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"DAMS" ON THE CANDELARIA

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Abstract

Much has been learned from the basin of the Candelaria River, Campeche, Mexico: the fabric of a densely settled pre-Historic landscape, including impressive ceremonial centers; the logistics of an ancient entrepôt; the process of exploitation of dyewood and *chicle* in historic times; as well as the doubtful results of the mid-twentieth-century colonization of an "empty" forested basin. It also yielded the first evidence of more or less intensive pre-Hispanic wetland agriculture in the Maya region and the remains of a profuse network of fluvial transportation from prehistoric times to the present. This article presents recent evidence regarding the management of the river system itself by means of barriers, or "dams," which facilitated agriculture in the wetlands upstream and extensive canoe travel. These structures seem to be elaborations or imitations of the numerous natural barriers already in the stream. Two models help explain context and function. It has become apparent that the human interventions into the wetlands and the river system are to be seen less as great attainments of civilization than as fairly desperate expedients in the face of climate change.

The Candelaria River basin in Campeche continues to yield new insights regarding pre-Hispanic land and water management (Figure 1). Earlier investigations suggested a new paradigm for subsistence in the lowlands of Mesoamerica, raised a polemic regarding the interpretation of the remains of canals, and contributed to the conceptualization of landscape diachrony in tropical lowlands (Figure 2). A key site (El Tigre) is under investigation by Mexican colleagues. In 1997, eight rocky impediments—"dams" in a qualified sense—were identified in the main channel, in addition to apparently related mounds, previously unappreciated wetland agricultural areas, and canals.

The initial work on pre-Hispanic wetland agriculture and transportation in the late 1960s focused on the basin of the Candelaria River upstream of the railway bridge at the town of Candelaria. Salto Grande, an array of falls some 14 km downstream from the bridge, was taken as a natural impediment to river transportation and as the western limit of Acalan, the pre-Hispanic culture region with many remains of intensive wetland agriculture and various kinds of canals. It has become apparent that the river floodplain is really an attenuated lake, particularly in the wet season; that Salto Grande is in part an artificial barrier; and that there are more such constructed impediments both upstream and downstream. Some sidestreams have barriers at their mouths, as well. The hydrology of the whole basin seems to have been managed. The challenge now is to understand how this was done, and it is irresistible to speculate on why it was done.

This article reports on the exploration of these impediments and the testing of the contention that they are man-made dams. We note the typical landscape context of these structures and related features and reflect on conceptual and substantive issues, including climatic change.

ANTECEDENTS

Frank V. Scholes and Ralph L. Roys (1968:50) excellently portrayed the basin of the Candelaria River around the time of Conquest Acalan,"the place of the canoe." Various archaeological investigations have been undertaken in the basin, especially at the site of El Tigre, usually accepted as Itzamkanac, the capital of Acalan (Ochoa 1986; Piña Chan and Pavón Abreu 1959; Vargas Pacheco 1994, 1995, 1997). The post-Conquest history of settlement, resource use, and transportation, has been undertaken by Sophia Pincemin (1993) and Claudio Vadillo López (1994), whose historical studies inform the interpretation of prehistory.

Our own work in the basin in the late 1960s and early 1970s provided the first evidence of pre-Hispanic wetland agriculture in the Maya region and traced a variety of types of canals (Siemens and Puleston 1972). Essays followed on the karstic context of the basin and many aspects of wetland agriculture in lowland Mesoamerica (Siemens 1978, 1983, 1989). They always included extensive use of original, oblique air photos.

In the 1990s, Siemens and colleagues "revisited" various wetland sites in the Gulf lowlands, testing earlier hypotheses (Heimo 1998; Siemens 1996, 1998; Sluyter 1994). Along the Candelaria this yielded a great deal of new physiographic, hydrological, and cultural geographic data, as well as numerous altitudinal measurements with a "total station" in the circum-El Tigre landscape, including links with sea level. New cores and lab analyses enhanced our interpretation of the basin's paleoecology.

In 1995, we were introduced to José Angel Soler Graham of the town of Candelaria. He had discovered a series of impediments in the river between the town and falls to the west called the Salto Grande, and he prepared a map that is remininscent of

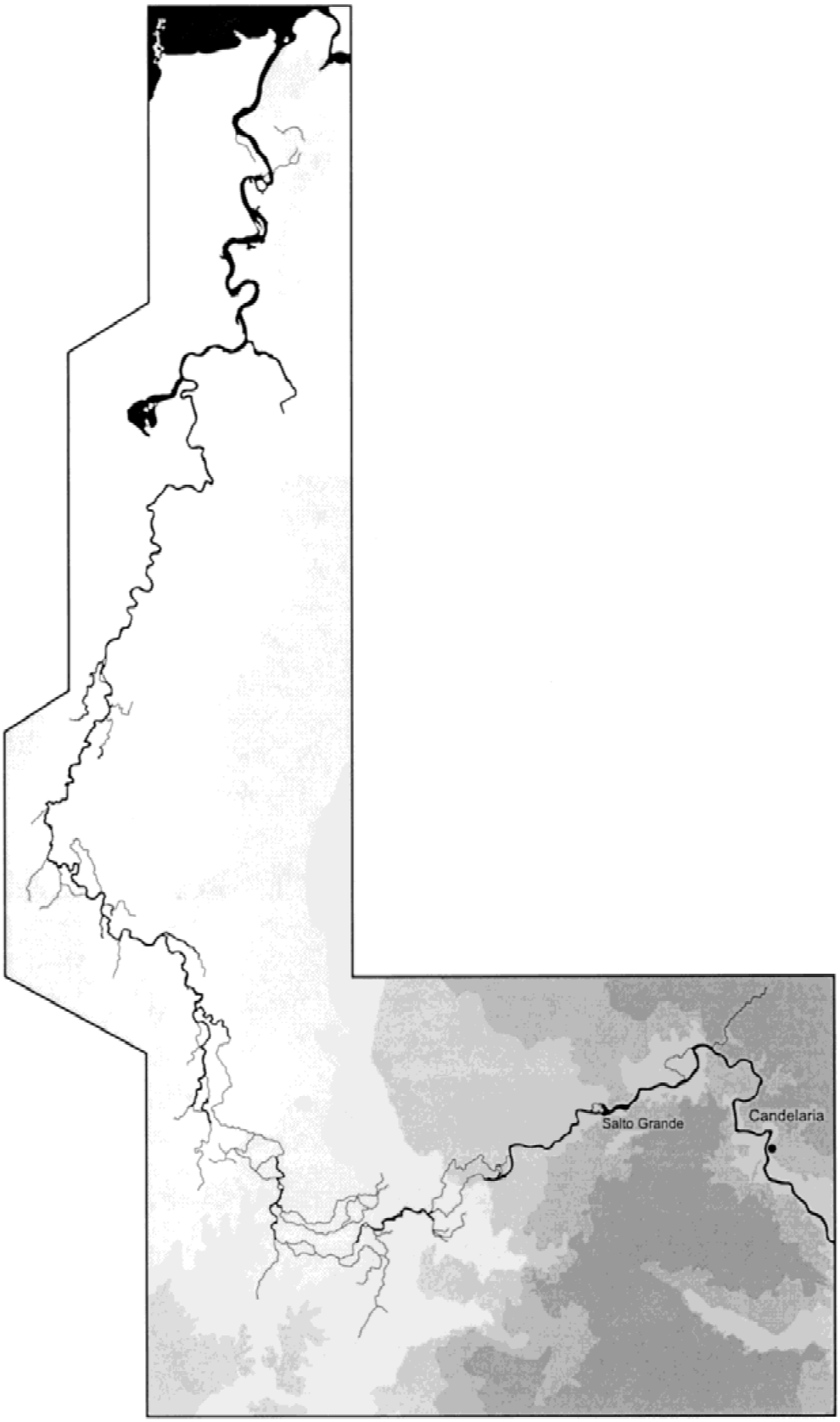

Figure 1. The Candelaria River below the town of Candelaria, in the state of Campeche, with surrounding topography. Most of the larger dams investigated to date are between the town and the falls at Salto Grande. There are numerous lower falls downstream, some over natural barriers and others over modified barriers. The river runs into the Laguna de Terminos.

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Figure 2. Complex of raised fields and canals in an embayment of the floodplain of the Candelaria River. The heuristic model presented in Figure 5 can be applied from the left lower corner to the center of the photograph (photograph by Alfred H. Siemens).

the sixteenth-century *pinturas* required of the authors of *relaciones geográficas* (Figure 3). The map is unscaled but shows the dimensions and forms of the impediments quite well, and it is based firmly on the premise that they are artificial. Soler has since produced several other very instructive maps of the river system.

Several field trips were undertaken by Siemens and Soler in 1999 and 2000: one to plot and measure the seven structures between the town of Candelaria and the Salto Grande (see, e.g., Figure 4), and two others in a freight canoe from the town to the sea to clarify the nature of waterborne transportation in historic and prehistoric times, as well as to explore impediments further and transect surrounding landscapes. Soler has undertaken several independent exploratory trips, during which he discovered more intriguing structures in the main river and its tributaries.

Several lines of thought and practice have dominated this investigation. First is the venerable discipline of the "reading" of landscapes—the consideration of what is around and between sites. Then there is the paradigm of environmental history (or historical ecology), which is currently useful in articulating relationships between people and their natural environment (see, e.g., Balée 1998:2). This paradigm facilitates the treatment of substantive

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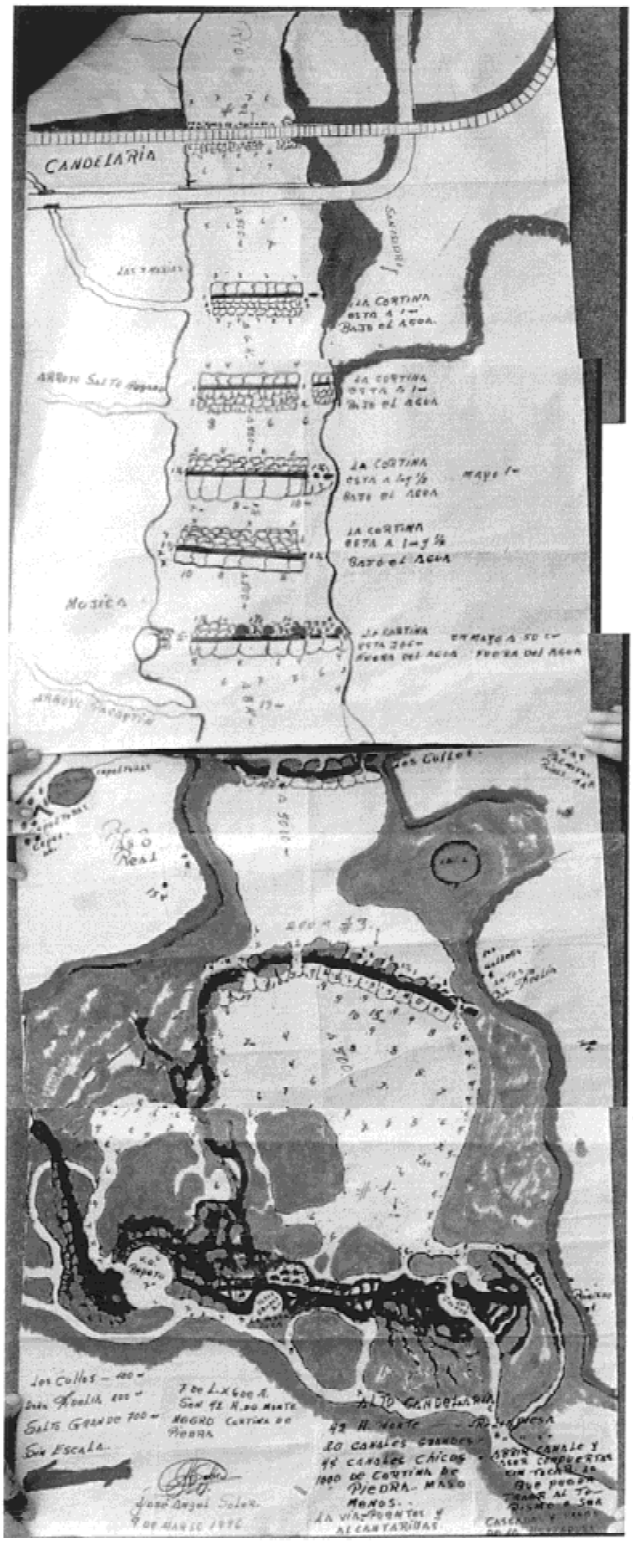

Figure 3. "Dams" along the Candelaria River between the town and the Salto Grande, according to José Angel Soler Graham.

issues such as the effect of climatic change on cultural development (Curtis et al. 1996; Steig 1999), the interlacing of evidence of various kinds out of various epochs (Siemens 1998), and the extraction of lessons form the distant past for the pathology of the present.

Explanations of the various aspects of hydrological management that interest us here are facilitated by some modeling—first, a reduced heuristic model of wetland margins, which are ecologically highly dynamic parts of the tropical lowlands, and then a more specific model of the typical landscape features found between stream and terra firma in the Candelaria's floodplain.

HEURISTIC MODEL

The typical topographic, geomorphological and hydrological context of wetland margins can be represented along a gentle slope (Figure 5; Siemens 1998: 36–44). Over this raked stage one can also array prehistoric, historical, and contemporary land use and trace processes of change.

HYDROLOGICAL PARAMETERS

The wetlands to which the model mostly applies are found on substantial accumulations of quaternary sediments, notably in a series of marine embayments along the Gulf coast filled in during the Holocene epoch. Of particular interest have been wetlands on the floodplains of rivers with seasonally dampened regimes—that is, the streams with limited lowland catchment basins that enter larger, through-flowing streams near their mouths, or streams arising in karst, where the storage and delayed release of rainwater from the porous rock moderates the yearly highs and lows of stream flow, as in the case of the Candelaria.

The outflow of through-flowing streams such as the neighboring Usumacinta is usually monitored, but the seasonal variations in water levels in the lesser streams and on the floodplains themselves are not. That information must be elicited ethnographically or observed directly. The common yearly rise of water levels on floodplains, which may vary in extent and impact from year to year, represents benign—indeed, necessary—flooding that involves a difference between maximum and minimum levels of only a meter or two. Occasionally, especially when hurricanes affect such a basin, water levels may be much higher than normal, bringing about a great deal of destruction, as happened along the Candelaria in 1963 and again in 1995.

ELEMENTS

The model posits a landscape with three main elements, or zones, each with specific physical environmental characteristics and offering specific points of departure for a discussion of use and change. At the upper end is terrain that is normally safe from inundation but that does not benefit from it (Zone A); farther down is the ecotone between high water and low water (Zone B); and at the bottom is the terrain taken up by swamps, in which water is just above or below the surface in even the driest period, or by lakes (Zone C).

Terra firma (Zone A) can take various forms. It may be part of the calcareous hill land that borders much of the floodplain of the Candelaria or islands of such terrain within the floodplain. It may also consist of the higher reaches of natural levees, terrain that normally does not flood. This recent alluvium is topped by well-drained soils that remain moist through seepage and capillarity during the dry season; they are prime agricultural land. Both levee

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Figure 4. One of the "dams" on the river between the town and the Salto Grande. The structure was breached to facilitate navigation (photograph by Alfred H. Siemens).

tops—the "islands" and the higher, safe margins landward of the floodplain—also serve as settlement sites, now as in the past.

At the base of the model, in Zone C, is the more or less open water of swamps or lakes, thick with patches of hydrophytes and forests of various kinds. It is easily set aside in a discussion of contemporary land use because it often constitutes a perceptual blank; people seldom go there. It was probably less of a blank for the ancient inhabitants who constructed canals and planting platforms just upslope, but rather an area in which to obtain important supplements to agriculture by hunting and fishing. It draws hunters still.

Zone B is the terrain subject to seasonal flooding. It is an *ecotone*, a term that has been used mainly with respect to the margins of ranges of plant and animal species and thus must be regarded as a metaphor in the discussion of human land use. It is commonly considered a zone of transition between two communities; within it, various *seres*, or processes of biotic succession, are in juxtaposition. It is highly attractive to a variety of flora and fauna, which leads toward a greater variety and density of species than in the communities flanking it—the "edge effect" (Odum 1971). Each seasonal flood deposits greater or lesser amounts of new sediment, enhancing fertility.

Left to itself, Zone B is likely to be covered in forest, probably *selva mediana subperennifolia*—that is, a tropical forest of medium height. Human use leaves only successional species. The soils are dark and clayey; they crack extensively during the dry season and swell again with the rains. This terrain was and is of great interest to agriculturalists who are able to grow dry-season crops on it and thus supplement their agriculture on the neighboring hill land in critical ways. In pre-Hispanic times, wetland agriculture here was intensified by the cutting of canals and the building up of planting platforms. The purpose of placing impediments in

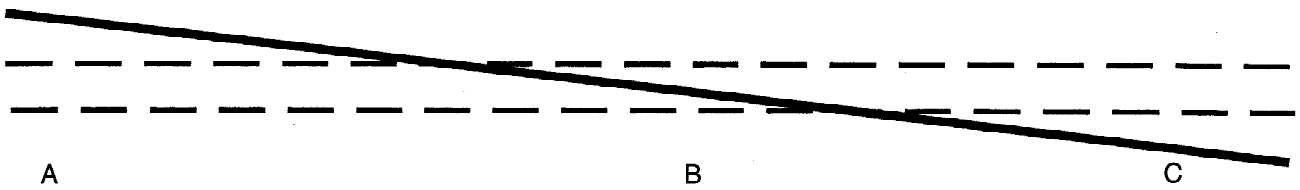

Figure 5. A heuristic model of the wetland margin. Zone A is terrain that is normally safe from inundation but does not benefit from it; Zone B is the ecotone between high water and low water; and Zone C is terrain taken up by swamps or by lakes.

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the main stream and its affluents would have been to maintain water levels in Zones B and C sufficient for canoe transportation and wetland agriculture.

Typical Sequence of Landscape Features in Basins of Rivers with Subdued Regimes

A further schematic profile is of use (Figure 6), a model of tropical lowland cultural landscapes maintained by dams in the main stream of the Candelaria and its tributaries—an exemplification of the preceding, more theoretical model.

The river. The Candelaria, as noted, is not one of the large rivers that cross the lowlands from much denuded mountain terrain to the sea. It is a river with a limited, karstic catchment that dampens fluctuations, as occurs on both the eastern and western flanks of the Yucatan Peninsula.

The Candelaria was not only the lifeline of the agriculturally highly productive Acalan region, but also part of a trans-Mesoamerican network of routes for trade, diplomacy, and espionage. Acalan was centered in Itzamkanac, an entrepôt along the river. This is the site that is currently called El Tigre. Acalan and neighboring regions were frequently in conflict, so waterborne skirmishing can be inferred. In historic times, the river served the extraction of dye-wood, timber, and chicle and eventually colonization.

Acalan was facilitated by impediments on the river. These are "place-making" features, as Antoinette WinklerPrins (personal communication, 2000) has aptly called modifications in the banks of side channels of the Amazon. The impediments kept the water high enough to allow canoe travel and seasonal fluctuations within the technological limits of intensive wetland agriculture. In other words, they made the flourishing cultural landscape described in the early Spanish documents possible (Scholes and Roys 1968).

Levee (Zone A in the heuristic model; Figure 5). In a regime such as that of the Candelaria, the levee is not very high, but sometimes it sustains a gallery forest. Throughout the lowlands, the levee has often been a prime location for settlement, gardens, and dry-season cropping. It remains a favored location for easily accessible dry-season crops.

Wetlands (Zones B and C). In the Candelaria basin, the wetlands are essentially attenuated lakes that may dry out enough in a tough dry season to allow crossing on foot. The sediments revealed by cores are largely lacustrine. In places, these wetlands are patterned by the remains of raised fields. They are also scored by the remains of various types of canals. Those between the planting platforms served as means of access and as sources of *riego a brazo*, a baffle to retain groundwater during the dry season and the runoff from springs on the landward side. Others served for transport across the alluvial plain to neighboring hill land. These often take the form of bundles of successive lines of various degrees of clarity; one among them that was recently cut and is still in use. Some of those lines are attributable to the removal of *palo tinto* (dye wood) in the eighteenth and nineteenth centuries, which had to be slid or taken out in hulls. There are also canal lines that run along the alluvial plain, cutting distances where the river is sinuous and allowing roundings in a time of riverborne menace. Fans of apparently contemporaneous lines were long thin lakes that served as fish nurseries.

"Islands" within the wetlands (Zone A). These are resistant outliers of various formations that make up neighboring terra firma—along the Candelaria River, they are karstic; elsewhere, they are composed of other materials. They are often capped by artifical mounds and littered with sherds. Where ranching predominates, wetlands provide choice dry-season pastures; corrals and milking sheds often perch on the islands. They usually remain dry during the seasonal high water.

Hill land, the terra firma proper (Zone A). From various important early Colonial documents analyzed by Scholes and Roys (1968), as well as our own field observations, settlement and agriculture can be deduced to have extended virtually continuously over the hill land of Acalan and its neighboring areas. Soon after the Conquest, the area was virtually abandoned, and reforestation ensued. With the in-migration of the twentieth century, especially the colonization of the 1960s, the hill land that for centuries had been mostly forested became a patchwork of *milpas* (maize fields), *acahual* (abandoned fields growing back into brush), and pastures surrounding substantial new communities. Until the recent construction of roads, it was always of critical importance to be able to move freely for planting, tending, and harvesting of crops from the main stream to this hill land, not only in the wet season, when it would be relatively easy to cross open water, but also during the dry season. The exploitation of chicle and palo tinto required similar access, as did pre-Hispanic agriculture on terra firma.

The Dams

These structures consist of substantial walls of placed rounded rocks transverse to the current (Figure 4). Soler initially showed them as unequivocally artificial—in fact, as though they were of masonry (Figure 3). On close examination, however, they are not so easily recognizable as artificial. It was obviously necessary for the builders to search out rocky foundations in the river bed and to adapt to the configuration of existing ledges, perhaps to enhance existing barriers. Some of the dams are bold, fairly straight lines drawn across the current; others are irregular. Also, the water com-

Figure 6. A schematic profile of a wetland landscape along the Candelaria or one of its tributaries. Its relationship to Figure 5's heuristic model is explained in the text.

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ing out of a calcareous basin encrusts anything left in it: bottles, shoes, branches fallen in from surrounding trees, and rocks. It is difficult to judge the joints.

From information gathered through soundings and dives over each of the structures between the Salto Grande and the town of Candelaria during the course of one day in 1999, dam heights were correlated with the level of the water in the river on that particular day. The river's gradient in the 14 km involved has been disregarded; it cannot have been more than a few tens of centimeters. Varying average heights present some of the most intriguing aspects of this investigation. What was the order of construction? What were the various constraints? Why do some of the dams appear to face upstream and others downstream? Much remains to be deciphered—or, perhaps more accurately, to be imagined. However, it does seem plausible to envision a sequence of ever bolder structures, even a construction sequence that would temporarily lay the channel dry in order to allow for the construction of larger dams.

Soler's map (Figure 3) show gaps in the structures, which he interprets as "*compuertas*," or gates, with logs or stones used to open and close. Such manageable gaps would indeed seem logical aspects of the total riverine manipulation.

Enter historical evidence, the overlay of all of our pre-Hispanic remains. Some of the gaps resulted from dynamiting to allow the transport of logwood or chicle downstream and merchandise upstream. Shipping was vital and always difficult. Good piloting was necessary to thread the gaps and run the rapids. All of this would have constituted a defense as well as a challenge for the inhabitants of pre-Hispanic Acalan. The basin was eventually made accessible by the railroad and roads; the latter led to the atrophication of river transportation. The impediments in the river channel may soon be turned to advantage: The lower Candelaria is expected to be made into a kayak run, and the higher islands in the stream will be cleared and topped with *palapas;*mo;que;4. Another suggestion has also been made, arising from the destructive floods of 1995: Why not dynamite the impediments thoroughly to hasten outflow and hence minimize flooding?

REFLECTIONS

Importance of Non-Prejudicial Terminology

We have insisted on using proto-*chinampas* rather than just *chinampas* as a synonym for "raised fields." There are differences between the two in the elaboration of water and land management. It has been important to recognize multiple hydrological functions in the remains of canals—not just reflexively drainage or irrigation, but both, and storage in various combinations.

Obviously, in this investigation the use of the term dam is still qualified. Even if an impediment looks like a dam and acts like a dam it may not be artificial—or, at least, not entirely artificial. However, since the beginning of this investigation evidence of artificiality has steadily strengthened.

Lessons Learned from Nature

It is logical to think that many expedients adopted through time in the management of land and water have resulted from taking advantage of processes that were already under way. For example, a stream can be manipulated with simple barriers in order to direct sedimentation in such a way that it builds terraces. The enriching, cleansing effects of seasonal flooding may be incorporated as a key element in river floodplain agriculture. Swamps tend to fill themselves in naturally and unevenly with hummocks; raised fields can be interpreted as enhanced hummocks.

The observation of the retaining effect of impediments in the river could easily have led to enhancements of that effect by evening out and raising the levels of the impediments. Further, the inclusion of gates would have allowed a certain amount of flood control. Natural, artificial, or combined types of impediments in the river seem to have been critical to the maintenance of water levels that were sufficient for transportation and intensive agriculture in wetlands, and thus the sustenance of considerable pre-Hispanic communities. This was the effect not only for Acalan itself, but also, according to new evidence, for areas up- and downstream of Acalan. Barriers found just north of the border with Guatemala apparently helped to maintain water levels in waterways into the interior of the Peten. Barriers downstream of Salto Grande apparently sustained "mini-Acalans" around tributaries of the Candelaria.

Regarding the Evidence

Along the Candelaria, as well as in detailed landscape studies elsewhere in the lowlands of Mesoamerica, we have had to interlace different types of evidence. While considering the prehistoric, we have been made aware of the historic and have been surrounded by the contemporary. Pre-Hispanic remains in the river, discovered and presented by a self-taught aficionado, have been investigated in a more or less scientific manner. Their interpretation has been forged in discussions from out of these two backgrounds, spiced by ethnohistorical accounts and informed by analogues as well as by written historical accounts, each out of its own world. If one accepts the metaphor of landscape as text, then this is intertextuality indeed.

Dating

How does one date "dams" in this context? Mound groups are often found at the termini of cross-river impediments; they are, perhaps, points of maintenance and control. These remains themselves strongly suggest the artificiality of the impediments and their integration into a cultural landscape. Ceramic accordance between structures at the termini and settlements on terra firma would be helpful. This has not yet been explored systematically. We hope to do it collaboratively within the El Tigre project.

The sediments accumulated as the consequence of damming have been cored in four locations upstream of the main series of dams and dated. We have a fairly well controlled and accordant suite of dates around 7,000 C-14 years B.P. from the layer of dark organic material that lies under the clearly lacustrine sediments. This is much earlier than the Classic–Late Classic chronology that we entertain now for the planting platform and canal complexes and presents a major challenge in interpretation.

Climatic Change

Any reflection on climatic change in this context must be highly contingent, but the general indications are interesting. For one thing, our dates for the initial blockage of the Candelaria River coincide with some recently reported evidence on mid-Holocene drying in the tropics (Steig 1999:1485). Our work on raised fields and canals in the Candelaria basin and E. Vargas's (1994, 1995)

determinations regarding the chronology of its settlements allow an approximate match with a relatively dry period in the Yucatan Peninsula between 1,785 and 930 C-14 years B.P. (Curtis et al. 1996:37). It is apparent that the basin of the Candelaria shows the remains of adaptations to the stresses of drying at various times in its history.

It is difficult to relate our evidence of dams to the projection of long-term variations in the flow of the Candelaria from recent outflow data (Gunn et al. 1995). The run on which the projection is based is only 32 years. It does seem valid to deduce the behavior of the river from measurements near the mouth, because the "dams" detain but do not completely impound seasonal variations. These measurements, however, would lag behind climatic data and be smoothed out as a result not only of the "reservoir" effect of karst (Siemens 1978) but also of the detaining effect of the dams.

It is not difficult to credit the seriousness of drought in general and in Maya history, as Richardson Gill (2000) has recently developed. A return to "catastrophism"—environmental explanations of cultural change and broad-brush generalizations about a regionally varied cultural realm—are less satisfying (Demarest 2001).

When we began the investigation of the extensive remains of ancient wetland agriculture and waterborne transportation in the Candelaria basin, they were considered concomitant of greatness. That is how they were rendered in academic and popular publications. Recently, however, it has become plausible to think of this skilled and extensive management of water and land as an adaptation to straitened circumstances—even a massive indication of desperation in the face of climatic change. This is the central suggestion of this paper.

RESUMEN

De la cuenca alta del río Candelaria ya hemos aprendido mucho. El tejido y la historia de su paisaje fascinan; la arqueología ha revelado mucho de sus sitios principales. Numerosas humedales en la cuenca están configuradas con restos de varios tipos de canales y *campos elevados*, los cuales implican una agricultura prehispanica mas intensiva que la de la rosa-tumba-quema, el concepto heredado del sustento de los antiguas mayas. La meta principal de este ensayo será esbozar nueva evidencia sobre el manejo prehispanico del río mismo por medio de impedimentos artificiales, los cuales facilitaban la agricultura en humedales y transporte fluvial. El trato representa una convergencia entre exploración informal en el campo y analisis cientifico, y es meramente geografico: siempre vemos los restos contextualizado en su paisaje, el cual es representado en dos modelos.

Tuvimos que distinguir entre lo natural y lo construido. La geología de la cuenca presenta una serie de bancos liticos naturales que ya impiden el flujo y ocasionan caidas. Aceptabamos que el ser humano va aprendiendo de los condiciones y procesos naturales, extendiendolos. Deducimos que en este caso los inhabitantes antiguos, observando la retención de agua por los bancos naturales, y lo deseable de esto turo efecto en varios sentidos, modificaron, amplificaron or imitaron este efecto con estructuras artificiales basados sobre fundamentos naturales.

Los estructuras en los caudales se puede discribir sencillamente como *barreras*, construidos con piedras en tamaños mas o menos movibles manualmente y amontonables segun variaciones estacionales, anuales o mas largos en los niveles de agua adentro de la sistema. Parece bien claro que la función basica de los *barreras* era la retención del flujo del agua, mateniendo niveles en los caudales y canales suficientes para permitir transporte fluvial, y al mismo tiempo manteniendo niveles suficientes en los humedales colindantes para permitir agricultura mas o menos intensiva sobre los *campos elevados*.

Nuestros fechas para el bloqueo initial del caudal arriba del Salto Grande (7000 años mas o menos antes del presente) coinciden con evidencia recientemente publicado sobre una secación en el trópico en el medio del *holoceno* (Steig 1999:1485). Nuestro trabajo sobre *campos elevados* y canales in la cuenca y las determinaciónes de Vargas sobre la cronología de asentamientos (Vargas 1994, 1995) permiten una correlación aproximada con una época relativamente seca en la peninsula de Yucatan entre 1785 y 930 años radiocarbono antes del presente (Curtis et al. 1996:37). Ademas, tenemos el trabajo reciente de Gill (2000) sobre la alta seriedad de esta prolongada sequía.

En los primeras etapas de nuestro trabajo sobre agricultura y transporte en los humedales de la cuenca del río Candelaria vimos estos construcciones como grandes logros de la cultura maya. Asi fueron tratado en las publicaciones populares derivados. Recientemente nos ha parecido razonable cambiar el enfasís: todo esta grán gama de construcciones para la retención de agua por fines agrícolas y transporte fluvial indican una adaptación a un estrechamiento climático, no tanto grandes logros ni practicas ecológicamente sofisticadas y sustentables, sino intervenciones por desesperación.

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