Original Concept:
Laredo Demonstration Farm

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Center for Maximum Potential Building Systems
Report to Meadows Foundation, 1988

1. INTRODUCTION

The Laredo Blue Print Farm Project was conceived to challenge agricultural convention in Texas, where, as in many U.S. States, the economic viability of farming is threatened. With scores of farm failures around the state, the need to introduce an alternative agricultural approach is imperative. Similarly, the importance of the built form to reinforce the resource efficient farming practices being introduced by Isreali agriculturalists was determined to be an essential component to this demonstration project. While often overlooked as integral to efficient farming practices, the built environment can lend enormous support to ensure the farm's maximum output and resource utilization.

To this end, the Center for Maximum Potential Building Systems has strived to design a building system for the Laredo Blueprint Farms consistent with the quest for a resource efficient, highly productive and sustainable agricultural approach for Texas farms. By incorporating earthen, agricultural and locally available materials for building, shade for cooling, water catchment systems for irrigation, solar systems for heating and cooling, and other systems detailed in the report, the Blueprint Farm's physical structure is a statement of how farms can begin to respond to the paralyzing operations and maintenance costs experienced by farmers across the state.

The demonstration quality of this project is enhanced in two ways: first, each component and material used will be mapped to show where its use is relevant in Texas; and, second, a Farmer's Planning Tool Kit will be available to enable farmers to engage in planning their future farm operations.

As we become more aware of the global forces influencing our land and climate, we realize there is more historical data from which to turn. This project status report brings together some of this information, both to gain perspective from the past and to move us confidently into the future.

II. ARID LANDS AND THE LAREDO BLUEPRINT FARM

A tremendous body of knowledge exists linking the Laredo Blueprint Farm project to the global conditions of arid lands and desertification. The desert tradition is a long and powerful statement about the survival of natural and human environments under extreme conditions of heat, cold, wind and water. In delving into this long and complex history, we are confronted with an illuminating perspective regarding tradition, technology, and the importance of shelter for all life forms. We also enter an empire of magnificent and sophisticated hydrologic engineering, developed with an understanding of nature's delicate balances, bringing vital blooming oases to our most harsh environments. Through this review we have learned also of a legacy of farming practices, some which have succeeded and some of which have failed, and of trends, problems and current research important to the task at hand.

In our approach to design engineering projects, we begin linking a project to a perspective of global patterns. If for a moment one thinks that Laredo, Texas is not subject to desertification (the man-made destruction of arable land), one need only spend five minutes with range ecologists such as Dr. Tim Fulbright at the Caesar Kleberg Wildlife Research Center at Texas A & I University at Kingsville. Better yet, read Dr. John Rappole's recently published paper in The Science of Total Environment. "Anthropogenic Pressures and Impacts on Marginal, Neotropical, Semiarid Ecosystems: The Case of South Texas" for a real eye-opener.

To justify the time required to review the myriad of factors affecting farming in such an environment is difficult when our "job" is defined as covering building design and engineering, and the use of renewable energy for electricity, drying, and refrigeration. But by subjecting the Laredo Farm project to a global perspective, what at first blush seem secondary issues, readily become imperatives.

- The use of all-important shade structures for planting
- The catchment of precious water sources
- The use of low-energy cooling systems for greenhouses
- The design and building of greenhouses
- The investigation and subsequent use of fabric structures for all aspects of built form.
- The development of an interactive decision-making planning model for farm personnel and future clients

Each year, twelve million hectares of agriculturally-productive soils are lost world wide. Of this total, forty percent are croplands that lose their topsoil and nutrient stocks directly due to the way we grow crops and the types of crops we grow. The remaining sixty percent of soil loss is due to overgrazing. In the U.S. particularly in the grain belt, approximately one and a half acres of topsoil are lost each minute. In the Southwest, overgrazing, or improper grazing, is a major soil destroyer, resulting from the combination of nutrient exploitation at improper intervals and lengths of time and root plowing intended to revert hardwood species back to grassland. Root plowing has resulted in a mono-condition of mesquite and bare ground, primarily due to the planting of buffalo grass to replace perennial range grasses. The native grasses required little range management and, depending on the species, little water.

Farming in the Southwest and other arid lands is distinguished from ranching in many instances as being a fertilizer-, water-, and energy-intensive operation having had the luxury of close proximity to petroleum reserves which exist in many of these same arid, and semi-arid conditions. The result has been unstable, inflexible farming practices dependent on petroleum-based fertilizers, pesticides, and even greenhouses. In 1974, immediately following the oil embargo, nearly two hundred such greenhouse operations failed in Texas alone.

The quest for more stable farming methods is not simple. Ecologically sound traditional methods are generally unable to respond to contemporary market demands resulting in most failing by the wayside. It is essential, however, to search through the historical accounts of ancient and modern civilizations to uncover those methods that fit the inevitable evolution of agricultural needs under arid conditions. One must seek out the techniques of the great black tent civilizations of the Bedouin people of the Arabian desert, the Tuaregs of Ahaggar, the Tekna Tribes of Southwest Morocco and join these with the reconstruction efforts of an ancient farm in Avdat, Isarael. These, together with the scores of research groups listed in the Directory of Desertification Control – P.A.C published by the United Nations' Environment Program (UNEP) can help reestablish a basis for stable farming practices in the world's arid lands.

Our investigation thus far has culminated in many conclusions, two of which are:

* That shadow in the desert, produced by shade structures, especially for crop propagation, is an enormously important part of the desert farming (lowering water use by up to fifty percent) and must be achieved through low-energy, low impact design/engineering. (Note the above photograph of the Israeli experimental farm; the most apparent and visible forms are not plants but structures that protect plants.)

* That the building system must be flexible enough to accommodate changes in use and size for eventual controlled plant/animal husbandry for the sustained nitrogen production if intensive farming practices are to be pursued in the local soil types. This effort can be supplemented by coordinating the farm with urban composting programs.

Only some of these efforts have been achieved in the six months which have elapsed since the inception of our project, during which time our principal pursuit has been the design and engineering of buildings for the farm, due to begin construction July/August 1988. We have compiled a reference list of individuals, groups, and organizations knowledgeable about arid lands, and placed their location on a global desertification map. Our consultants and informal advisors who have provided invaluable assistance are listed below.

INFORMAL ADVISORS

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REGIONAL RESOURCES: PHYSICAL AND HUMAN

From regional perspective, both the Slaughter and Laredo Junior High College Blueprint Farm sites are in the Tamaulipan Biotic Province of the U.S. Desert Division. These sites are particularly interesting since Laredo is poised on the edge of the Chihuanhuan desert immediately to the south, and the Temperate Grasslands thirty to fifty miles to the north. This positioning enables one to put into play, a unique set of natural resource conditions that relate to both desert and grassland regions.

A. <u>Climate</u>

The South Texas climate in similar to both the Eastern Arabian Peninsula and Northwestern Brazil in that it combines oppressively-high sensible temperatures, high humidity, and low rainfall. Relative to other global desert conditions, (desert is defined as an area with 250mm or 9.8 inches annual rainfall), our site is classified as a boundary desert zone. The most extreme annual rainfall condition in Laredo over a twenty-five year period is 12.67 inches. This is especially significant when one compares this to annual rainfall statistics in areas with productive desert farming operations. For example, in reconstructing some ancient desert farms in the Negev (in Avdat and Shivta) only

29mm, or 1.1 inches of rain falls in a drought year and 160mm, or 6.3 inches, in a wet year. Even with such minute amounts of precipitation, these farms rely totally on rainfall collection for irrigation and use a collection area some twenty to thirty times the size of the area under cultivation. (See "Ancient Technology and Modern Science Applied to Desert Agriculture", L. Shanan et al, Ekistics – date unknown.)

By incorporating these ancient practices in an updated configuration, Laredo's average annual rainfall of 22 inches (564 mm) allows for a 1:1 to a 3:5:1 ratio of collection to use area, especially considering that the evaporation rate in the Negev is far greater than in Laredo. Ancient farming practices such as those in the Negev demonstrated that a variety of fruit trees, vines, grains, and leguminous crops could be produced in such adverse conditions. Certainly, the successful adaptation of these arid lands agricultural practices has tremendous implications for vast areas of Texas experiencing water shortage. By mapping Texas' precipitation/evapotranspiration conditions similar to Laredo's, one can identify areas where the farming practices employed on the Blueprint Farm would be relevant. A map of Texas showing the areas where evaporation is higher than precipitation (often considered to be potentially desert prone) is as follows, a global insert map is also included:

The Laredo Blueprint Farm site also shares climatic and rainfall conditions with West Texas. In fact, if one were to look carefully at a map of the West Texas average annual evaporation rate of eighty-two inches, we find that Laredo is similar to areas around El Paso, but not as high in this regard as the Presidio region. According to the Climatic Atlas of Texas, precipitation averages approximately twenty-two inches of annual rainfall. Therefore, more than 3.7 times the amount of surface water collected from rainfall is subject to evaporation unless protective measures are taken. The area's dry periods are December, January, February, and March, with monthly rainfall not approaching much more than one inch during any one of these months. It is important to recognize that the conditions of lowest rainfall are coincident to times when the greenhouses would be most in use. Thus, the greatest control of water use rates is technically possible during this winter period.

Wind is a significant factor in the Laredo climate with annual averages of approximately 9.7 mph. Summer and winter winds are predominately from the southeast as indicated by the usual low summer winds and high winter winds typically used for proper integrated solar/wind electric systems is that the Laredo winds experience their worst, or lowest period during winter months with a December average of 6.7 mph. However, the use of strong summer breezes helps with the Farm's proposed down draft cooling tower structures. Wind also can be a significant factor in the proposed structural types. The Laredo Wind also can be a significant factor in the proposed structural types. The Laredo wind speed used for the engineering wind load design in 80 mph.

(missing windroses diagram)

Solar radiation is an important, albeit under-utilized, resource in South Texas. Relative to the rest of the U.S., solar radiation in the South Texas region is easily within the top ten percent of the country with an average annual output of 4.5 kwh/m2/day. The most efficient and cost effective application for the region's solar radiation is in low temperature, direct-use applications. Creating steam, melting metal, or generating electricity through photovoltaic cells are not as efficient as directly heating water for domestic hot water purposes or heating a space in the winter time directly through windows such as office space or solar drying apparatus. Furthermore, any sophisticated equipment (even pumps in conjunction with active flat collectors for domestic hot water) creates unnecessary system operations and maintenance complications and contributes to unreasonable payback periods. Simple passive solar hot water heaters are the best all around methods for utilizing South Texas' abundant solar energy.

Heating and cooling design temperatures for the Laredo region are 25 degrees during the winter and 100 degrees during the summer. An important interpretation of these numbers is that temperatures just below freezing, to 25 degrees, are considered controllable from a crop freezing point of view by using radiant barrier protectors and/or mist water spraying over the crops. Both these considerations have been taken into account in the plans that follow. The summer design temperature (dry bulb) is particularly important when combined with the wet bulb temperature since the obtainable temperature possible from evaporative down draft coolers as incorporated in these plans is 80 percent of the difference between wet and dry bulb giving us a plant and human comfort condition of 70-80 degrees Fahrenheit and 20 to 75 percent relative humidity is required.

Human comfort zone conditions have been plotted on the Olgyay comfort zone chart. This chart indicated that ----percent of the time falls in under-heated periods, ---- percent of the yearly period falls into comfort zone and ---- percent of the time on a yearly basis falls in an area that can be controlled either by sufficient breeze or by evaporative cooling or both assuming that shade is supplied. Only ---percent of the year cannot be controlled through such means.

Soils

As in other global desert regions, the Laredo soils are highly calcareous alkaline soils with little organic matter. The predominant soil type along the Rio Grande River throughout Webb County is the Lagloria-Rio Grande Series. This soil is characterized as deep, nearly level, non-saline, and loamy. Using engineering criteria, such as soils as we find in Laredo, are nearly ideal for adobe and soil stabilization procedures. U.S. Soil Conservation Service data shows this soil series to be well within the limit of soils normally considered ideal for adobe block, rammed block, rammed earth monolithic based on combination of the following limits:

- **pH** – no less than 7.2 or above 8.2 for asphalt – cement no less than 7 nor higher than 8.5
- **Salinity** – less than .5-.8 percent for asphalt and less than one percent for cement
- **Gravel** – should be less than ten percent by volume and less than 3/8 in size

- **Sand** – should be angular under magnification and should be from 60-80 percent
- **Clay and Silt** – (unlike what conventional wisdom usually tells us) should only be ideally 18 to 20 percent but can reach 20 to 30 percent for soil cement and rammed earth purposes

No organic matter combination should exist in soils used for building. The Lagloria soil type covers 30,350 acres in Webb County. Other soil types in the county may also be useful for building purposes. Historic use of adobe along the Rio Grande is thoroughly documented by Professor Eugene George of the University of Texas at Austin's School for Architecture.

Geologic Based Materials for the Farm

As with soils, the key to sustainable and low energy technologies in the building and farming sectors rests with the ability to understand total use potentials and relate these in different combinations according to a variety of needs.

From a geologic perspective, the Blueprint Farm region contains many resources useful to farming and building practices. Some examples of these resources are caliche, pozzolanic cement, zeolite, and coal. Borate, although not available in Webb County proper, is a valuable preservative for cellulose-based materials and is available in many desert climates in the U.S. and the world.

As in many other global arid, semi-arid areas, Webb County has an abundance of high calcium carbonate materials, known as **caliche**, within its lower soil horizons. Upon learning of our Center's work with caliche several years ago, U.N. and Church World organizations informed us that approximately fourteen percent of the world's land surface is caliche based. This abundance of calcium carbonate materials is partially due to an intermittent dissolving of dispersed calcium carbonate at upper soil horizons and the re-depositing of the material in a more concentrated form at lower soil horizons which continue to become plugged and collect still more material. Caliche, therefore, is located below surface and is considered a surface geological condition. There is insufficient rainfall in semi-arid conditions to leach out these calcium carbonate deposits.

Over the years, our Center has demonstrated caliche to be a valuable low energy building material using simple stabilization procedures. When mixed with a small portion of stabilizing cement (either a naturally occurring cement like pozzolan or man-made cement like Portland cement), caliche can easily surpass building codes for unfired masonry materials by up to three fold.

Caliche is recognized in soil surveys at a B and C horizon. In Webb County, the soil series that contains appreciable caliche deposits useful for building with calcium carbonate levels of 70 percent and above exits in six (6) of these series: Cuevitas, Delmita, Jiminez, Quemdo, Randado, and Zapata or the Bkm horizon. Together these soil types comprise 222,000.

Historical precedents for caliche-use in buildings in our hemisphere include Mayan buildings. In Mexico's Yucatan Peninsula and Montezuma's Castle in New Mexico. Also, caliche was demonstrated as a home building material in the 1940s by Texas A & M University. Our Center has completed several caliche building including a demonstration building for the Department of Energy in Carrizo Springs, Texas and a school dormitory in Ingram, Texas. When its calcium carbonate content is 80 percent and above, caliche may be fired and used as a source of **lime**.

Zeolite, Pozzolan and Coal exist in what is referred to as Jackson-Yeque group in the eastern part of Webb County. The zeolite and pozzolan appear as an overburden and/or parallel vein to the coal. For our purposes the value of coal is two fold:

1) When it is burned, coal produces a fly ash substance that ends up almost identitcal to the pozzolan, both being excellent sources of hydraulic cement, and…
2) Coal's value as a supplement to fertilizer in the form of trace minerals makes it valuable farm fertilizer especially when mixed with compost. **Flyash** and **pozzolan** need to be mixed with **lime** in order for their cementatious properties to be exhibited. The disadvantage to the coal is that it must first be burned for it to create the flyash material, while pozzolan required only a fine grinding before use. Test results from our lab using Rio Grande pozzolan showed the following results.

Flyash from this strain was also tested and appears in the following table.

Zeolite is a particularly interesting mineral in that it has the ability to absorb moisture up to 30 percent of its weight and is able to release this moisture at relatively low temperatures. This absorption/desorption capacity makes it valuable as a refrigeration medium particularly using medium temperature solar concentrator at three times concentration power. A detailed summary and feasibility study of zeolite refrigeration appears in the Appendix. The system proposed is an equally valuable hot water producer similar to a heat pump in operating theory. It is proposed that the hot water so produced be incorporated on the farm for showering and for produce and equipment cleaning.

Borate

Borate is proven to be both an effective fire-proofing agent and a natural non-toxic pesticide and anti-fungal agent when applied to cellulose products. All forms of borate occur in arid climates as a result of the drying of lake bottoms and the resulting concentration of hydrous borate. Because they easily dissolve in water, their application is easy and safe. Borate's application in the demonstration farm will be limited to the fire and bug-proofing of straw bales used as low-cost building blocks on certain buildings. These blocks will be encased with stucco plaster to prevent water penetration.

Borate is not found in Webb County but is available in many other areas of the Southwestern deserts including West Texas. For further references on borate, contact The United States Borax and Chemical Corporation and Popular Science magazine. (1988, pp 84-90)

Plant Materials for Building

Several plant materials used in the fabrication of the demonstration farm are prevalent in the Laredo region: cotton, wheat, and oat chaff; corn starch-based plastics; and mesquite.

Cotton

Cotton is a well-known natural fiber with a long history of use in various fabrics. One of these fabrics is canvas used as tarpaulins, tents and other outdoor protective uses. It's most important property, relative to its use as an agricultural crop in South Texas, is that the most economical growing technique is dryland farming (using no irrigation). Although cotton is not longer considered a significant crop in Webb County (the peak was in 1929 with approximately 5,000 bales), studies have shown that a 108 dollars versus a 25 dollars per-acre profit can be accrued in the Lower Rio Grande Valley by not irrigating the fields. This information, along with Dr. Heilman's (USDA, Weslaco) discovery of the one-pass plow system for tilling cotton which can reduce in-field energy costs some ten-fold makes cotton an excellent material for low-cost farm fabric structures. Presently, approximately 100,000 cotton bales are produced in the Lower Rio Grande Valley.

Wheat and Oat Chaff

Building durable, stable, northern climate structures with straw as a primary non-load bearing infill for walls has a several-hundred-year history in Europe and, quite independently, in the grassland regions of the U.S.. In the European continent, waste straw from the farm was used in combination with a very small proportion of clay as the foot-thick material behind the plaster of the classic half-timber frame buildings in Germany. Due to a recent renaissance of traditional building in Europe augmented by environmental concerns, these methods are being used in such projects as demonstration public housing project in Grenoble, France.

Although the European methods were more sophisticated than those practiced in the U.S., particularly with regards to fireproofing techniques, straw was used in the northern plains of the U.S., especially in Nebraska around the 1850s where the land was barren of trees. In both cases, the buildings' exteriors were encased with stucco plastered directly onto the straw or onto chicken wire. In the U.S., this building method reached a brief peak upon the introduction of square bailing equipment around the 1890s which supplied a strongly-packed large insulating block that was pierced together with wood dowels or metal re-bar. In the 1930s, Niels Ryberg, a Swede, patented a totally straw-based building panel, based on the phenomenon that straw will use its own lignon base to glue its strands together without the need of extra adhesive measures when heated and placed under pressure. In the last several years, a Texas company, Mansion Industries, based in Carrolton, has patented a building system based on the original Swedish patent but extended to include the floors, walls, and roof: a one-story modular structure made entirely of straw.

Wheat, oat, and straw are virtually interchangeable in this type of building. The production of these items in Texas, therefore, covers the entire state. With high per-acre production fields of these materials, it is possible to produce one 800 square-foot building every year from five to ten acres. This, compared to wood production of _ acre over a 30 to 40 year period, according to the U.S. Forest Service, translates into nearly a three-to-one difference in how much land we use for producing building materials. The Center has estimate that in central Texas, all low-income housing requirements within a seven-county area could be met within a two-year period simply by using the agricultural waste at the mill. While northern Texas is the state's big producer of wheat, with approximately two to four million bushels per county, northeast and south Texas contain oat and hay production in counties adjacent to Webb County, with an annual yield from 2500 bushels for oats to 20,000 tons for hay.

Corn starch-based plastics will be reviewed in the final report.

Recycled Materials

Oil Rig Equipment

With the drop in energy prices, the Texas petroleum industry has placed an excess of used oil well drilling equipment on the market. One component of this equipment, the drilling rod, is very useful for farming. This material presently exists in surplus quantities of several 100,000 linear feet and consists of high-grade structural steel. Many ranchers have used the rod as a replacement for wood fences. We find a better use that matches the actual quality of this surplus item by using the poles for holding up the farm's shade structures. These hollow rods are available for $1 to $2 per linear foot delivered to the site and come in lengths of thirty feet.

Developing a State of the Art Building System for Arid and Semi-Arid Farms

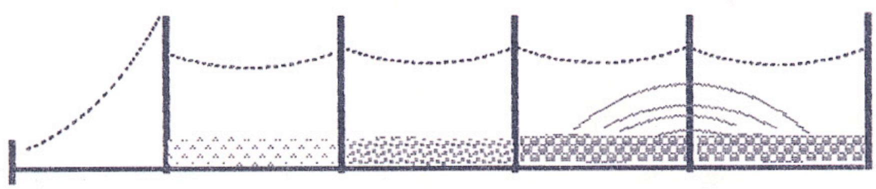
A synthesis of issues past, present, and future with physical and human resource potentials become the bases for this demonstration farm. Farm technologies were chose so that immediate use with economic return can take place. However, these technologies are tentative to the extent that water, energy, and the use of localized resources will gain importance due to the unpredictable nature of the world market place. In a few cases, technologies come from afar, but have the potential to be replicable by U.S. manufacturers, some located in the south Texas region.

Flexibility was another important consideration in our design/engineering process, both in the use and in the ability to change a structure quite dramatically, if necessary, to fit the unpredictability of the market place. This means that the farmer could become a farmer/rancher in an integrated farming approach, or could convert a large portion of structures into greenhouses and use the superstructure to hold up shade materials to sell seedlings to other farmers. This flexibility concept should enable the farmer/rancher to make maximum use of dollars invested in years to come.

Central to the theme of desert architecture is the use of shade. In our farm proposal, shade and their supporting structures become the dominant superstructure. All other buildings and even some technologies for heating and cooling fit within this overall system. This core (superstructure) becomes the basis for flexibility within which change and adaptation of spatial components can take place.

Multiple-use of shade materials is summarized in the following diagram. As one can see, the use of shade can provide physical protection from elements such as wind, hail, water consumption, freezing, etc. in addition to sunlight.

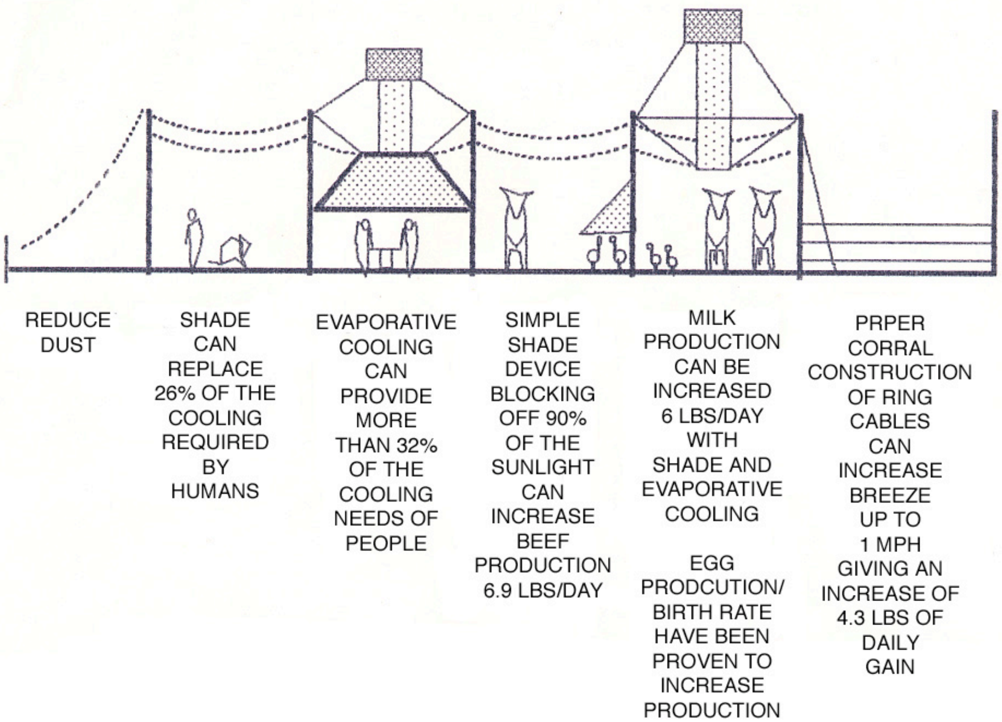
SHADE SYSTEM



PROTECTION FROM WIND	PROTECT YOUNG PLANTS FROM EXCESSIVE SUN DURING FALL AND SUMMER	REDUCES WATER CONSUMPTION UP TO 50%	PROTECTS FROM HAIL REDUCES TEMPERATURE STRESS FROM 10-15 F USE OF COLOR SHADING CAN ENHANCE PLANT GROWTH UP TO 20%	SEPARATE IRRIGATION LINES FROM CULTIVATION PROVIDES FOR LEAF FERTILIZATION SYSTEM PROTECTS PLANTS FROM FREEZING BY BLOCKING NIGHT SKY RE-RADIATION

Further amplification in the use of the system to include animals as well as the effect on people and their productivity is shown in the following diagram.

SHADE AND WALKING CRITTERS



Upon studying this superstructure grid, it was discovered that a variety of building types and shapes could be accommodates by utilizing fabrics as the basis of the structures to be used. If these fabrics were cotton-based and treated for weather, including for sunlight, we could be supporting farmers through the very structure proposed on the demonstration farm. A study of the flexibility and different degrees of longevity required by different structural use types follows.

LONGEVITY OF FABRICS

COTTON (WATER REPELLANT ANTIBACTERIAL) 15 MONTHS-2 YEARS	ACRYLIC PAINTED COTTON DUCK 5-8 YEARS (LOW HUMIDITY)	VINYL COATED COTTON DUCK 5-8 YEARS
VINYL COATED POLYESTER 5-8 YEARS	WOVEN 100% ACRYLIC 5-10 YEARS	VINYL COATED POLY-COTTON 5-8
WOVEN 100% MODACRYLIC 5-10 YEARS	ACRYLIC COATED POLYESTER 5-8 YEARS	TEDLAR 10-15 YEARS

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The farm buildings requirements fit into five (5) basic areas relative to climate: 1) shade, wind, hail structures, 2) protection from precipitation, sun and wind, 3) protection from all the above as well as venting to prevent heat from being trapped below the structure, 4) buildings containing the above plus requiring cooling, 5) buildings requiring sun for heating. These building types could fit within different geometric and structural systems based on the pole grid system, and fit into four areas: 1) single-pole system, 2) double-pole system, 3) four-pole system and 5) diagonal-pole system. These climate and geometric shapes are summarized below.

(missing diagram)

To understand the significance of these basic form types in three-dimensional plan, the following pages summarize a computer generation if different building types that could conceivably be found on the farm. Some are structurally more difficult to accomplish than others. For this reason, the proposed farm system only uses those building types that seemed most feasible to accomplish while utilizing the maximum number of repeated elements found in other structures. The list that follows on the next four pages includes all types.

The proposed Laredo farm system uses a specific cross section of these building/climate types. These include: 1) an office maintenance shed, 2) bathroom and bathing facilities for workers, 3) packing sheds, 4) shade structures for seedlings, 5) high tunnel greenhouses, 6) a protective shed for the filter system, 7) solar dryers, 8) houseplant greenhouses, 9) a solar refrigeration system, 10) a compost system, 11) a photovoltaic system, and 12) a water/wastewater system. Of these, 4), 5), 8), and 10) are not projected into the budget for this period, and 4) (shade structures) is not included in the original budget for this period but is proposed to be built. The sire is directly south of the large tank near the center of the farm. The proposed site plan uses the diagonal of the four-pole grid as its south orientation, setting the grid askew to the north/south axis by 45 degrees. The proposed site plan including all buildings is shown below:

(missing diagram)

A symbolic representation of the above site plan showing materials and functions appears below.

(missing diagram)

An explanation of how this symbol system has been incorporated into a…

(missing two pages of diagrams)