SEEDS OF SUSTAINABILITY

Seeds of Sustainability
Lessons from the Birthplace of
the Green Revolution

Edited by
Pamela A. Matson

Washington | Corvallis | London

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TIMELINE FOR AGRICULTURAL DEVELOPMENT IN THE YAQUI VALLEY, 1890–2004

- 1890 The Ministry of Development grants to Carlos Conant the right to open irrigation channels on the margins of the Yaqui, Mayo, and Fuerte Rivers and to launch their colonization.
- 1891 Conant and US investors establish the Sonora and Sinaloa Irrigation Company to execute the contract for irrigation and colonization.
- 1900 The Sonora and Sinaloa Irrigation Company completes 39 km of channels from the Yaqui River.
- 1901 The Sonora and Sinaloa Company goes bankrupt.
- 1902 The Sonora and Sinaloa Irrigation Company and its shareholders reach an agreement on payments. The company pays its debt with land.
- 1903 Conant receives a new concession from the Ministry of Development to irrigate and colonize the Yaqui Valley.
- 1904 Conant begins the *Compañía de Irrigación del Valle de Yaqui* to accomplish development work in the valley.

The Sonora and Sinaloa Irrigation Company sells its rights to the Richardson Construction Company, a California-based land development company.
- 1907 Conant dies at the age of 63.

The railroad reaches the point known as Esperanza Station, which, years later, gives rise to Ciudad Obregón.
- 1909 Richardson Construction Company forms the *Compañía Constructora Richardson* and negotiates a new contract with the Ministry of Development regarding construction and colonization.

David Richardson begins a new company, the Yaqui Land and Water Company, with an initial capitalization of US\$15 million.

Esperanza Station grows to a population of 450.

- 1911 Compañía Constructora Richardson establishes an agricultural experiment station and publishes a crop calendar, including recommendations for 72 crops.
- 1913 Civil war extends into Sonora.
Farmers in the Yaqui Valley plant 11,000 ha.
- 1914–17 Development in the Yaqui Valley is delayed because of the war.
- 1920 The government and the Yaqui people sign a peace agreement, concluding fifty years of intense warfare.
- 1925 Irrigated area increases from 15,000 to 37,000 ha.
- 1926 The government cancels the concession to the Compañía Constructora Richardson and buys its shares of the Yaqui Land and Water Company, paying US\$6 million. The company turns all of its shares over to the government development bank.
- 1927 The State of Sonora declares the creation of Cajeme County.
Agricultural producers organize a research station.
- 1928 The National Bank of Agricultural Credit takes over the irrigation system and land.
- 1930 Cajeme County (including Ciudad Obregón) grows to a population of 12,000.
- 1936 The National Bank of Agricultural Credit assumes control of development but later transfers control to the National Irrigation Commission.
- 1937 The government applies the Land Tenure Law and expropriates private land to distribute among new *ejidatarios*. Altogether, 17,000 ha of irrigated land is distributed to *ejidatarios*, with 27,000 ha remaining in the private sector. An additional 34,000 ha of new land is also allocated to *ejidatarios*.
The government launches the construction of the Angostura Dam.
- 1938 Farmers harvest 53,000 ha.
- 1940 Cajeme County grows to a population of 28,000.
- 1942 Angostura Dam is completed, adding an additional 60,000 ha of irrigated area.
- 1943 The government and the Rockefeller Foundation launch a collaborative agricultural research program, forerunner of the International Maize and Wheat Improvement Center (CIMMYT).

- 1950 Cajeme County grows to a population of 63,000.
- 1951 Wheat yields average 1.5 t/ha.
The government creates the Yaqui Valley Irrigation District.
- 1953 Oviachic Dam is completed, adding 108,000 ha of irrigated area.
- 1955 Farmers in the Yaqui Valley harvest 210,000 ha of crops.
- 1960 Cajeme County grows to a population of 124,000.
- 1961 The government establishes the Instituto Nacional de Investigaciones Agrícolas (INIA), the National Institute of Agricultural Research.
- 1963 Improved seed from CIMMYT is first released to producers.
El Novillo Dam is completed, mostly for electricity generation, but also allowing total Yaqui Valley irrigated area to grow to 233,000 ha.
- 1964 100% of producers use improved seed.
- 1966 International Maize and Wheat Improvement Center (CIMMYT) is formally established as an international center.
- 1970 Cajeme County grows to a population of 183,000.
Wheat yields average 3 t/ha.
- 1975 The government expropriates 34,000 ha of private irrigated land, which is transferred to new *ejidos*. The Yaqui Valley is thus divided among private landowners (41%), *ejiditarios* (55%), and colonists (4%).
- 1980 Cajeme County grows to a population of 256,000.
- 1990 Wheat yields average 5 t/ha.
- 1994 Whitefly invades the Yaqui Valley.
- 2000 Wheat yields average 6 t/ha.
- 1997–2004 Regional drought seriously depletes reservoir levels for the Yaqui Valley.

ACRONYMS

- AOASS** Asociación de Organismos de Agricultores del Sur de Sonora (Association of Producer Organizations of Southern Sonora)
- ASERCA** Apoyos y Servicios a la Comercialización Agropecuaria (Support and Services for Agricultural Marketing, Mexico)
- BANCOMEXT** Banco Nacional de Comercio Exterior (National Bank for Foreign Trade, Mexico)
- BANRURAL** Banco Nacional de Crédito Rural (National Rural Credit Bank, Mexico)
- CGIAR** Consultative Group on International Agricultural Research
- CIMMYT** Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center, Mexico)
- CIRNO** Centro de Investigación Regional del Noroeste (Research Center for the Northwest Region, Mexico); formerly CIANO (Centro de Investigación Agrícola del Noroeste)
- CNA** Comisión Nacional del Agua (National Water Commission, [CONAGUA] Mexico)
- COFEPRIS** Comisión Federal para la Protección contra Riesgos Sanitarios (The Federal Commission for Protection Against Health Risks)
- CONASUPO** Compañía Nacional de Subsistencias Populares (National Company of Basic Commodities, Mexico)
- ENSO** El Niño-Southern Oscillation
- EPA** Environmental Protection Agency (US)
- EQIP** Environmental Quality Incentives Program (US)
- FERTIMEX** Fertilizantes Mexicanos (Mexican Fertilizer Company, Mexico)
- FIRA** Fideicomisos Instituidos en Relación con la Agricultura en el Banco de Mexico (Trust Fund for Agriculture, Mexico)

FIRCO Fideicomisos de Riesgo Compartido (Trust Fund for Shared Risk, operated by the Ministry of Agriculture, Mexico)

FONAES Fondo Nacional de Apoyo para Empresas en Solidaridad (National Fund for Social Enterprises, operated by the Department of Social Development, Mexico)

GATT General Agreement on Tariffs and Trade

INEGI Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography)

INIA Instituto Nacional de Investigaciones Agrícolas (National Institute of Agricultural Research)

INIFAP Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (National Institute of Forestry, Agriculture, and Livestock Research)

ITSON Instituto Tecnológico de Sonora (Sonoran Institute of Technology)

NAFTA North American Free Trade Agreement

NARS National Agricultural Research System

OECD Organization for Economic Co-operation and Development (Paris, France)

OSHA Occupational Safety and Health Administration (US)

PAIS Programa Agrario Integral de Sonora (Integral Agrarian Program of Sonora, Mexico)

PEMEX Petróleos Mexicanos (Mexican Petroleum Company, Mexico)

PIEAES Patronato para la Investigación y Experimentación Agrícola del Estado de Sonora (Agricultural Research and Experimentation Board of the State of Sonora)

PROCAMPO Programa de Apoyos Directos al Campo (Direct Farmer Support Program, Mexico)

PROCEDE Program de Certificación de Derechos Ejidales y Titulación de Solares Urbanos (Program for the Certification of *Ejido* Land Rights and the Titling of Urban House Plots, Mexico)

SAGARPA Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food, Mexico)

SEMARNAT Secretaría del Medio Ambiente y Recursos Naturales (Ministry of the Environment and Natural Resources, Mexico)

WTO World Trade Organization

P R E F A C E

This book is being completed in the second half of 2010, but the story it tells stretches from the early part of the 1990s until the late 2000s. It is a story about an agricultural region in the very early stages of what we hope will be a sustainability transition. It is also about the interdisciplinary team effort to which we devoted our time and energy for many years, an effort that has resulted in some important things—scientific discoveries, new management tools for crop production and water resource management that are now used well beyond the Yaqui Valley itself, new perspectives on how knowledge and action can be most effectively linked, new insights into interdisciplinary research and outreach, and new insights into sustainability transitions. It is also a story about frustrations—research that didn't get done, relationships that we struggled to develop and maintain, knowledge that we could not link with action. Despite those frustrations, this has been an exciting and useful project, and we hope the book communicates some of that.

The operational origins of the Yaqui Valley project trace to an event in 1992. During the summer of that year, Rosamond (Roz) Naylor (an economist) and I (a biogeochemist) hosted a two-week workshop at the Aspen Institute for Global Change. Each year, the Aspen Institute tackles interdisciplinary issues related to global environmental change, and among its goals is the hope of improving the interactions between natural and social scientists in order to address these issues. The focus of this particular workshop—at the interface of food, agriculture, and environmental issues—was an outgrowth of discussions at a biweekly forum of environmental faculty from all disciplines that Roz had begun at Stanford University three years earlier. The institute's twenty plus participants included Peter Vitousek, a Stanford biologist, Walter Falcon, a Stanford economist, and Donald Winkelman, an economist who was then the director general of the International Maize and Wheat Improvement Center (CIMMYT) headquartered in Mexico. All were critical to making this project a reality. G. Philip Robertson, an ecosystem ecologist at Kellogg Biological Station (Michigan State University) with enormous experience in agricultural

systems, was also a major and influential player in these discussions, and there were many other social and biophysical scientists as well.

Discussions at Aspen were provocative and wide ranging. After amusing and sometimes exasperating interchanges, for example, on the meanings of *productivity* in our different professional languages, we found common cause in sustainability issues related to nitrogen fertilizer and its agronomic and environmental effects, irrigation, and agricultural policy. We also found common cause in our focus on high-productivity agricultural systems of the type that now feed most of the planet's people, even though we realized that sustainability challenges might be more easily addressed in small, local, and even subsistence systems where decisions are less externally driven. Several research proposals were roughed out during the discussions at Aspen, but interestingly, the Yaqui Valley per se played no role in them.

The location issue was resolved in a second key meeting held at CIMMYT headquarters in Texcoco, Mexico. As a follow-up to Aspen, Winkelmann invited several of us to Mexico in 1993 to interact with members of his professional staff, especially those from the wheat program. CIMMYT was beginning to move more aggressively on environmental questions, and the head of the wheat program at the time, Anthony Fisher, felt that collaboration with Stanford might prove both scientifically and politically valuable. Soon the discussion moved to *who* and *where* questions. Those questions were answered simultaneously with the inclusion of Ivan Ortiz-Monasterio, a senior CIMMYT agronomist located in the Yaqui Valley at CIMMYT's premier wheat experiment station. In the years that followed, Ortiz-Monasterio became the lynchpin in the leadership trio, serving as both research coleader and our most critical boundary-spanning individual, linking our research community with the farmers and decision makers of the valley, who are his friends.

Those early discussions across disciplines and across nations were critical to launching this project, but they were leavened by other critical influences that helped the project evolve. Perhaps most important for me was my involvement as a board member of the National Research Council's (NRC) Board on Sustainable Development, starting in 1994 and extending through 2000, and then as a leader of the NRC Roundtable on Science and Technology for Sustainability through the 2000s. Those roles challenged me to see the world through the eyes of the many other member experts, all of whom represented different disciplines and walks of life related to sustainable development and environment. Most critical of those members were Robert Kates, geographer emeritus from Clark University and the

cochair of the NRC board, and William Clark, the Harvey Brooks Professor of International Science, Public Policy, and Human Development at the Kennedy School at Harvard University. Their early engagement in, and encouragement of, the Yaqui research helped lay the groundwork for much of the most integrative research that followed. Indeed, Bill Clark played an instrumental role throughout this project, especially in the knowledge systems research and vulnerability research discussed in this book. At the same time, I think it is fair to say that the Yaqui Project, a real honest-to-goodness, on-the-ground project, brought real-life experiences and perspectives to ground the board and roundtable discussions, and influenced the work of subsequent projects and committees. Ultimately, I hope that it contributed to the emergence of the field of sustainability science and encouraged others to work within place-based, human-environment systems in a quest for sustainability.

Other influences were also critical. The perspectives of the International Geosphere-Biosphere (IGBP) and Human Dimensions of Global Change Programs (IHDP) underlay much of our early interest in greenhouse gases, agriculture, and land-use change, and NASA's land-use/land-cover change program funded some of the early research. Perspectives from the Consultative Group on International Agricultural Research (CGIAR), of which Wally Falcon was a board member, influenced our perspectives on food security, food production, and sustainable agriculture. Roz Naylor and Ivan Ortiz-Monasterio brought their expertise on different dimensions of those perspectives as well as their enthusiasm for interdisciplinary problem solving. CIMMYT and its leaders made it possible to do the work.

For me personally, my husband and Stanford professor Peter Vitousek was a continuing and most important influence. He is an ecosystem ecologist and a global change scientist who has an uncanny ability to see the whole system and to identify the really important things to be done. He helped launch this project, advised throughout, read many manuscript drafts (including parts of this book), and with our kids, Mat and Liana, held down the fort at home during my many trips to the Yaqui Valley. Wally Falcon was a research team member but so much more—his savvy in the international agricultural world made many things possible, his wisdom kept us on track, and his writing abilities helped us to both find funding and get the word out. In addition to the authors of this book, Stephen Gorelick, a hydrologist, Karen Seto, a geographer, and Steven Monismith, a physical oceanographer, all professors at Stanford, brought their knowledge and expertise and ideas and great students to the project, as did Tracy Benning, Greg Asner, and many other scientist friends. José Luis Minjares

of the Mexican Water Commission and Carlos Valdes-Casillas, who was at the Monterrey Technical Institute in our early years, brought management reality to much that we did, and José Luis, along with Ivan, were essential linkers of knowledge and action.

Of course, there were many other people from Mexico and the United States who made the project work; the individual chapters of this book include acknowledgments of them. My personal thanks go to Peter Jewett, who managed the Matson lab through much of the research and has played a critical role in getting this book to press, and to Tina Billow, who managed in the start-up phase and in the “buried-in-data” stage, keeping multiple projects going in the field and lab. Lori McVay was our administrative leader throughout, and Ashley Dean, our research coordinator for much of the project; without them we could not have grown and expanded in the way we did. Mary Smith helped make our meetings happen efficiently and with great fun. These, our students and post docs, and countless other people made the Yaqui Project vibrant, and its successes are thanks to them. Finally, a great many funding sources made this work possible; they are listed in individual chapter acknowledgments, and include the Packard Foundation, the USDA, NASA, NOAA, and NSF, the Ford Foundation, the Pew Charitable Trusts, the Hewlett Foundation, the Andrew Mellon Foundation, and the MacArthur Foundation (whose generous fellowship to me helped give me the freedom to start down this road). The Packard Foundation provided the critical support that allowed us to develop an interdisciplinary effort rather than a project with many disciplinary pieces, and it also supported the synthesis effort that resulted in this book as well as other outreach products.

We hope that the contributions discussed in this book are lasting ones, both to the Yaqui Valley and, more broadly, to the field of sustainability science.

Pamela Matson