

AIR-EARTH INTERFACE MODEL FOR RESTORING RIPARIAN HABITATS¹

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The Santa Cruz River originates in the Patagonia Mountains in south-eastern Arizona, flowing south for about 24 km into the Mexican State of Sonora before curving to the west and then proceeding northwest back into United States at the twin border cities of Nogales. From the border it courses north to Tucson and then northwest to the Gila Indian Reservation where it merges into the Gila River for a total distance of about 290 km.

The riparian system of concern in this paper is that portion of the watershed above Cortaro, Arizona (16 km northwest of Tucson). This part of the watershed has a total area of 9073 km² and includes the densely populated Tucson area along with the retirement community of Green Valley to the south.

This riparian system has been severely degraded by human activities during the past century. Severe overgrazing has eliminated most of the perennial grass communities, thereby denuding much of the watershed. Lacking protective vegetative cover, severe erosion has deeply gullied the watershed to accelerate runoff to the river channel. Over pumping of the aquifers (which once fed the Santa Cruz River) for agricultural and municipal purposes has lowered the historically shallow water tables to current depths of more than a hundred meters.

Now high-intensity long-duration rainfall runs off (instead of infiltrating) the Santa Cruz watershed, building into devastating and very costly floods as occurred in the Tucson area in October 1983. The response of the City of Tucson and Pima County to the flooding has been to straighten the river channel and smooth the floodplain wherever possible. The sidewalls of the river channel and floodplain are then stabilized with soil cement. However, this approach to flood control merely accelerates water flow, thereby causing severe cutting of the channel bottom and floodplain with resulting severe flooding and silting downstream where the channel and floodplain have not been straightened, smoothed and stabilized. Vegetative restoration of the Santa Cruz watershed is the only long term solution to this malfunction of the hydrologic cycle which is both ecologically and economically sound.

This poster paper outlines a new strategy for vegetative restoration of the Santa Cruz riparian system. The strategy has been successfully tested in both upland and lowland areas and is more cost effective than

conventional alternatives when used in the arid Southwest.

The new strategy called the Air-Earth Interface (AEI) Model involves four interrelated and interacting AEI processes—*desertification*, *infiltration*, *imprintation* and *revegetation*—each of which will be briefly outlined on the following pages.

Desertification

Definitions

Generally, desertification is a land degradation process, triggered by human disturbances, which increases the aridity of the microclimate to which plants are exposed. Specifically, desertification denudes, smooths, and seals the air-earth interface to inhibit infiltration and revegetation processes.

Causes

Some causes of land desertification are:

1. Overgrazing of grasslands, shrublands, savannas, forests and associated riparian areas.
2. Overplowing of croplands usually for the production of annual plant species grown in a monoculture.
3. Overlogging of woodlands and forests for the production of lumber and paper pulp.
4. Industrialization involving the construction of pipelines, powerlines, well fields (oil and water), mining facilities, powerplants, factories refineries, warehouses, railways, and highways.
5. Mining, primarily pit and strip operations.
6. Urbanization involving the installation of utilities and the construction of streets, parking lots, housing, shopping centers, hotels and convention centers, and schools and playgrounds.
7. Flood control to mitigate the watershed effects of the preceding disturbances by straightening, smoothing, stabilizing, diking and diverting natural water courses to protect low-lying urban and industrial developments.

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Problems

Some problems caused by desertification are:

1. Accelerated water runoff, soil erosion, flash flooding, and sedimentation, all of which are caused by reduced rainwater infiltration.
2. Reduced soil moisture, reduced groundwater recharge (falling water table), and reduced spring, stream and river flow, again caused by reduced infiltration.
3. Increased aridity of microclimate with corresponding deterioration in the habitats for plants and animals caused by a combination of low infiltration and high soil erosion.
4. Increased land denudation and decreased land productivity, also caused by low infiltration and high soil erosion.
5. Severe wind erosion, low visibility, and intense air pollution.

Two Examples



Figure 1. — Desertified upland watershed in the hot desert region of the Southwestern United States, caused by a century of severe overgrazing of Sonoran Desert shrubland. Both wind and rainwater from intense summer thunderstorms sweep freely across this smooth barren surface stripping away topsoil which took millennia to form.



Figure 2. — Floodplain erosion, caused by upland watershed desertification, exemplifies the twin hazards of desertification—upland droughts and lowland floods.

Infiltration

Definitions

Generally, infiltration is a process in which water moves vertically downward through the soil surface into the soil below to recharge soilwater and subsequently groundwater. Specifically, the process exchanges rainwater and soil air across the air-earth interface (AEI). Infiltration is rapid across a rough, open AEI and slow across a smooth, closed AEI.

Vegetation

Soil surfaces covered with vegetation, which are naturally rough and open, infiltrate water about 10 times faster than the smooth, sealed surfaces of desertified land. This means that a vegetated surface infiltrates most, if not all, of the rainfall on-site, whereas the barren desertified surface sheds most of it to erode and flood land lying down-slope.

Erosion

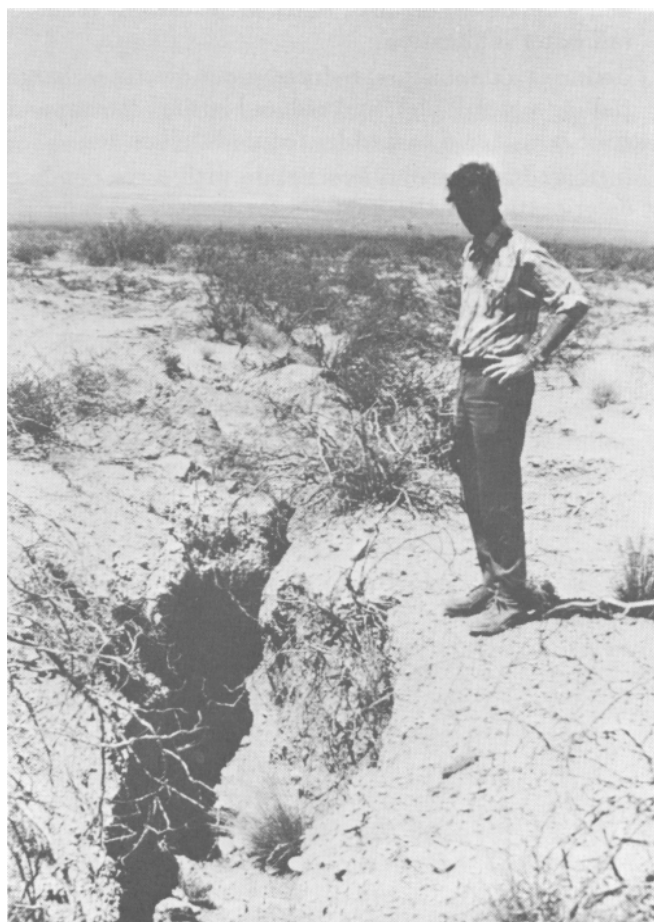


Figure 3. – Rainwater erosion of topsoil caused by severe overgrazing. Accelerated soil erosion is caused by accelerated rainwater runoff, in turn, caused by decelerated infiltration in response to desertification. This chain of cause-and-effect processes becomes a vicious circle that perpetuates itself in the fragile ecosystems of the southwestern United States, long after the original disturbance (such as overgrazing) has been removed.

Imprintation

Definitions

Generally, imprintation is a mechanical process in which angular teeth are forced into the soil surface to form funnel-shaped indentations, where seeds germinate and seedlings establish with a minimal amount of rain-fall. Specifically, it is a process that roughens and opens a smooth, closed air-earth interface to accelerate infiltration, revegetation, and reversal of desertification.

Two Examples

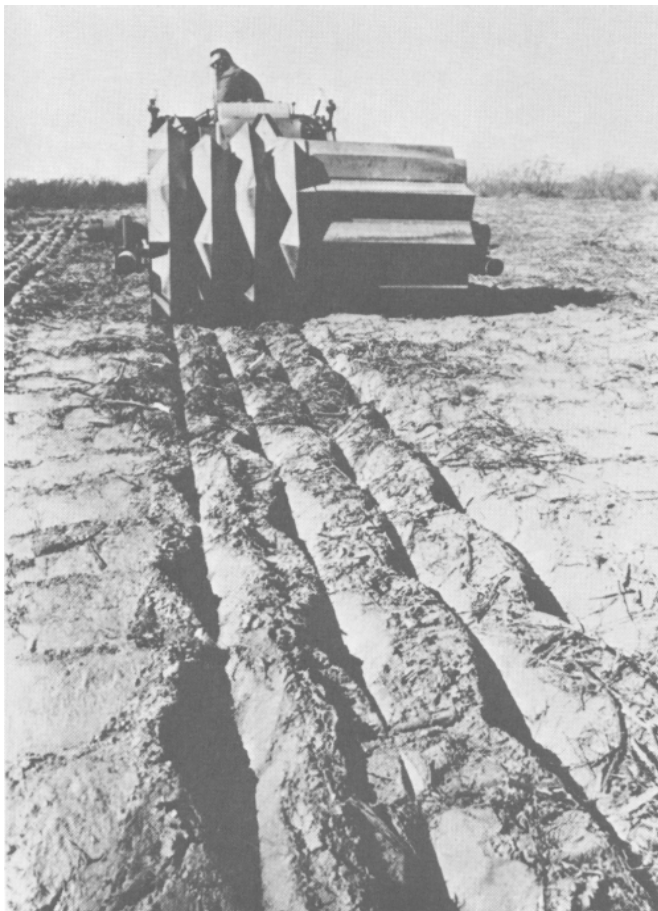


Figure 4. – Imprinting a desertified upland watershed converts the smooth sealed air-earth interface into the rough, open condition, thereby accelerating infiltration and revegetation processes.



Figure 5. – Imprinter seeding a 243-ha desertified floodplain near Cortaro, Arizona in November, 1987. Imprinting and seeding the floodplains as well as the upper parts of the watershed can prevent destructive flash flooding (and associated erosion and sedimentation) of the river channel.

Revegetation

Definitions

Generally, revegetation is the reestablishment of plant communities destroyed by the desertification process. Specifically, it is a process, beginning with seed germination and seedling establishment, that needs, creates and maintains a rough, open air-earth interface to reverse desertification and rebuild topsoil.

Two Examples

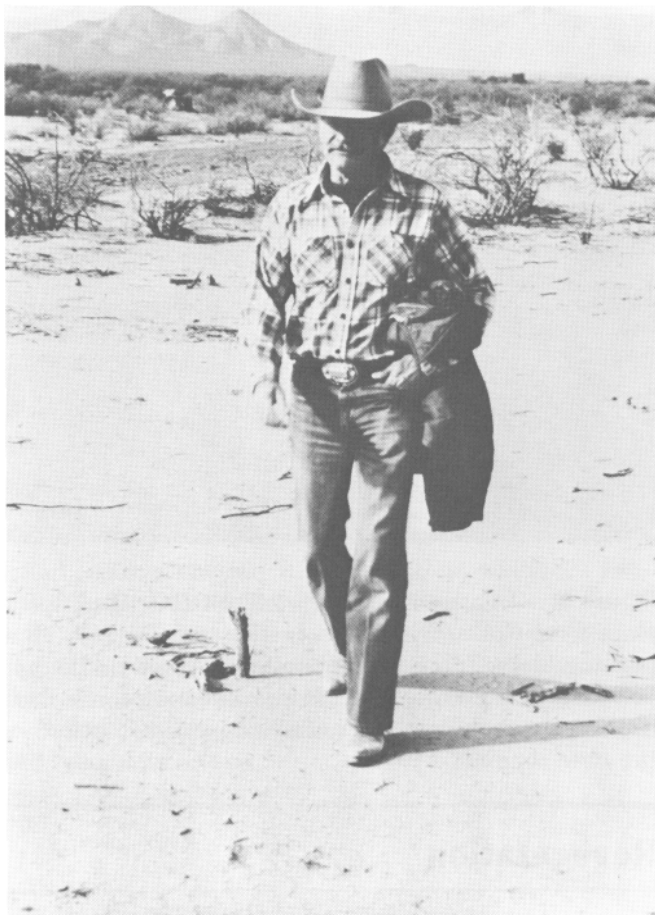


Figure 6. — Upland watershed revegetation through imprinter seeding of 13 species. Before imprinting (left): Barren rangeland on the Agua Blanco Ranch west of Tucson severely desertified through a century of overgrazing (Nov. 1982). During imprinting (center): Freshly imprinted land except for center foreground area of the picture (Nov. 1982). After imprinting (right): Vegetative response to imprinter seeding (Oct. 1983).

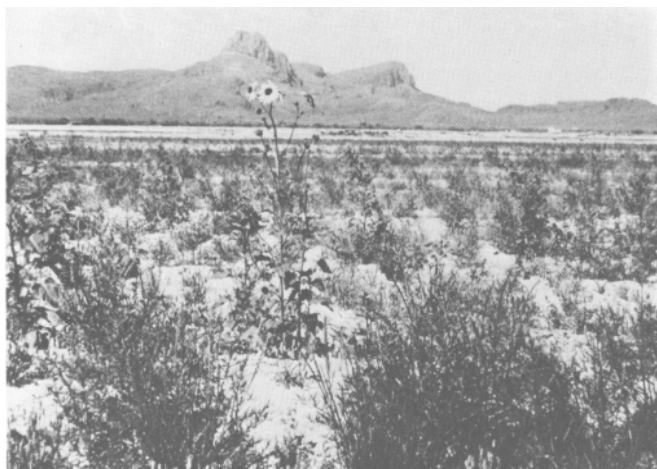


Figure 7. – Vegetative response to the imprinter seeding of the Santa Cruz floodplain shown in Figure 5. Winter rain brought up this good stand of annual and perennial cool-season species (May 1988).

Summary

1. DESERTIFICATION



A PROCESS THAT DENUDES, SMOOTHS, AND SEALS THE AIR-EARTH INTERFACE TO INHIBIT INFILTRATION AND REVEGETATION PROCESSES.

2. INFILTRATION



A PROCESS THAT EXCHANGES RAINWATER AND SOIL AIR ACROSS THE AIR-EARTH INTERFACE (AEI). INFILTRATION IS RAPID ACROSS A ROUGH-OPEN AEI AND SLOW ACROSS A SMOOTH-CLOSED AEI.

3. IMPRINTATION



A PROCESS THAT ROUGHENS AND OPENS A SMOOTH CLOSED AIR-EARTH INTERFACE TO ACCELERATE INFILTRATION, REVEGETATION AND DESERTIFICATION REVERSAL.

4. REVEGETATION



A PROCESS, BEGINNING WITH SEED GERMINATION AND SEEDLING ESTABLISHMENT, THAT NEEDS, CREATES AND MAINTAINS A ROUGH-OPEN AIR-EARTH INTERFACE TO REVERSE DESERTIFICATION AND REBUILD TOPSOIL.

Figure 8. – The AEI Model evolved out of a quarter century of basic and applied research conducted under a wide diversity of plant, soil and climatic conditions. It integrates principles drawn from edaphology, hydrology, climatology, biology, and ecology to form a relatively simple and cost effective strategy for reversing land desertification through revegetation. An important application is the restoration of riparian systems to benefit people, wildlife and plants.