction surface sealing, crusting) and the removal of vegetation (loss of stem infiltration and litter removal) limits water capture. Plant protection can reduce plant water demand by reducing transpiration and evaporation. This is one of the key benefits of tree shelters or rock mulch.

Shaping the ground to concentrate available rainfall has been very effective for vegetation establishment in deserts (Evenari et al., 1982; Bainbridge, 2000; Edwards et al., 2000). Microcatchments have been used in North Africa since Roman times and are now being used in many arid regions (Shanan et al., 1970: Shanan and Tadmor, 1979). These basins can be irregularly shaped to appear more natural. A typical microcatchment might concentrate water from 100-300 ft^2. Microcatchments have been extensively used in China with plastic aprons for runoff collection.

Most desert plants will require additional irrigation. Once the plant is established the irrigation can be tapered off and terminated. Pulsed irrigation may be more desirable than continuous irrigation for species that are very sensitive to over-watering. To get the most from limited water supplies only very efficient systems should be used.

Deep pipe irrigation uses an open vertical pipe to concentrate irrigation water in the deep root zone (Bainbridge and Virginia, 1990; Bainbridge, 2001b). Deep pipe irrigation commonly uses 2 inch diameter vertical pipe placed 12"-18" or deeper near the seedling, with a series of small holes drilled on the side nearest the plant. The top of the pipe should have a screen (1/8" mesh hardware cloth) cover to keep lizards, insects, and animals out of the pipe. Water delivery takes only 5-10 seconds per pipe versus 60-90 seconds for surface basins. Little water is lost to evaporation or runoff even on steep slopes.

Buried clay pot irrigation has proven to be very effective in establishing and growing plants in arid environments (Bainbridge, 2001b). Buried clay pot irrigation uses an unglazed, low-fired clay pot filled with water to provide a steady supply of water to plants growing nearby. The water seeps out of the clay walls of the buried clay pot at a rate that is in part determined by the plant's water use. This leads to very high efficiency. Most standard red clay garden pots are suitable if the bottom hole is plugged with a rubber stopper or silicone caulk. A tight fitting lid with drain hole should be used or animals may knock loose lids off to drink the water.

Several different systems for drip irrigation have been tried in the desert. The standard commercial systems are expensive and have proved troublesome. Coyotes, rabbits, and other animals chew on the polyethylene tubing and emitters are easily clogged by debris in the lines and from salt accumulation at the emitter orifice. Revised systems are being evaluated.

Where water is available overhead sprinklers have sometimes been effectively used to mimic natural rains. Over-watering can lead to disease problems with desert plants and weed growth.

The Challenges Ahead

The challenges we face in restoring and better managing dry lands are daunting, but can't be avoided. The can be divided into four major categories:

Understanding the causes and effects of dry land degradation both locally and globally. This will involve research in many areas of the world to better characterize the adverse effects of past actions and the underlying economic and social causes. Case studies are particularly helpful; because although many factors are similar others are unique to a specific situation.

Recognizing regional and global change agents and impacts. This will involve integrated research around the world on atmospheric dynamics, pollutants, and precipitation.

Developing simple, cost effect strategies and methods for restoration of dry lands in a wide range of habitats. This effort must also find new methods of funding restoration projects to increase active restoration of degraded dry lands. This effort must also include coordinated studies and cooperative projects to guide evaluation, research, and monitoring of damaged and restored sites.

Demonstrating sustainable resource management in dry lands to improve quality of life and to minimize adverse effects of current and future activities. Ideally restoration through use will be possible in some cases. Poor resource use has limited the ability of dry land residents to make a living, destroyed communities, led to conflicts over land and water, reduced health and life expectancy and severely affected natural systems and biodiversity.

If the advantages are apparent, and the potential is real, then why hasn't there been more activity and success in desert restoration? The primary problem is the failure to consider social factors, economic subsidies, tenure, and the value of Nature's Services. These are often intimately interwoven and though not insoluble, certainly challenging. The growing interest and activity in ecological economics suggests this obstacle may be one of the most easily overcome.

The enormous and ever worsening problems of environmental degradation combined with increasing population, millions of farmers and pastoralists, makes action imperative.

New Hope for Desert Lands

Recent research across the Southwest has demonstrated the feasibility of restoring damaged desert lands, but the challenges remain daunting. They include: understanding the causes and effects of degradation, developing simple, cost effect strategies and methods for restoring dry lands in a wide range of habitats and uses, and demonstrating sustainable resource management practices that can improve quality of life and minimize adverse effects of current and future activities. In almost 20 years of research and applied testing in restoration projects I have begun to answer some of these questions with the help of students, staff and colleagues. We have learned how to make the unthinkable possible, beginning restoration of desert areas with rainfall as low as 3 inches a year. The keys for success are effective planning to use money, labor and time wisely.

With a modest investment we can begin to turn back the incremental but almost inexorable changes that lead to desertification and bring new hope to the desert. This is one of the great international challenges for the next Millennium. It will require international cooperation on many levels, from farmer to farmer exchanges to international debt relief and financing for education, extension and restoration.

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