Reports

New Perspectives on the Madrid Codex

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The pre-Columbian Maya of southeastern Mexico, Belize, Guatemala, and western Honduras had screen-fold books written in a hieroglyphic script and illustrated with pictures that dealt with a number of topics, including calendrics, astronomy, and ritual (fig. 1). In contrast to later colonial-period texts written by native Maya-speakers that were influenced by contact with Europeans, the Maya codices represent primary sources of information about pre-Hispanic astronomy, mythology, ritual, and daily life. At the time of the Spanish conquest in the middle of the 16th century, many of these books were destroyed by Spanish civil and religious authorities in their attempts to convert the Maya to Catholicism, and records exist of some of these destructions. As far as we know, only four of these books survive. One of them—the longest one—is known as the Madrid Codex because for more than a century it has been curated in a museum in Spain (now the Museo de América in Madrid). Exactly where this book was written and how and when it reached Spain have been quite uncertain.

Over the past century of research, scholars have debated the question where and when the Madrid Codex was originally produced and by whom. On the basis of its content and painting style, it has most commonly been linked to the Late Postclassic period (from the 13th century until the Spanish conquest) of the northern Maya lowlands (the Yucatán peninsula) (Coe 1987:161; Graff and Vail 2001; Love 1994:9; Taube 1992:1, 3; Thompson 1960:26; 1972:16), although there have also been suggestions from time to time that it derived from the Petén region of Guatemala (Coe and Kerr 1998:181; Porter 1997:41, 43–44; Thompson 1960:26; Villacorta C. and Villacorta 1976:176). Efforts to anchor the codex in both time and space are extremely important to Maya scholarship because the manuscript offers an in-depth look at rituals, deities, technologies, and material culture at a specific point in the past. The closer we can come to fixing a date and provenience for the manuscript, the more relevant this information becomes both in its own terms and for comparisons with archaeological and ethnohistorical material from a particular ethnic group and region.

In two workshops held at Tulane University on June 22–24, 2001, and February 28–March 2, 2002, researchers presented a series of papers addressing the theme "Issues in the Provenience and Dating of the Madrid Codex." The impetus for the first meeting was to examine claims that the Madrid Codex is a postconquest manuscript that was painted in the vicinity of Tayasal, as Michael Coe and Justin Kerr (1998:181) and James Porter (1997:41, 43–44) have proposed. Coe and Kerr base their interpretation on the presence of a piece of paper with European writing on page 56 of the manuscript, whereas Porter's argument is premised on depictions of two items that he interprets as being of European origin on page 39.

Rather than supporting this idea, the evidence presented by the workshop participants converged to suggest a Yucatecan provenience and a probable Late Postclassic date for the manuscript. The issue of whether the codex is pre- or postconquest has important implications for the interpretation of the information represented in it. If it was painted prior to Spanish contact in the middle of the 16th century, then it can offer researchers a detailed glimpse of Maya ritual, religious, and astronomical practices prior to acculturation and can be used to help understand the archaeology and material culture of the pre-Hispanic Maya area. It was the consensus of the workshop participants that the painted hieroglyphic and iconographic material in the manuscript is preconquest in date and that the paper with European writing that prompted Coe and Kerr to suggest a postconquest date for the codex is a later addition.

Several related themes emerged from the presentations and discussion of the provenience and dating of the manuscript, among them connections between the Madrid and the Borgia group of codices from Central Mexico, calendrical methodologies and models for interpreting the almanacs that compose the Madrid Codex, and the structure and function of codical almanacs from both the Maya and Borgia manuscript traditions.

THE PROVENIENCE AND DATING OF THE MADRID CODEX

Two of the presentations, by Harvey Bricker and John Chuchiak, focused on evaluating pages 1 and 56 of the codex (and pages 57 and 112 on their reverse) in light of Coe and Kerr's (1998:181) statement that "fragments of European paper with Spanish writing are sandwiched or

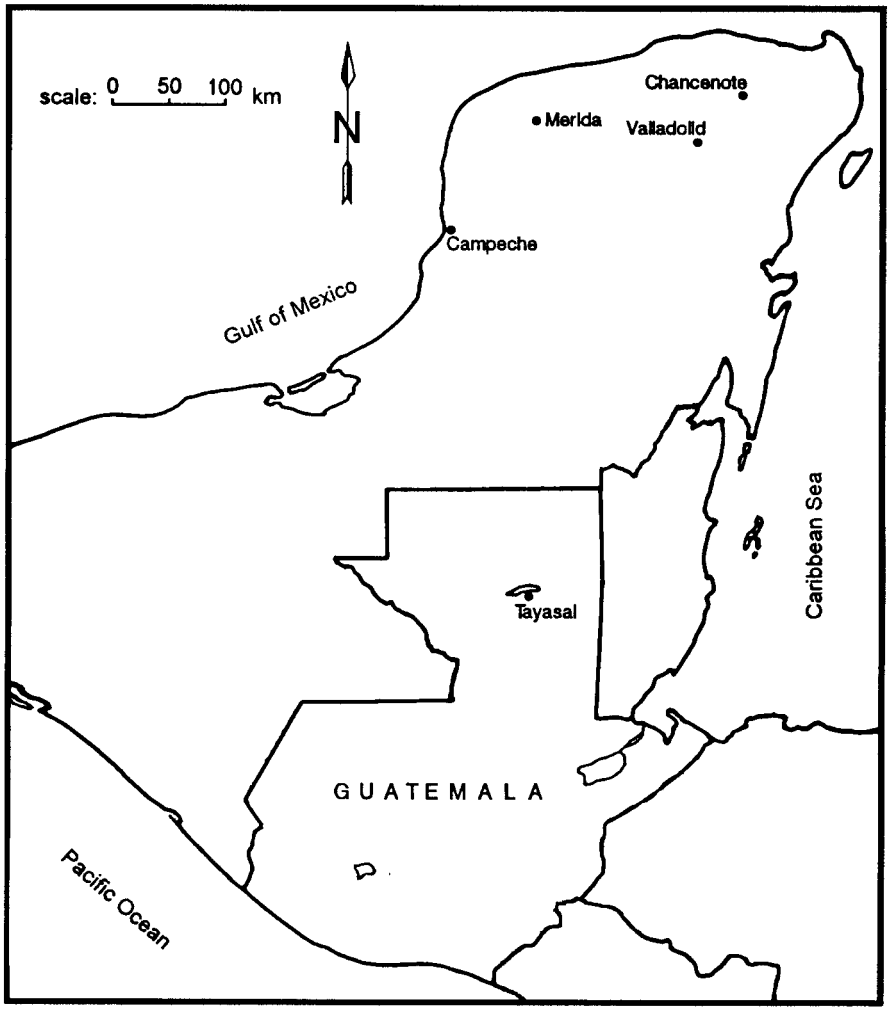

FIG. 1. *The Maya area.*

glued between layers of bark paper [on these pages], and can be seen where the latter has been worn away." Coe and Kerr interpret the text on page 56 (of which they identify two words, "*prefatorum*" and ". . . *riquez*") as a possible reference to a Franciscan missionary who was killed in the Petén village of Sacalum in 1624, leading them to conclude that the Madrid Codex is postconquest in origin and may have been composed at Tayasal.

Bricker, who reviewed photographic and other facsimiles of the codex available at Tulane University's Latin American Library and elsewhere, was able to show that the European writing on page 1 is a late addition to the manuscript, as it is written on top of a variety of surfaces, including the original plaster coating and sections where this had been eroded away. His analysis further demonstrated that the European paper on page 56 (fig. 2) is not integral to the codex as Coe and Kerr suggested but a patch that appears above a very eroded plaster writing surface with a bark fiber substrate. Ferdinand Anders (1967:37–38), in the principal other published reference to the European writing, reached the same conclusion when he examined the original page while photographing the Madrid Codex to produce the Graz facsimile. His statement that the European paper was stuck onto the page and then partially torn away does not support the Coe and Kerr suggestion that the European writing on the paper is being exposed by the removal of an overlying layer of bark paper. That Anders's view of the matter is the correct one was revealed by Bricker's analysis of several sets of 20th-century photographs of the original codex, the earliest of which was made for William Gates in 1911. Bricker demonstrated that the paper is a patch because its edges cast shadows on the surfaces beneath it, including a small area bearing part of the original Maya calendrical notation of the almanac that was once covered by the patch. Furthermore, some thinning and attrition of the patch throughout the 20th century can be seen in the series of photographs. The hieroglyphic manuscript itself, therefore, cannot be dated on the basis of the patch with European writing.

FIG. 2. *Patches of European paper at the bottom of page 56 of the Madrid Codex (after Codice Tro-Cortesiano 1991) (courtesy of the Museo de América, Madrid).*

Chuchiak, an ethnohistorian who specializes in colonial Mexican paleography, examined the handwriting on the patch and the content of the remaining text. His analysis suggests that the European text is part of a papal bull of the Santa Cruzada that, from the style of the handwriting, appears to have been written between 1575 and 1610. Only 25 words are still partially visible on the patch, but they are not only consistent with the text of a bull of the Santa Cruzada but also apparently reference a specific prefecture (*prefatorum* in the text), that of Don Martin de Enriquez de Almaza (. . . *n Enriquez d(e)* . . .), who can be identified as the third viceroy of New Spain (1568–80). Given the history of the two areas during the late 16th century, this combination of evidence suggests a provenience in the northern part of the Yucatán peninsula, which belonged to the Viceroyalty of New Spain, rather than in Tayasal, which did not.

Chuchiak identified four possible scribes in Yucatán who, given the time frame, could have written the papal bull. Of these, he found that the handwriting was most similar to that of Gregorio de Aguilar, who was the cousin of the chronicler Pedro Sánchez de Aguilar. Sánchez de Aguilar is perhaps best known for his *Informe contra idolorum cultores* (1892[1639]), in which he describes confiscating several Maya codices in the Chancenote region of the eastern Yucatán peninsula in 1606–7. Several of these were destroyed in autos-da-fé, but reports indicate that others were taken to Spain and presented to the king along with documents from the idolatry trials.

Chuchiak also addressed the question of how and why a papal bull was attached to the Madrid Codex and by whom. During the 16th century, papal bulls of the Santa Cruzada were sold to Maya natives, who at first regarded them with suspicion. By the end of that century, however, they were viewed as sacred objects. Chuchiak speculates that the papal bull was added to the Madrid Codex by a Maya priest or scribe as a means of sanctifying or blessing the manuscript. This is similar to other examples involving the appropriation of Christian ornaments and symbols by Maya natives during this time period.

Two of the other presentations also supported the likelihood of a Yucatecan provenience for the Madrid Codex. Gabrielle Vail's analysis of lexical and morphological evidence from the manuscript indicates the presence of vocabulary items from both Yucatec and the Western Cholan languages (Chol and Chontal), as was first noted by Lacadena (1997). Additionally, there are morphological features suggestive of Yucatec, Eastern Cholan (Chorti' and Cholti'), and Western Cholan. However, whereas the Cholan vocabulary occurs throughout the codex, Cholan morphology is more limited in its distribution, and the predominant pattern suggests a Yucatecan origin. On this basis, Vail proposes that the Cholan items are in some way intrusive to the codex; they may represent borrowings, archaic or codified forms, or untranslated words or passages from a previous (Cholan) version of various almanacs that were recopied by a Yucatec scribe. This patterning is analogous in many respects to the use of Spanish loanwords (and sometimes complete clauses) in Colonial Yucatec texts such as the *Books of Chilam Balam* (V. Bricker 2000).

Merideth Paxton was concerned with evaluating whether there is any iconographic evidence from the codex to indicate that it was painted in Tayasal, as suggested by the recent studies by Coe and Kerr (1998) and Porter (1997). She compared the manuscript illustrations with art and artifacts known from Tayasal and the broader Maya region and with early eyewitness accounts of Tayasal. She determined, for example, that three forms of human sacrifice were practiced at Tayasal and that none of these is depicted in the codex. Instead, the heart-extraction technique of the Madrid, in which the victim is shown lying over an arched stone (page 76), is similar to that painted in the murals of Chichen Itza and mentioned in the *Relación de las cosas de Yucatan* of Diego de Landa (Tozzer 1941:118–19, including nn. 541, 542). Her general conclusion was that the ethnohistorical data and the material culture represented in the manuscript do not suggest a Tayasal origin but rather are more closely related to the Yucatán peninsula. The closest parallels are with Mayapan, Chichen Itza, and the east coast sites of Tulum, Tancah, and Santa Rita. These findings support the conclusion concerning the material culture previously reached for other reasons by Don Graff (1997, 2000; Graff and Vail 2001).

CONNECTIONS TO THE BORGIA GROUP

Ongoing research by several of the participants has revealed a number of specific iconographic and calendrical parallels between the Madrid Codex and the Borgia group of codices from Central Mexico, including a shared emphasis on Mixteca-Puebla stylistic conventions.[1] Although previous scholars—most notably Eduard Seler (1923)—had commented on some of these connections, they had not been systematically examined, nor had they been investigated in terms of their broader significance for cross-cultural studies of the two areas during the Late Postclassic period. These issues were addressed in presentations by Christine Hernández and Victoria Bricker, Christine Hernández, and Bryan R. Just.

At the time of Spanish contact, the two areas had similar calendar systems, which included a 260-day ritual calendar (referred to as the *tzolkin*, or "count of days," by Mayanists) and a solar calendar of 365 days, known as the *haab* in the Maya lowlands. These two calendars combined to form a 52-year period that has come to be called the calendar round. The calendar round was especially significant among the cultures of Central Mexico, where it was associated with ideas of world destruction and renewal. The Maya also measured time by an absolute calendar known as the long count, which included five units of time—the *kin*, or day, the *uinal* (20 days), the *tun* (360 days), the *katun* (a period of 20 *tuns*), and the *baktun* (a period of 20 *katuns*, or almost 400

1. Mixteca-Puebla is an art style that spread throughout much of Mesoamerica, including parts of the Maya area, after A.D. 1100.

years). The long count was apparently not used outside of the Maya area after the 2d century A.D.

In his presentation, Just considered four almanacs in the Madrid Codex that are structurally related to the Borgia group, including the *in extenso* almanac on pages 12b–18b,[2] the "calendar round" almanac on pages 65–72 and 73b, the formée cross almanac on pages 75–76, and the *trecena* almanac on pages 77–78.[3] He demonstrated not only that they share novel, Mixteca-Puebla structures but also that they are related in terms of their physical location and orientation in the codex. Additionally, his analysis revealed that many of the so-called errors in these almanacs can be understood as attempts to reconcile distinct notational systems and as such seem to index the novel (i.e., original) adoption of Mixteca-Puebla conventions. Other anomalous aspects of these almanacs, which include a mixed orientation of pages 75–76 and 77–78, suggest a method of cross-referencing the opposing sides of the Madrid Codex, integrating not only the four almanacs discussed but a number of additional ones that have iconographic ties to the *in extenso* and "calendar round" almanacs. The fact that the four almanacs involved in the proposed cross-referencing also constitute the best cases of Mixteca-Puebla structural influence suggests that this cross-referencing was intrinsically tied to the structure of the *tzolkin* and that the *in extenso* and related structures may have been adopted to help reveal calendrical parallels among temporally disjunctive seasonal and astronomical phenomena (see Bricker, Bricker, and Wulfing 1997, V. Bricker 1997, Just 2000).

Additional ties between the Madrid and Borgia group codices were discussed by Hernández and Bricker, who linked the planting almanacs on pages 24–29 of the Madrid Codex with an almanac from Borgia 27–28 that relates to rainfall and the maize crop. The two almanac groupings have a number of iconographic similarities that may allow the dating of several of the Madrid almanacs in real time on the basis of correspondences with the Borgia group. Whereas the Borgia almanacs place planting events within the 365-day year, the Madrid planting almanacs are structured in terms of the 260-day *tzolkin*. Hernández and Bricker proposed that the almanac on Madrid 24c–25c, which was first shown to have yearbearer associations by Seler (1923:486), may have been consulted in order to anchor the Madrid planting almanacs in real time. This almanac begins on 5 Cauac (2 Pop), which is correlated with August 14, 1468, according to Hernández and Bricker's model. They also suggested a means of cross-dating this almanac with the one that follows on pages 26c–27c, which references a vernal equinox in its final frame. Further associations were made between Borgia 27–28 and a series of almanacs that show rainfall on Madrid pages 30–33.

In her analysis of the Madrid New Year's pages (34–37), Victoria Bricker proposed a new interpretation for the series of *haab* dates that occur in the upper (and occasionally in the lower) register on all four pages (fig. 3). These include dates referring to the months of Yax and Ceh. The Ceh dates are particularly interesting because they can be linked to vernal equinox dates in 1485–88 and provide a means for explaining the planting iconography in the upper right of each of the yearbearer pages. Hernández and Bricker argued that these pages refer to events taking place at various times during the year that are represented iconographically and anchored chronologically by *tzolkin* coefficients and *haab* dates. Borgia pages 27–28 and 49–52 use a combination of year and *tonalpohualli* (260-day) dates for the same purpose.

FIG. 3. *Page 34 of the Madrid Codex (after Villacorta C. and Villacorta 1976:292).*

2. *In extenso* almanacs are those in which all 260 days of the ritual calendar or *tzolkin* are recorded in sequence.
3. A *trecena* consists of a 13-day period of time.

Hernández examined the calendrical structure of these Borgia almanacs, demonstrating that they were used in conjunction with each other to derive ritually important dates related to New Year's events and the planting season during multiple years in the 52-year calendar round. Through her analysis, she was able to suggest a date in the latter half of the 15th century for all three almanacs. Pages 49–52 in particular reveal a number of correspondences with the yearbearer almanac in the Madrid Codex. Both almanacs not only include dates in the 260-day calendar as well as year dates but also have iconography that interweaves activities from throughout the year, including the beginning of the rainy season, planting, and New Year's rituals.

On the basis of the proposed Madrid-Borgia comparisons, Hernández and Bricker suggested that the planting almanacs in both codices can be dated to the second half of the 15th century and that they place the beginning of the agricultural season in late March and early April in Central Mexico and the Maya area. Furthermore, they argue that the reason the Madrid Codex has so many nearly identical planting almanacs is that they were intended to refer to different years of a 52-year calendar round, following, in this respect, a pattern implied by the planting almanacs in the Borgia Codex.

The correspondences between the Madrid and the Borgia codices noted by Just and Hernández and Bricker appear too systematic and pervasive to be coincidental. Instead, the evidence suggests that some kind of scribal translation took place in which the author or authors of the Madrid Codex reconfigured the information on several pages of the Borgia Codex (or a closely related manuscript) into a Maya format. This involved the deconstruction of the highly integrated Central Mexican pages into the multiple Maya almanacs that are found in the planting and rain-dominated sections of the Madrid Codex. Other aberrant characteristics in the Madrid Codex—as seen in the iconography, hieroglyphic texts, and structure of certain almanacs—may be the result of its connections with contemporary traditions and divinatory manuscripts in Central Mexico. On the basis of these findings, we think it would be very productive for researchers studying Late Postclassic cultures in the northern Maya lowlands and Central Mexico to work together to develop and test models to account for the types of interaction suggested by the codical evidence.

CALENDRICAL MODELS FOR INTERPRETING THE MADRID ALMANACS

The third theme examined by the workshop participants was the calendrical structure of the codex. Several of the papers included models for dating specific almanacs from the Madrid Codex in real time. Dates proposed included an eclipse prediction that was correlated with a *katun* ending of 9.17.0.0.0 (January 22, 771) for page 5b by Julia Drapkin, the possibility of a 1460 date for Madrid 33a, as suggested by Vail, and a series of dates in the late 15th century (1461–1503) for pages 24–37 by Hernández and Bricker. Drapkin's model for page 5b (developed in detail in Drapkin 2002) is especially intriguing, since it would indicate that the 15th-century scribes who drafted the Madrid Codex were interested in recording a *katun* ending and eclipse that occurred 700 years before the proposed use date for the codex. The almanac must involve some means of placing this long-ago event, which is also recorded in the Dresden eclipse table and on several Classic-period monuments, within the context of the historical present. How this was accomplished remains to be determined.

Anthony Aveni focused on the role of numbers in the Maya codices, specifically the intervals connecting *tzolkin* dates in the Dresden and Madrid almanacs. He developed a four-class taxonomy of almanacs that describes intervalic structural patterns in order of increasing complexity. The first class, called archetypal almanacs, consists of the simplest, most symmetric and repetitive arrangements of intervals (e.g., bipartite [13, 13], quadripartite [13, 13, 13, 13], or quinquepartite [13, 13, 13, 13, 13] almanacs). From this archetype at least three other classes of almanacs might have evolved, including expanded almanacs in which the 13s, for whatever reason, became further divided, expanded almanacs that have been shifted to a new starting point, and expanded/shifted almanacs, wherein one or two days have been added or subtracted to alter an almanac of the second type. Motivations for the changes that result in one or another form, including the need to arrive at or avoid a particular date, astronomical events requiring targeting, or numerological rules emanating from pure considerations of number properties, will be considered in the next phase of the investigation, which will address specific questions using a database compiled by Vail (2002).

The second part of Aveni's study consisted of a search of the Dresden and Madrid codices for parallel or cognate almanacs based on an examination of their intervalic sequences. Fifteen such pairs were discovered, and each was categorized using the taxonomy. Subtle differences among almanac pairs are now being explored with the goal of determining which has chronological primacy. Two of the most promising cases are instances in which one of the members has been dated in real time by reference to specific astronomical events. Aveni's analysis of one of these almanac pairs, involving the cognates on Madrid 10a–13a and Dresden 38b–41b, suggested that the Madrid almanac was drafted 131 years after its Dresden counterpart and that the subtle alterations that were made in terms of the iconography and the intervalic structure were intended to provide a better fit with the astronomical and meteorological events at the later date.

THE STRUCTURE AND FUNCTION OF CODICAL ALMANACS

Elizabeth Boone and Martha Macri, serving as discussants at the conclusion of the first workshop, pointed to the perception shared by all present that, as a result of the presentations and discussions, we are now much closer to understanding where and when the Madrid Co-

dex was painted. They also stressed the importance of using a range of methodologies to explore the issue of Maya–Central Mexican connections during the Late Postclassic period and of integrating the data on the Madrid Codex with studies of the other Maya manuscripts. Boone called for a consideration of all the features of the Madrid and Borgia almanacs (i.e., their structure, iconography, and calendrics) when drawing comparisons and for attention to the way almanacs actually functioned both in the context of a particular codex and as part of the culture that produced them.

This issue was addressed by several papers at the second workshop, including one by Vail entitled "A Reinterpretation of *Tzolkin* Almanacs in the Madrid Codex." The presence of explicit dates referencing the 365-day year, or *haab*, in several of the Madrid almanacs led Vail to develop a model to demonstrate how different categories of Maya almanacs could have been used to schedule yearly events in accordance with the 52-year calendar-round cycle. The idea that Maya almanacs could have been structured in terms of the calendar round marked a radical departure from previous interpretations of them as 260-day repeating instruments. Nevertheless, the presence of *haab* dates in several almanacs in the Madrid Codex suggests that certain almanacs were indeed intended to be used in this manner. References to these dates explicitly mark the associated almanacs as 52-year instruments.

Although only a small percentage of Maya almanacs contain references to the *haab*, this model may be extrapolated to other instruments in the Maya codices that meet certain conditions. Vail demonstrated that almanacs having either five rows of 52 days or ten rows of 26 days contain an embedded structure allowing them to be used to schedule events in the 52-year calendar round. This is possible because the intervals associated with these almanacs represent not only the number of days separating successive frames but also the number of years. According to Vail's model, almanacs having repetitive iconography in each frame (i.e., a series of similar activities being performed by different deities) and texts or imagery that can be associated with ethnohistoric descriptions of *haab* rituals may have been used as calendar-round rather than as 260-day instruments. Examples include almanacs that picture fire-drilling, the weaving of new cloth, and other activities related to the Maya New Year's ceremonies discussed in Landa's *Relación de las cosas de Yucatan* (in Tozzer 1941).

In a related study, Vail and V. Bricker reported on the identification of over 30 new *haab* dates in the Madrid Codex. These data, in combination with Vail's study, provide suggestive evidence that Maya almanacs must be seen not as focused primarily on the *tzolkin* calendar but as instruments for recording ritual events that encompassed various periods of time. It is now clear, for example, that Maya scribes recorded cycles of varying lengths—of 260 days and of 52 years—in the instruments that compose the Maya codices, suggesting that the temporal unit of currency was often the year rather than the day. By encoding this information within the structure of 5 × 52 and 10 × 26-day almanacs, Maya daykeepers had a reliable means of determining when a particular *haab* ceremony or yearly activity (such as planting, harvesting, or the carving of deity images) would take place from one year to the next. A reexamination of the Maya codices in light of this model offers researchers an opportunity to reevaluate traditional assumptions about how almanacs were structured and used by pre-Hispanic Maya cultures.

Hernández's analysis, in which she identified calendrical notations in three almanacs in the Borgia Codex referring to named years in the calendar round, suggests that the Borgia scribes likewise encoded various calendrical cycles within the almanacs in this Central Mexican manuscript. These discoveries represent significantly new and different ways of understanding how both Maya and Central Mexican divinatory almanacs were used and what they reveal about the ritual life of the cultures that produced them. The similarities of the two systems, as demonstrated for the first time at the second workshop, give rise to a number of questions about the scribes who drafted the two manuscripts. Were they in direct communication, or are the correspondences simply the result of a shared cultural and calendrical tradition that was pan-Mesoamerican in nature? A third workshop is being planned to explore the interconnections between the two manuscript traditions in light of archaeological and ethnohistoric evidence for Late Postclassic interactions among Maya and Central Mexican populations.

CONCLUDING REMARKS

As a result of the two workshops on the Madrid Codex sponsored by Tulane University, the structure and content of this manuscript, which until recently have been relegated to the back burner of Maya studies by all but a few scholars, are becoming better understood. Research by workshop participants indicates that the codex is not, as certain studies have suggested, a postconquest manuscript from the Petén but was most likely painted during the pre-Hispanic period in the northern lowlands, perhaps in the vicinity of Chancenote. The presence of a 16th-century Spanish document affixed to page 56 implies that the codex was still being used during the early colonial period, but it does not provide a date for the painting of the manuscript. However, the iconographic, linguistic, and hieroglyphic evidence discussed by the workshop participants strongly suggests that it was drafted in the late 15th century, meaning that it was painted prior to Spanish contact. Chuchiak interprets the European paper that he identifies as a papal bull of the Santa Cruzada as a sacred object that was used to bless the codex at a later date.

Other studies reported at the workshops offer new ways of interpreting the iconography and calendrical structure of the Madrid Codex. This document, long considered anomalous and sloppy in an artistic sense, can no longer be viewed in isolation but must be seen as part of a pan-Mesoamerican tradition of manuscript painting.

Connections with the Borgia group of codices should prove important to future analyses, as will models suggesting that certain almanacs were structured to record ritual events over the course of the calendar round. The identification of year dates in the Madrid and Borgia codices offers evidence that both manuscripts were concerned with placing events within cycles of time that may have had historical and astronomical significance. This represents a topic for further exploration along the lines of that begun by Aveni (1999, n.d.) and V. Bricker (2001).

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Dam Impacts in a Time of Globalization: Using Multiple Methods to Document Social and Environmental Change in Rural Honduras[1]

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The El Cajón region of central-western Honduras (fig. 1) is an interesting case for the study of social and environmental change because it is the site of a major hydroelectric dam constructed in the early 1980s that flooded

1. This research received support from the National Science Foundation, the National Geographic Society Committee for Research and Exploration, the Council for the International Exchange of Scholars, the University of Colorado, Mississippi State University, and California State University, Chico. The Geographic Information Center of CSU, Chico, assisted with GIS analysis. Sally Loker and Randy Hall aided with the preparation of maps. This article benefited from comments by anonymous referees and the journal editor. I thank the residents of the study area for their close collaboration and assistance in helping me understand the issues discussed in this article. I am responsible for the views expressed; any errors of fact or interpretation are my own. More information is available at http://www.csuchico.edu/anth/loker/index.htm. [Supplementary material appears in the electronic edition of this issue on the journal's web site (http://www.journals.uchicago.edu/CA/home.html).]

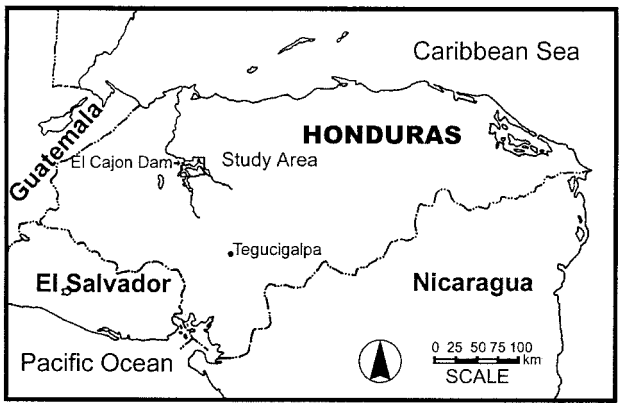

FIG. 1. *Location of the study area.*

extensive areas of land and affected thousands of people. Dam-induced changes coincided and interacted with widespread changes in Honduran rural society. My research on the region addresses several long-standing interests in anthropology: the social causes and consequences of environmental change, the long-term effects of large infrastructure projects, and general processes of social change. The goal of this report is to document the environmental changes caused by the dam, their effects on local people, and subsequent social and economic changes, especially in agricultural land use, within the broader context of a changing political economy.

The interaction of dam impacts with broader political-economic changes complicates our analysis and makes a strictly local account incomplete. These changes, affecting rural Honduras, other areas of Central America, and the Third World in general, are associated with globalization and present serious challenges to rural livelihoods, precipitating a variety of responses from households and communities (Bebbington 1993, 1999; Loker 1999). "Globalization" in Honduras includes increased incorporation into international markets via trade liberalization, the implementation of structural adjustment packages to effect market-oriented economic reforms, greater economic volatility in terms of prices, inflation, and macroeconomic policies in general (see Thorpe et al. 1995), and an increase in the flow of "global" cultural ideas and images that is reducing the cultural isolation of rural communities. These broad international and national changes are manifested in the study region in (1) the rise of assembly plant industries (maquiladoras) around San Pedro Sula, providing a relatively accessible migration target and employment alternative for people living in the region (Bickham Méndez and Kopke 1998, Flores and Kennedy 1996); (2) structural adjustment policies that have liberalized markets for agricultural goods and led to currency devaluations and high rates of inflation, contributing to a more volatile economic situation in terms of wages and prices for a variety of commodities and increasing the uncertainty of the economic returns to agriculture (Salgado 1994:29–32); (3) volatility and a general downward trend in coffee prices since the collapse in 1989 of the International Coffee Agreement, leading to increased uncertainty in the availability of work and wages paid in this sector; and (4) increased exposure to new cultural images and ideas and to people with broader experience outside the region, including those who have migrated to the United States. All of this has occurred in the context of rapid population growth that has placed increased demographic pressure on agricultural resources.

These trends make it difficult to isolate the social and environmental impacts of the dam from more general processes of change. However, information drawn from agricultural census documents and other national and regional studies will be used to compare processes occurring in the El Cajón study area with related changes occurring elsewhere in Honduras to determine the specific effects of the dam. One of the principal arguments advanced here is that the effects of the dam and those of globalization have unexpected and unsettling similarities and synergies such that the dam has greatly accelerated the more general changes associated with globalization.

The results reported here are based on 28 months of fieldwork, from 1981 to 1984 and 1994 to 1999. The first period covered the construction of the dam, its closure, and the filling of the reservoir. This report focuses on the results from the second period, drawing on the earlier research primarily as a baseline for assessing change. The methodology employed included (1) in-depth, structured interviews carried out with 51 household heads in the largest community in the immediate vicinity of the reservoir, Montañuelas (population 869 in 1998), focused on household demography and economy and opinions about the dam; (2) 53 interviews (using the same set of questions) of household heads living in seven different settlements outside Montañuelas around the reservoir; (3) a full census of Montañuelas and the adjacent community of El Encinal, gathering information on age/sex composition of households and landownership; (4) oral histories of 17 individuals ranging in age from 19 to 83, totaling some 20 hours of tape-recorded information; (5) detailed information on the costs of production derived from a milpa plot rented in 1998; (6) observations (recorded in field notes) derived from hundreds of hours of participant-observation and informal interviews focused on land use and environmental change in the study area; and (7) analysis of two sets of 1 : 20,000 black-and-white aerial photographs, dating from 1981 and 1994, to map the location and extent of vegetation cover in the study area (see table 1). The vegetation categories defined attempt to capture the varying states of an extremely dynamic (agri-)cultural landscape. Particular spaces on this landscape may cycle rapidly through milpa (fields cultivated with maize and beans), pasture, brushy pastures, and fallow/secondary forest. These categories are aggregated at varying points in the analysis to reflect this dynamism and the difficulty of distinguishing these types of vegetation both in the photos and on the ground and to simplify the presentation of research results. The

TABLE 1
Distribution of Land Cover Types Before and After Construction of the El Cajón Dam

Vegetation Type	A Total Study Area Before Flooding (1981)		B Unflooded Portion of Study Area (1981)		C Flooded Portion of Study Area (1981)		D Unflooded Portion of Study Area (1994)		(D−A) (Unflooded 1994−Total Before Flooding 1981)		(D−B) (Unflooded 1994−Total After Flooding 1981)	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Towns/trails	23	0.1	23	0.1	0	0	49	0.3	+26	+0.2	+26	+0.3
Agricultural land												
Cleared												
Milpa	225	0.9	111	0.6	114	1.9	191	1.1	−34	+0.2	+80	+0.5
Clean pasture	2,895	12.2	1,945	11.0	950	15.8	2,607	14.8	−288	+2.6	+662	+3.8
Savannah	269	1.1	269	1.5	0	0	235	1.3	−34	+0.2	−34	−0.2
Total	3,389	14.3	2,325	13.1	1,064	17.7	3,033	17.2	−356	+3.0	+708	+4.1
Brush												
Brushy pasture	2,418	10.2	1,379	7.8	1,039	17.3	3,523	20.0	+ 1,105	+9.8	+ 2,144	+12.2
Fallow	2,366	10.0	1,342	7.6	1,024	17.1	1,623	9.2	−743	−0.8	+281	+1.6
Cleared riparian	1,068	4.5	618	3.5	450	7.5	786	4.5	−282	0.0	+168	+1.0
Total	5,852	24.7	3,339	18.9	2,513	41.9	5,932	33.7	+80	+9.0	+ 2,593	+14.8
Total agricultural	9,241	39.0	5,664	32.1	3,577	59.6	8,965	50.1	−276	+11.9	+ 3,301	+18.0
Forest												
Pine-oak												
Thin	3,082	13.0	2,281	12.9	801	13.3	3,739	21.2	+657	+8.2	+ 1,458	+8.3
Closed	8,940	37.8	8,327	47.1	613	10.2	3,766	21.4	−5,174	−16.4	−4,561	−25.7
Total	12,022	50.8	10,608	60.1	1,414	23.5	7,505	42.6	−4,517	−8.2	−3,103	−17.5
Broadleaf												
Intact riparian	1,002	4.2	544	3.1	457	7.6	123	0.7	−879	−3.5	−421	−2.4
Broadleaf	920	3.9	787	4.4	133	2.2	414	2.3	−506	−1.6	−373	−2.1
Total	1,922	8.1	1,331	7.5	591	9.8	537	3.0	−1,385	−5.1	−794	−4.5
Total forest	13,947	58.9	11,939	67.5	2,005	33.3	8,042	45.6	−5,902	−13.3	−3,897	−21.9
Water and unclassified	461	1.9	34	0.2	427	7.1	558	3.1	+97	+1.2	+524	+2.9
Total	23,669	100	17,660	100	6,009	100	17,614	100				

vegetation maps derived from the aerial photographs were digitally scanned, ortho-rectified, and analyzed with geographic information systems software to identify and quantify changes in vegetation cover in the intervening years. When combined with ethnographic research, analysis of vegetation cover enables us to link environmental change with land-use choices made by local people, an important step forward in documenting and understanding human-induced environmental change.

This research focuses on the interrelationships among the choices people make, the cultural means that both constrain and enable these choices, and the ecosystems that sustain human life and culture. The interactions among action, social structure, and ecosystem are informed by a variety of theoretical approaches, including the literature on farmer decision-making (Barlett 1982, Netting 1993), cultural ecology, especially the notion of adaptive strategies and processes (Bennett 1976, 1993), and various of the "new ecologies": political ecology (Blaikie and Brookfield 1987, Greenberg and Park 1994, Stonich 1993, Painter and Durham 1995), the ecology of practice (Nyerges 1997), and historical ecology (Balée 1998). These approaches are combined in a hybrid approach that focuses on the social, political-economic, and environmental factors that shape human agency over time in particular places and circumstances (Bebbington and Batterbury 2001).

The principal state institution affecting adaptive strategies in the El Cajón region is the Honduran national electrical company, the Empresa Nacional de Energía Eléctrica (ENEE), the entity charged with managing the dam and reservoir. While the ENEE is powerful and the dam had tremendous impact on the local environment, local people were still faced with choices and had considerable room for maneuver in coping with that impact. The hybrid approach pursued here analyzes how the social situations of individuals and groups affect their creative responses to changing circumstances and how institutional frameworks that shape access to resources affect the ability of individuals and households to construct sustainable livelihoods.

After a brief discussion of background information on the dam and the social and environmental conditions in the region, I will describe the patterns of environmental change apparent in the aerial photographs and the associated changes in land use and other relationships. Finally, I will explore the implications of this case for our understanding of the interrelated effects of this large infrastructure project and globalization on social and environmental change in the study area.

THE EL CAJÓN DAM

The El Cajón dam is a double-curvature concrete arch structure 226 meters tall, the highest in Central America and one of the highest in the world. It was conceived and planned in the 1970s, when the upward spike in petroleum prices sent oil-importing countries such as Honduras scrambling for alternative sources of energy. Financed largely by loans from the Inter-American Development Bank and the World Bank, it cost about $800 million to build. The dam created a 92-square-kilometer reservoir that flooded about 6,000 hectares of land, and in good years it has generated up to 70% of Honduras's electricity. The project has been beset by management problems, including low levels of water in the reservoir that reduced generating capacity, leaks, and a fire in the generating room. Most relevant to the current study, the project included elaborate plans to resettle the approximately 1,800–3,000 people directly displaced by the dam.[2] These plans were never fully implemented, and only 47 of the 300 families who lost land and/or houses to flooding were resettled. Most people simply moved upslope, creating a massive and instantaneous increase in demographic pressure on a greatly impoverished land base.

About 80% of the population of the study region make their living from agriculture, with the other 20% depending primarily on commerce, construction, and other trades. Some 60% of the population relies on some combination of milpa agriculture (maize and beans) and agricultural labor, sometimes combined with other minor income-producing activities. The other agriculturalists (15–20%) focus on cattle and coffee, the two high-value, high-status activities. These households are the region's large landowners. Coffee is not a prominent crop in the study area, which at less than 900 meters above sea level is not prime coffee land. The small patches of coffee present are generally remnants of rustic, ill-tended plots of coffee grown in natural forest conditions and are of limited economic importance. Those who derive significant income from coffee generally have modest-sized plantations (< 20 hectares) in nearby highland zones. Virtually all the wealthier landowners were born and reside in the region (absentee landownership is rare), are linked by kinship to other local families, and would not be considered very wealthy even by Honduran standards. My 1998 census indicated that only 41 of 151 households (27%) owned land. In summary, the El Cajón region is one in which agriculture remains overwhelmingly important in terms of livelihood and land is very unequally distributed.

Ecologically, the El Cajón region is characterized by rugged topography—low but steep hills and narrow river valleys now filled by the reservoir. The climate is seasonally wet and dry, with an average of about 1,500 mm of rainfall, 80% of which falls between May and November. The vegetation of the region is dominated by pine-oak forest, scrub vegetation produced by the clearing of forest for agriculture, and small remnants of the broadleaf tropical forest that formerly existed in the now-flooded river bottoms and in upland areas of better soil and the narrow canyons of smaller rivers and creeks.

2. In addition to the approximately 1,800 people directly displaced by the dam, about an equal number lost access to land flooded by the reservoir.

ENVIRONMENTAL CHANGE

Figures 2–4 present vegetation-cover maps derived from the interpretation of aerial photos for 1981 and 1994 and a map of vegetation-cover change. The information presented visually in the maps is summarized in table 1. The reservoir flooded about 6,000 hectares of land, of which about 60% were in some sort of agricultural use. Before flooding there had been 9,241 hectares of agricultural land (milpa, pasture, fallow, etc.); immediately thereafter there were 5,664 hectares, representing a loss of 40%. By 1994, however, there were 8,965 hectares of agricultural land, nearly the same as before the dam. Pine-oak forest was reduced from 12,022 hectares in 1981 to 7,505 hectares in 1994. Flooding was responsible for 1,414 hectares of this loss while the rest was cleared for agriculture between 1984 and 1994. Broadleaf forest declined from 1,922 hectares in 1981 to 537 hectares in 1994, a reduction of nearly 60%. The reservoir flooded about 590 hectares of broadleaf forest, and in the ensuing ten years an additional 794 hectares of broadleaf forest were cleared for agricultural uses (milpa and pasture).

As a proportion of the landscape, agricultural land increased from about 39% in 1981 to slightly over 50% in 1994 while forest declined from 59% to about 46%. Much of the land cover classified as forest is actually a hybrid land use involving grazing (thin pine-oak forest) or shade for coffee (broadleaf forest). In 1981, 74% of the pine-oak forest was closed forest; in 1994 just 50% was closed. Thin pine-oak forest (modified by logging, selective clearing, and/or burning to maintain a more open habitat for grazing) grew from 24% to 50% of the total area in this vegetation class. If we include it as part of the agricultural landscape, the area devoted to agriculture is closer to 74% of the total.

In summary, the El Cajón dam flooded a significant portion of the region's agricultural land. In response, from 1984 to 1994 people replaced, almost hectare-for-hectare, the agricultural land lost to the reservoir. In terms of total area, pine-oak forests suffered the greatest decline, but in terms of percentage, species-rich broadleaf forests suffered the most, probably leading to local extinctions of flora and fauna in this ecotype.

LAND USE AND SOCIAL CHANGE

The filling of the El Cajón reservoir dramatically affected the productive capacity of the local environment. As we have seen, the dam flooded approximately 40% of the agricultural land in the study area, and one of the principal adaptive priorities of local people was to recoup this loss through accelerated clearance of land for agriculture. That they succeeded in recovering the lost land

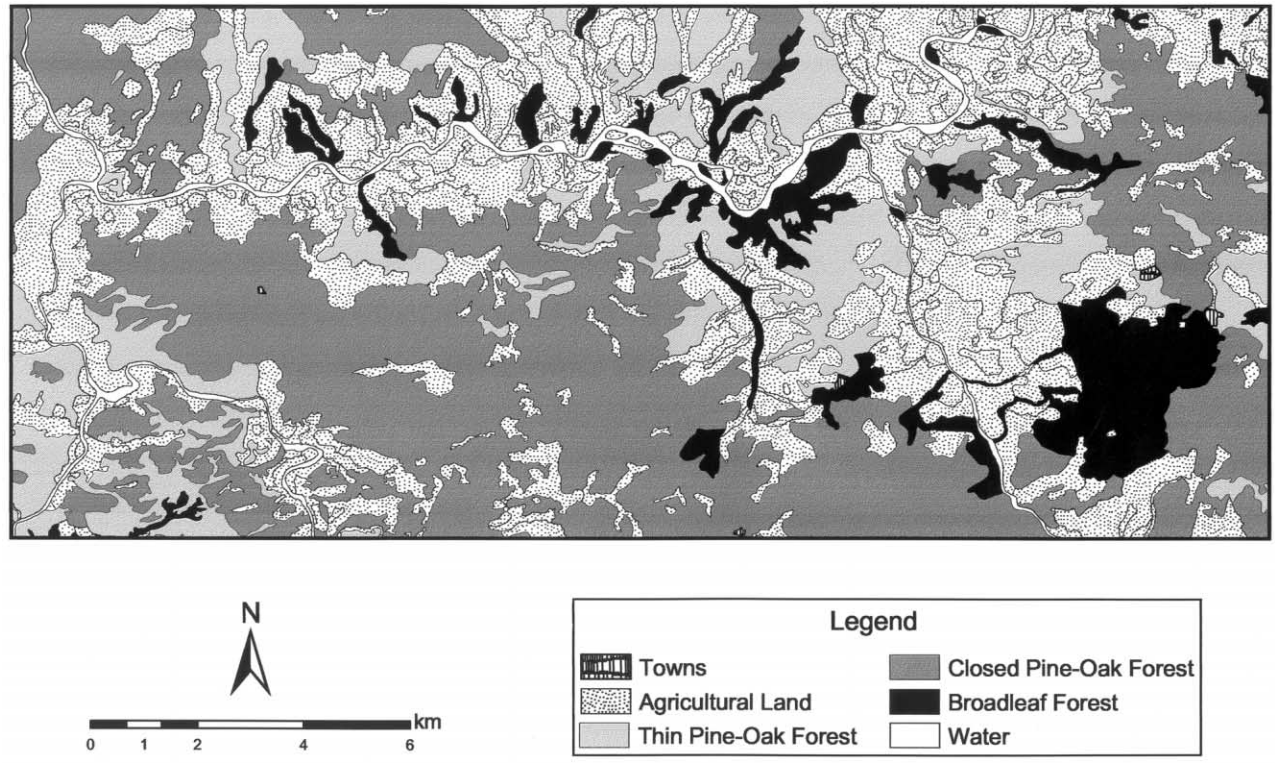

FIG. 2. *Land cover in the El Cajón region, 1981.*

in the aggregate does not mean that all individuals or households had their access to land and livelihood restored. The lands cleared after 1981 were generally of lower quality than the now-flooded alluvial lands, and 88% of the residents interviewed in 1994 said that land was "scarcer" or "much scarcer" than ten years before. In subsequent years, people often reported that cattlemen had either grabbed or bought up land to devote to pasture after the creation of the reservoir.[3] Here is an excerpt from my field notes of June 21, 1998, on this subject: "As C puts it, after criticizing the high milpa rents, in which he basically accused ganaderos of renting out lands that were *tierras nacionales* [government lands], he said, 'I am not asking for a handout, I just want a place to work and feed my family,' with resentment in his voice." Those interviewed mentioned that large landowners, who were more likely to have valid legal documents to demonstrate landownership, used the compensation they received from the state when their lands were flooded to buy unflooded lands (a notion supported by analysis of the compensation paid by the ENEE [see Loker 1998]). The net result was a severe attenuation of access to land for the vast majority of households. Older individuals also remarked that lands that had formerly been secondary forest or milpa lands were now sown with pasture grasses, which made them more difficult to use for growing maize (field notes, June 24, 1998).[4] People have coped with the loss of prime agricultural land through extensification (expansion of agriculture into previously uncultivated areas), intensification (the rapid adoption of chemical inputs, especially herbicides and fertilizers, in the context of a change from shifting to nearly continuous cultivation), and migration (some to jobs in the maquiladora plants around San Pedro Sula, some to the United States).

The average size of milpas has declined 28%, from 2.5 ha in 1983 to 1.8 ha in 1998, a statistically significant change ($p < 0.05$). Average yield has declined 15%—from 1,440 kg/ha in 1983 to 1,220 kg/ha 1998 ($p < 0.05$)—but this actually underestimates the magnitude of the impact of the dam for two reasons. One is that the average yield before construction of the dam on river-bottom lands (all of which were flooded) was 1,831 kg/ha. The other is that yields reported for 1998 include milpas on which fertilizer was used; the average yield of unfertil-

3. The state of land titling in the study area is highly confused. Local land records are in disarray and have not been updated since the mid-1980s. People claim to own land on the basis of informal titles and land sales that are not formally registered and therefore of questionable legal validity. The Ley de Modernización Agrícola (Agricultural Modernization Law), whose major provision includes formalization of land titles, has had no discernible effect in the study area (see Salgado 1996:118–19).

4. Because of the difficulty of distinguishing recently sown milpas from pastures in the photographs, this trend is difficult to document solely through aerial photograph interpretation. Only detailed ethnographic research brought this trend to light.

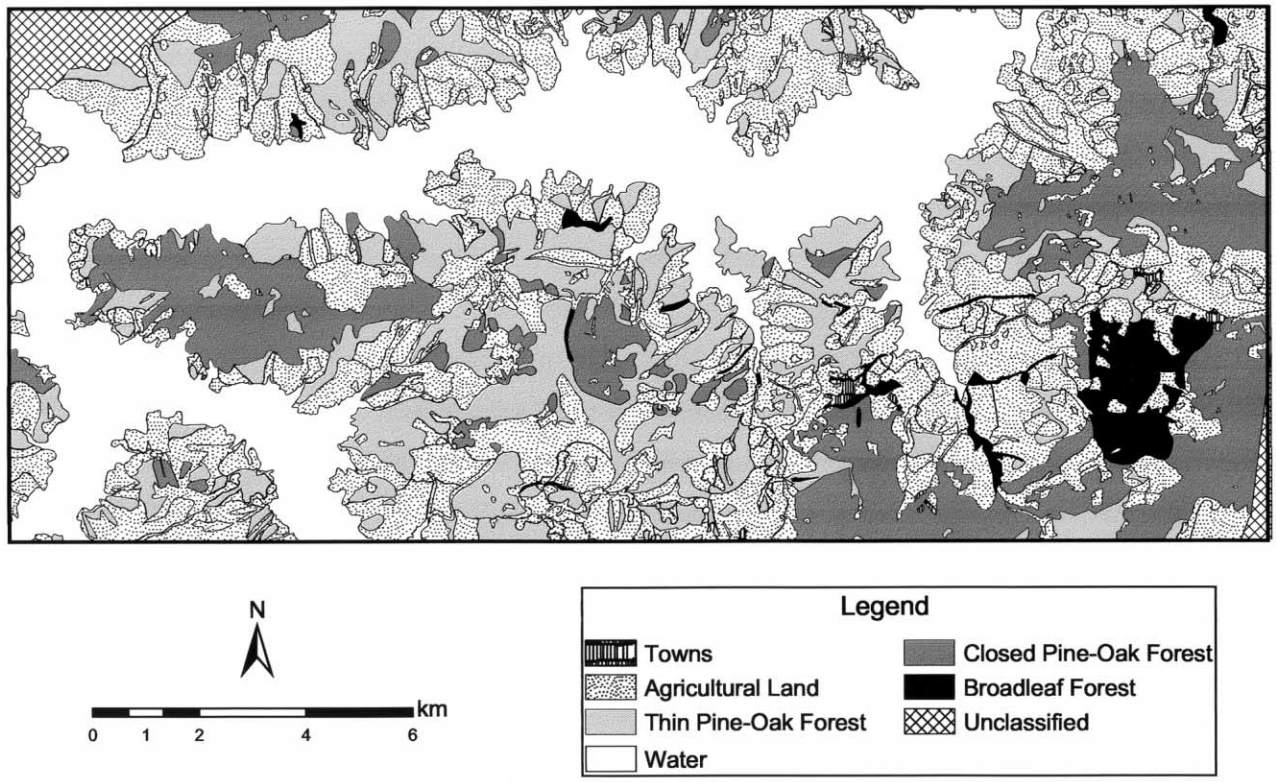

FIG. 3. *Land cover in the El Cajón region, 1994.*

ized lands in 1998 was only 850 kg/ha. None of the farmers interviewed in 1983 used fertilizer, while 82% of those interviewed in 1998 did. Thus, if we compare the average yield of unfertilized lands in 1983 (1,440 kg/ha) with the average yield of unfertilized milpa in 1998 (850 kg/ha), the result is a 40% decline. This comparison supports the frequently voiced claim that fertilizer is absolutely necessary to maintain acceptable yields because "the land is tired."

The land is tired because, increasingly, it is under continuous cultivation. When not under cultivation, it is in pasture; rarely is it left fallow long enough for forest to regenerate. In 1983, before the dam, the average fallow period for upland milpas was five to ten years. Now agricultural land goes rapidly through a cycle of milpa cultivation, grazing immediately after harvest for a variable period of time, and a brief fallow of two to three years or, alternatively, from milpa to grazing and back to milpa again without fallow, often through land rental from the cattleman to the landless campesino. Forest regeneration is a critical aspect of successful shifting cultivation as a means of restoring soil fertility and suppressing weeds (Nair 1987, Ewel et al. 1981, Szott et al. 1987). Multiyear cropping increased from 57% of milpas in 1983 to 78% of milpas in 1998. Continuous cultivation has been accompanied by increased use of chemical inputs in an attempt to maintain acceptable yields and combat persistent weeds, including aggressive pasture grasses.

Agricultural census data indicate that there has been a general trend of fertilizer adoption in Honduras during the period covered here. In the late 1970s about 5% of Honduran farmers used chemical fertilizers, and this figure rose to 25% in 1987–88 and 35% in 1993 (Baumeister and Wattel 1996). Jensen (1998), reporting on research carried out in Santa Barbara, Honduras, in 1994, indicated that 45% of his sample used fertilizer and 50% used herbicides. As we have seen, fertilizer use in the El Cajón region, absent in the 1980s, had increased by 1998 to well above these figures. Herbicide use increased from 65% of farmers in 1983 to 100% in 1998, with producers citing the same reason as Jensen's (1998:118) respondents: the weed invasion associated with shorter fallows. The adoption of fertilizer and herbicides in the El Cajón region is driven by land scarcity induced by flooding and a social system that forces a largely landless farming population to rent (degraded) pastures for milpa production. Chemical fertilizers and herbicides are necessary to maintain adequate levels of production on these lands. Thus the construction of the dam has accelerated trends found elsewhere in the country.

Land scarcity and rising costs of production are felt differentially and most acutely by the poorest and the landless. Larger landowners may not face scarcity, but they do face higher production costs (640 person-hours/ha in contrast to 400 before the dam) and demands for land to rent from dispossessed kin and neighbors. Land

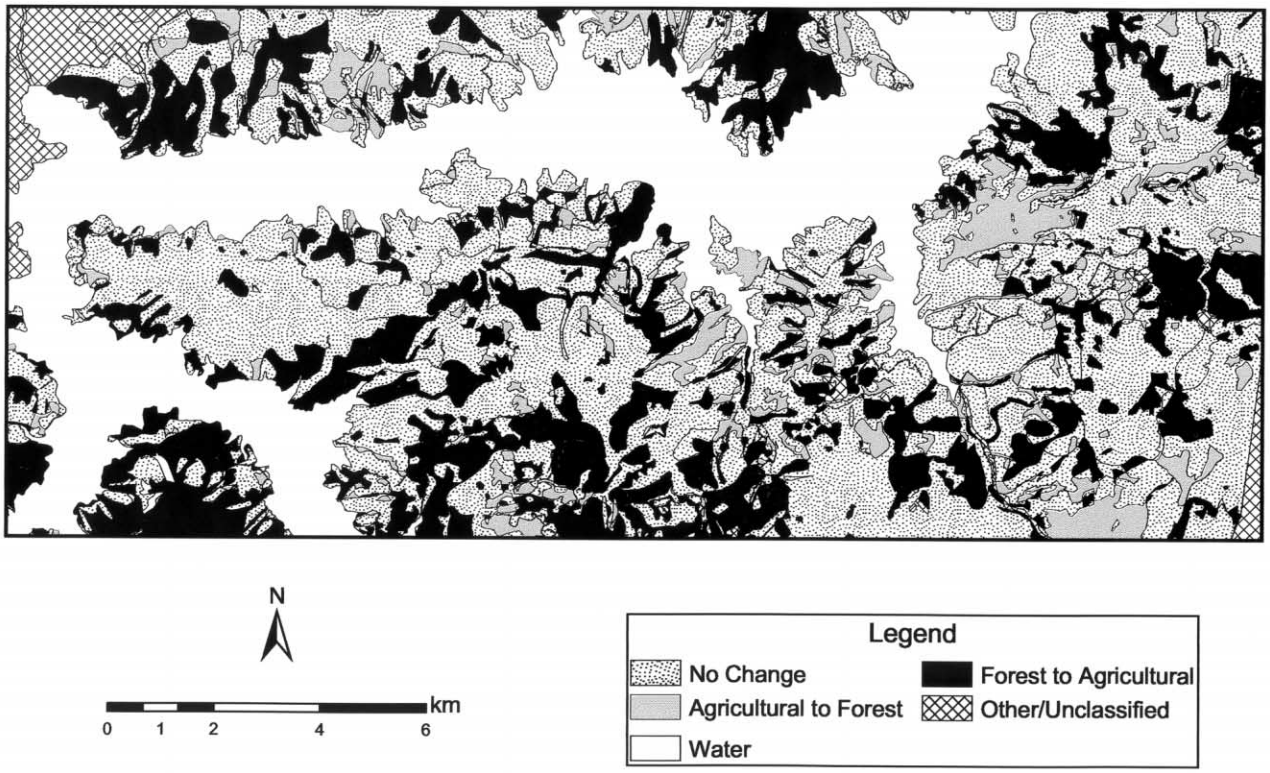

FIG. 4. *Land cover change in the El Cajón region, 1981–94.*

rental has increased from 28% to 34% between 1983 and 1998, while the incidence of cultivation on government lands, the most common form of land access in 1983, has declined from 32% to none. This is another trend documented for Honduras as a whole in which the El Cajón region represents an extreme. Nationally, the percentage of farms of government lands fell from 34% in 1952 to 33% in 1974 and 23% in 1993, while rental land increased from 9% in 1952 to 23% in 1974 then declined to 17% in 1993 (Salgado 1996:95–96). On a regional level, approximately 18% of the plots studied by Jensen in 1993 in Santa Barbara were rented and 21% were located on ejidal (common) lands[5] (Jensen 1998:119). Between 1983 and 1998, El Cajón's government lands "disappeared." Some were privatized by fencing with barbed wire, and some were flooded. The loss of these lands represents a "closure of the commons" in which poorer households are losing access to land as tenure becomes more formalized and restrictive. This process is not unique to the El Cajón region and could be considered linked to the market-based reforms and liberalization typical of globalization. Here the process was catalyzed and accelerated by dam-induced flooding.

The main social effect of the dam and its reservoir has been to increase the insecurity, marginalization, and vulnerability of poorer households. These social changes have increased dependency and intensified patron-client ties. The social response of the poor to this situation has been to seek access to productive resources from their better-off neighbors—kin and/or patrons who rent milpa plots to the landless. Other strategies that strengthen the dependence of the poor on the wealthier households include informal moneylending (at rates of 10% per month) and the pawning of future maize harvests at deep discounts as poorer families struggle to scrape together the cash necessary to rent land, buy inputs, and deal with daily contingencies. This further indebts and obligates the landless poor to the better-off local households. In exchange for access to land, the poor are basically on call to work for the patron for low wages. The result is an economic system increasingly inimical to the interests of the poor majority.

MIGRATION

In the face of increasingly precarious livelihoods, one of the most common individual and household responses has been out-migration. Parents may encourage a daughter of young working age (over about 14 years old) to seek work in the city or encourage a son or daughter to make the trip north to the United States, always with the intention that he or she will send money home or accu-

5. Ejidal lands and government lands are not in the same legal category, but both imply rent-free use rights. These categories are combined in Salgado (1996).

mulate cash to assist in setting up an independent household and acquiring land or other assets upon return. Migration is not new or necessarily damaging: physical mobility often opens up routes to social mobility. But when the decision to migrate is forced on a household or individual by lack of economic opportunities at home and often involves great personal risk, migration must be seen in a more negative light (Bebbington 1993:9–10).

Out-migration has increased since the dam was constructed. Nearly 80% of respondents feel that migration is affecting the area, and 71% have a close relative who has migrated. My 1998 census produced a list of 348 people who had left in the past ten years. Major targets of migration are San Pedro Sula (Honduras's "industrial capital") and Tegucigalpa. Significant numbers are also migrating to the United States. Nearly 50% of those interviewed have relatives in the United States, and about 16% of the households report remittances from these relatives as a significant source of income. Quantitative data on migration patterns before the dam are unavailable, but my observations lead me to believe that migration is much more common now than in the past. Conducting research in Copán, Honduras, in 2001, I asked the same questions regarding migration. The Copán and El Cajón samples are similarly rural and predominantly agricultural and are experiencing the same national-level political-economic forces. In Copán, only 21% of respondents indicated that migration was affecting their town, only 25% of those interviewed had close relatives in the United States, and about 8% of households received remittances. That all these migration indicators are higher in El Cajón suggests that the dam has greatly accelerated migration in the region.

The maquiladoras of San Pedro Sula provide migrants much-needed employment, but wages are very low, making it difficult for people to accumulate any savings. They provide jobs to people with little education, especially young women, who in the past had few prospects after finishing primary school beyond early childbearing and "marriage." Working conditions are harsh: hours are long, and there have been numerous cases of abusive behavior on the part of employers. Protection of worker health and safety is often inadequate (Flores and Kennedy 1996). All of the problems enumerated here were confirmed in interviews with local people from the El Cajón region who had worked in maquilas, who also complained of crime and the difficulties of raising children in the disorder of the periurban fringe.

Migrants to the United States come from a variety of backgrounds, including the relatively well-off and the very poor. Two of the most important aspects of migration are the demonstration effects of the benefits of having a child migrate to the United States and the channels of information and images opened up by returning migrants who share their experiences when they return. In one case, a man with three children in the United States now owns a truck paid for by his children and is breaking into the potentially lucrative trade in cattle on the basis of remittances. The son of one of the better-off shopkeepers has sent money back to buy some of the best remaining agricultural land near town for when he returns in a few years. Returning migrants are also bearers of information: tales of the difficulties and rewards of life in the United States. Many have a sense of vague dissatisfaction with life "back home." As one migrant expressed it, it is tough to work all day in the hot sun of a milpa for $2.25 per day when you've mowed lawns on Long Island for $5.00 an hour. Some migrants lose touch with their families or end up in jail for crimes committed in the United States, and there is the constant threat of deportation.

While not all migration is due to scarcity and not all scarcity is due to the dam, there is a definite link between the undermining of subsistence rights by the dam and the ensuing exodus from the region. The irony is that migration represents a response to the failed resettlement at the time of the dam's construction. Through migration, residents of the region are carrying out, at their own risk and expense, the resettlement that the government failed to accomplish.

CONCLUSIONS

This research explores the coping strategies of people in a particular region of rural Honduras in response to a greatly altered natural and social landscape caused by the construction of a major hydroelectric dam, recognizing that the environmental perturbation represented by the dam and reservoir occurred in the broader context of the relentless and fundamental social change represented by globalization. Both the dam and globalization represent challenges to the preexisting form of rural livelihood. This old economy was based on milpa and livestock in an isolated rural setting where the means for subsistence were available to most and a few generated substantially more than subsistence. In the wake of the flooding we see a much-modified landscape with a reduced capacity to provide decent livelihoods for the vast majority of people who have remained. How have people coped with these challenges?

First, in a "Romer's rule" effort (Kottak 1990), people have attempted to maintain livelihoods based on preexisting patterns: either milpa agriculture (for the vast majority) or the cash crops of cattle and coffee (for the wealthier). These coping strategies have led to the extensification and intensification explored above. Extensification—clearing land for agriculture in an attempt to recover the land base destroyed by the dam—has not been excessive, as people replaced agricultural land lost to the reservoir on almost a hectare-for-hectare basis. Intensification has involved the adoption of chemical inputs in a partially successful attempt to maintain crop yields on a less abundant and less productive land base. These processes have occurred in the context of competition between cattlemen and campesinos over a dwindling resource, land.

A significant subset of people has opted out of this struggle and left the region, migrating to cities in Honduras or to the United States. Some have left permanently. Others engage in relay migration, working in the

city and returning periodically to the countryside, because of the difficulty of constructing a viable and meaningful livelihood based on sweatshop wages. Some are engaged in a migration of desperation to the United States in an attempt to accumulate the assets that will enable them to reproduce a viable livelihood "back home" via land purchase or setting up a small business, and some of these never return.

In the process, rural society in the El Cajón region has undergone significant and often contradictory change. There has been a deepening of patron-client ties of dependency as people "intensify" a preexisting social institution in an effort to survive. At the same time, there has been an opening up of the local to broader social forces—through economic and cultural globalization, migration, remittances, tales of returning migrants, dependency on external inputs for survival, and so on. These contradictory behavioral adjustments do not look like adaptation, but they are, in Bennett's (1976, 1993) sense of coping behavior by socially situated actors using available social and natural resources to meet culturally defined needs and wants. If anything, social theorists have underestimated both people's creative potential and the challenges that they face. We frequently speak of cultural context and contextualization as if there were a broader frame that people were drawing upon in their efforts to create livelihood and meaning. Today even this contextual framework seems malleable and subject to change, increasing the uncertainty with which people must cope. This is doubly the case in the El Cajón region: the dam has compounded the uncertainty besetting rural society everywhere.

In this sense the effects of the El Cajón dam are instructive about broader patterns of social change affecting rural Honduras, Central America, and elsewhere. These effects are like an extreme or accelerated version of the effects of globalization and rural social change identified by Kearney (1996), Bebbington (1999), and others. The undermining of livelihood, the shifting social frame, the challenge to subsist and create meaning in an extremely fluid, often capricious, environment—all effects of the dam—are analogues to globalization. In this sense it is difficult to isolate the effects of the dam, and this is why I have opted here to describe the dam as synergistically *accelerating* existing patterns of social and cultural change.

The result in the El Cajón region has been a more diversified rural society. There are numerous contingent, almost personalistic, factors involved in the variable success of the coping process, but there are also general trends. One is that the initial conditions of social actors, especially variable resource endowments, are important to their success in coping. Access to land has been an important determinant of the variable success that people have had in coping with rapid change. Other endowments, such as access to education and information, may also be important, but these have not been systematically explored here. This research documents how the subsistence economy has been undermined by the dam through loss of land; it is more difficult to document the effects of the restless uncertainty of globalization. Each has led to a different kind of flood: that of the dam but also that of the cultural images contributed by returning migrants, the mass media, and other sources, images that inform people that their "old" way of life is somehow unsatisfactory. Unfortunately, neither the dam nor globalization has provided a hint of a viable alternative to the old economy and the old meanings. The dam accelerated the destruction and dismantling of an older, secure rural poverty for the new, unsettled brand of want characteristic of globalization.

This case has several lessons for the social science of big infrastructure projects. First, effective implementation of plans to mitigate the social effects of a large infrastructure project is essential. Mitigation plans for the El Cajón dam existed, but state institutions failed to take them seriously and implementation was utterly ineffective. Since the social science input on resettlement was advisory, the advice could be ignored with impunity (see Loker 2000). The result is a degraded ecosystem and a poor and desperate population living on the edge of the reservoir, threatening the largest single piece of infrastructure in the country. It may be unrealistic to expect the entities that build dams to have the will or the skills to deal with social impacts. A powerful independent entity must take on these functions. Second, the seeming uniformity of rural poverty often masks a contentious social stratification that causes large infrastructure projects to have differential impacts. Finally, the most important element of mitigation is provision of the resources to deal with the changes people will face. Rather than try to prepare for every contingency, those responsible need to provide the affected people with information, organization, and the capability for creating viable livelihoods.

This research employs a hybrid conceptual framework that combines actor-based approaches (ecology of practice, farmer decision-making) with attention to broader political-economic forces (political ecology) and to the historical context and the importance of contingent, historical events (historical ecology). This framework provides comprehensive explanations of environmental change and the sociocultural processes linked to changing socio-natural landscapes by careful documentation of environmental conditions and detailed ethnographic research that links environmental change to social and cultural conditions at multiple levels and scales—from the global to the local.

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Matrilineality and the Melanesian Origin of Polynesian Y Chromosomes[1]

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Linguists and archaeologists are in general agreement that the Austronesian languages originated in Southeast Asia on or near Taiwan around 3000 B.C. and that Austronesian-speakers dispersed through Island Southeast Asia, reaching Melanesia by 1450 B.C. and Western Polynesia by 950 B.C. (Shutler and Marck 1975, Bellwood 1978, Blust 1984–85, Pawley and Ross 1993, Kirch 2000; see fig. 1). This dispersal, because of its rapidity, has been characterized as the Express Train to Polynesia (Diamond 1988). This model is supported by genetic data showing a predominantly Asian origin of Polynesian mitochondrial DNA (mtDNA) (Melton et al. 1995, Redd et al. 1995, Sykes et al. 1995). Recently, however, Kayser et al. (2000) have shown a Melanesian origin of Polynesian Y chromosomes favoring a Slow Boat to Polynesia model with substantial population interaction components in relation to indigenous non-Austronesian (Papuan) populations in Melanesia. Our hypothesis is that the predominance of maternally transmitted mtDNA of Asian origin and the significant presence of paternally transmitted Y chromosomes of Melanesian origin in Polynesian ancestry can be accounted for as an effect of matrilocal residence and matrilineal descent in Proto-Oceanic society.

For present purposes matrilineal descent groups are lineages or clans in which membership is traced exclusively through female links to a founding ancestor. In matrilocal residence a married couple lives "with or near the female matrilineal kinsmen of the wife" (Murdock 1967). In a matrilineal chiefdom, as hypothesized for Proto-Oceanic society (Hage 1999*a*, Hage and Harary 1996), a man is succeeded by his sister's son. In a patrilineal descent group membership is traced exclusively

1. We thank Henry Harpending for discussions of certain points in this paper. We also thank Matthew Hurles, Jared Diamond, and the referees for their comments. Responsibility is, of course, solely our own.

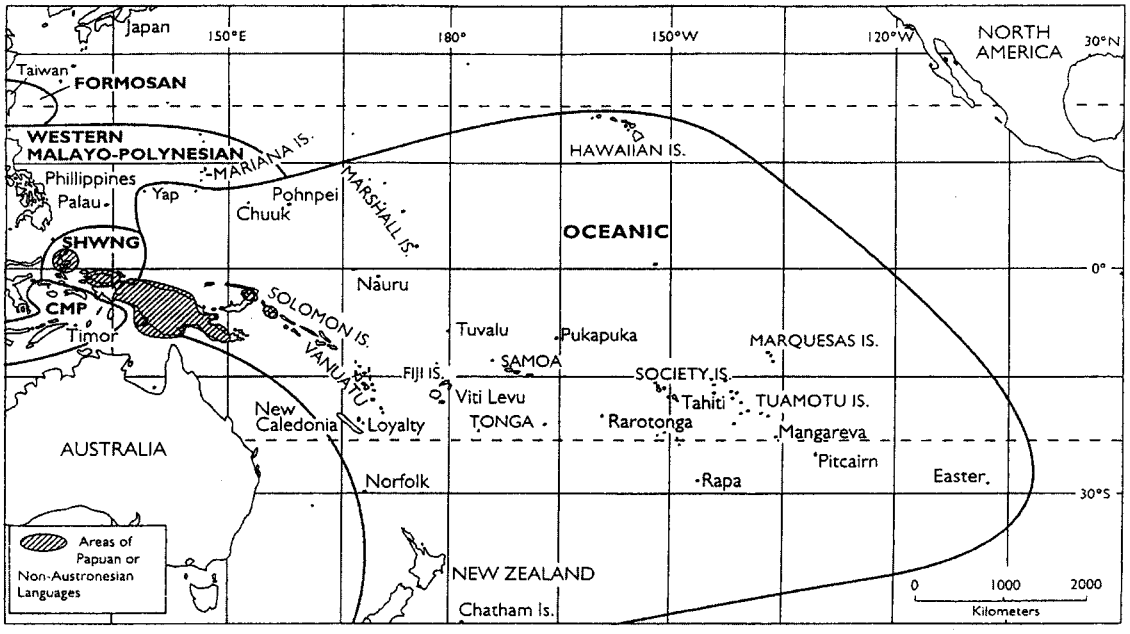

FIG. 1. *The distribution of the Austronesian and non-Austronesian languages in Oceania. The heavy lines delineate major subgroups of the Austronesian languages.* SHWNG, *South Halmahera-West New Guinea;* CMP, *Central Malayo-Polynesian (courtesy of P. V. Kirch).*

through male links to a founding ancestor and a man is succeeded by his son. In patrilocal residence a married couple lives "with or near the male patrilineal kinsmen of the husband." In a cognatic descent group membership is traced through either male or female links. Double descent (not to be confused with cognatic descent) refers to the presence of both matrilineal and patrilineal descent groups in the same society.

GENETIC DATA

There are three lineages of Polynesian mtDNA (Melton et al. 1995, Redd et al. 1995, Sykes et al. 1995). The predominant lineage, accounting for 90–95% of Polynesian mtDNA, is a haplotype possessing a 9-base-pair intergenic deletion shared with Asian populations. The greater diversity of this haplotype in Indonesia, the Philippines, and Taiwan implies an Asian origin and an eastward expansion of Austronesian-speakers into Polynesia. A second haplotype, accounting for 3.5% of Polynesian mtDNA, is also found in Melanesia, in Vanuatu and in coastal New Guinea (Sykes et al. 1995).

Kayser et al. (2000) have discovered three haplotypes (lineages) of Polynesian Y chromosomes. The dominant haplotype, DYS 390.3del/RPS4Y711T, accounts for 82% of Cook Island, 70% of Western Samoan (Forster et al. 1998, Hagelberg et al. 1999), 26% of Coastal Papua New Guinean, and 9–12% of Indonesian Y chromosomes. This haplotype is not found in any other Southeast Asian or Asian population. It originated in Melanesia an estimated 11,500 years ago, long before the intrusion of Austronesian-speakers into Melanesia about 3,500 years ago. A second haplotype, M122C/M9G, is infrequent in Polynesia, accounting for 7.1–10.7% of Polynesian Y chromosomes, but frequent in East and Southeast Asia. It probably originated in Asia on the order of 11,000 years ago (Kayser et al. 2000:1242).

Kayser et al. conclude from the Y-chromosome data that the express-train model should be replaced by a slow-boat model in which the Austronesian-speaking (Oceanic) ancestors of the Polynesians moved slowly across Melanesia, "mixing extensively" with indigenous non-Austronesian-speaking (Papuan) populations, leaving behind their genes and "incorporating" many Melanesian non-Austronesian genes.

This model is consistent with cultural and archaeological evidence of Austronesian–non-Austronesian interaction and with the linguistic "pause" in the spread of the Austronesian languages between the arrival of the Lapita archaeological culture in 1450 B.C. and about 1100 B.C. On general comparative grounds, some century or centuries of change would seem to be required to account for the common linguistic innovations that mark all Austronesian Oceanic languages (and no other [living] Austronesian languages). Several related studies of Polynesian DNA confirm Kayser et al.'s genetic data.

Underhill et al. (2001) found that 43% (25/54) of Maori and 41% (7/17) of Polynesians in their sample had the DYS 390.3 deletion. Following Kayser et al., they interpret this as unequivocal evidence for an important Melanesian lineage in Polynesian ancestry. By contrast, the

mtDNA 9-base-pair deletion was present in 85% of their Maori sample; the remaining 15% belonged to European haplogroups.

Hagelberg et al. (1999) found the DYS 390.3 deletion in Melanesia—in the Trobriand Islands (9%), in the Tolai of New Britain (19%), in the Roro of the south coast of New Guinea (17%)—and in western Samoa (70%) but not in Southeast Asia or the New Guinea Highlands. Forster et al. (1998) found the DYS 390.3 deletion in 6% of Papuan New Guinea Highlanders and in 25% of north-coast New Guineans.

Lum et al. (1998) cite genetic data showing that Polynesians and Micronesians have predominantly (95%) Asian mtDNA but share 30% of their nuclear DNA with Near Oceanic, Papuan-speaking Melanesians.

matrilocal residence and matrilineal descent in proto-oceanic society

Kayser et al.'s model does not specify the type of "intermixing" between Austronesian- and non-Austronesian-speaking populations in Melanesia, but we suggest that it took place in the framework of matrilocal residence and matrilineal descent in Proto-Oceanic society. By "Proto-Oceanic" we mean the language at the end point of its common development in the Bismarcks before the various incremental and abrupt dispersals that led to more localized varieties of speech. By "Proto-Oceanic society" we mean, formally, what can be reconstructed, linguistically, about the social vocabulary of Proto-Oceanic-speakers and what we infer from that about their society. By "Lapita society" the archaeologists mean what was surely the same community and what can be inferred about it through archaeology, comparative ethnography, and comparative linguistics (Kirch 1997, Green 2002). Proto-Oceanic (Lapita) society was a sophisticated maritime and horticultural society of Austronesian origin which developed in the region of the Bismarck Archipelago in western Melanesia around 1500 B.C. The society was based on an extensive voyaging and exchange network (Kirch 2000). By 1100 to 1200 B.C. daughter societies were expanding eastward, arriving in the Fiji-Tonga-Samoa area by 950 B.C. (Kirch 2000). After a "long pause" in Western Polynesia of as much as 1,000 years, as evidenced by numerous innovations in Proto-Polynesian (Pawley and Ross 1993), colonization resumed, reaching all islands in Eastern Polynesia by A.D. 1000.

There are two complementary, interconnected perspectives on the relation between matrilineal institutions and long-distance voyaging (Hage and Marck 2002). The first perspective is due to Harris (1980, 1985), who argues, generally, that the development of matrilocal residence and matrilineal descent is favored under conditions of prolonged male absence for purposes of trade, warfare, or resource exploitation. In contrast to patrilocal residence, in which absent husbands must rely on wives "whose alien descent group loyalties override any obligation to [their] husband[s]" (Harris 1980:97), matrilocal residence allows absent brothers to rely on their lineage sisters to manage their common corporate interests. Ethnographic examples of this model include the Iroquois, the Huron, the Mundurucu (Harris 1985:282), and the Haida (Hayden 1993). Historical and archaeological evidence includes the development of matrilocality in eastern North America following upon changes in subsistence practices that required extended male absence in hunting, trading, and raiding expeditions (Harris 1980: 97, citing Trigger 1978). A significant Caribbean parallel is Keegan and Maclachlan's (1989) reconstruction of the initial colonization of the West Indies as the expansion of a matrilineal-matrilocal society of long-distance seafarers and traders.

The second perspective is due to Lévi-Strauss (1984), who observed with reference to Micronesia that males are easily assimilated to matrilineal descent groups. He also pointed out that matrilineal institutions, because of their inherent instability (resulting from conflicts between men over the control of their own and their sisters' children), are apt to disappear when societies become isolated (p. 183):

> Some Micronesian societies have lived in relative isolation; elsewhere migrations, wars and intermarriages have mixed up the populations. Further, we find in the first group of societies a retreat from matrilineal institutions; left to themselves, these institutions, by reason of their well known instability, have a tendency to evolve spontaneously towards other forms. Contrariwise, they provide the second group of societies with a sort of common denominator and a convenient means . . . of incorporating [male] immigrants.

In Micronesia the continuation of matrilineal descent was clearly associated with the continuation of regular long-distance voyaging (Hage and Marck 2002). In the isolated atolls of the eastern Carolines (Pingelap, Mokil, and Ngatik), in the outlier atolls of the Marshalls (Enewetok and Ujelang), and in the atoll groups (Kiribati), where regular long-distance voyaging declined or never developed, matrilineal descent gave way to patrilineal, double, or cognatic descent. The same thing happened in western Polynesia during the long pause, when interisland voyaging came under the control of chiefly elites involved in a prestige-goods system (Kirch 2000).

In matrilineal societies paternity is not an overriding issue. It matters little who the father is, since only women continue the lineage. In the Micronesian and larger Oceanic context, if husbands and fathers were lost (always a possibility in seafaring) they could be readily replaced by other men, Papuan as well as Oceanic.

In the "classic" theory of kinship (Murdock 1949, Lowie 1950, Fox 1983), the development of social organization proceeds from changes in residence rules to changes in descent rules to changes in kinship terminology. By Proto-Oceanic times residence (matrilocality), descent (matrilineality), and kinship terminology (bifurcate merging) were perfectly aligned. Many of the daughter societies of Proto-Oceanic retained this pattern while

others underwent changes in residence—from matrilocal to avunculocal (a male-centered residence in a matrilineal society in which a married couple lives with or near the maternal uncle of the husband), changes in descent from matrilineal to double, patrilineal, and cognatic, and changes in kinship terminology from bifurcate merging to generational.

The evidence for matrilineal descent in Proto-Oceanic society as presented in Hage (1998) can be summarized briefly. Linguistically, Proto-Oceanic kinship terminology was bifurcate merging in type, with one term for father and father's brother (**tama*) and a separate term for mother's brother (**matuqa*) (Milke 1958). Cross-culturally, bifurcate-merging terminologies are associated with unilineal—matrilineal or patrilineal—descent 85% of the time and (using a slightly different sample) with unilocal residence 91% of the time (Hage 1999*a*). The rare bifurcate-merging terminologies found in nonunilineal (cognatic) societies are best interpreted as survivals of earlier unilineal regimes, bearing in mind the lag between changes in descent rules and kin terms.

Ethnographically, matrilineal descent is widespread in Oceanic-speaking societies in Micronesia, in the Caroline and Marshall Islands, and in Island Melanesia in the Huon Gulf and parts of New Britain and New Ireland (in the Bismarcks), Bougainville, the Solomon Islands, and Vanuatu (Allen 1984). Double descent (usually interpreted as a sign of the transition from matrilineal to patrilineal descent [Murdock 1940, Fox 1983]) is also found in Oceanic-speaking societies in Melanesia. It results when an integrated matrilineal society is undermined by patrilineal institutions, beginning typically with a shift from matrilocal to patrilocal residence. Patrilineal descent groups then become important in economic and political contexts, eventually leaving matrilineal descent groups with few functions other than exogamy, hospitality, and ritual. Classic examples of double descent in Oceania are Yap in Western Micronesia and Pukapuka in Central Polynesia. In Island Melanesia double descent is found in a number of societies in the Admiralty Islands, the Huon Gulf, Vanuatu, and Fiji (Murdock 1967). In Murdock's *World Ethnographic Atlas* (1967) 74% (26/35) of all unilineal Oceanic-speaking societies have either matrilineal or double descent. Historical linguistic evidence from Island Melanesia (Malaita) reveals shifts from matrilineal to patrilineal descent but not the converse (Blust 1986–87).

Not all Oceanic-speaking societies are matrilineal, but the majority of them display a matricentric orientation that we interpret as the historical residue of a matrilineal Proto-Oceanic society. If Proto-Oceanic society was patrilineal, one would expect a continuing patricentric orientation in daughter societies. In Burton et al.'s (1996) analysis of social structure in world ethnographic regions, matricentric traits include "localized or dispersed matrilineal groups, matrilocal or uxorilocal residence, monogamy, and the absence of marriage exchange . . . generational aunt terms, bifurcate merging aunt terms and Crow cousin terms" (p. 93). Oceanic-speaking societies in Melanesia, Polynesia, and Micronesia are generally matricentric (fig. 2).

The relative unimportance of paternity in matrilineal societies in Oceania is clearly illustrated in the matrilineal chiefdoms of the Marshall Islands in eastern Micronesia (Hage and Harary 1996). Male ancestors were often omitted from chiefly genealogies. In the words of an early ethnographer, "When Kabua [a paramount chief of the Ralik chain of the Marshalls] dictated the genealogical tree of his ancestors to me and mentioned only women, I asked him to name the men too as is generally customary in Polynesia. He laughed and said that they were completely irrelevant, and therefore he did not know them" (Krämer 1906:431). Children in the Marshalls were considered chiefly (*iroij*) if their mothers were chiefly.

DISCUSSION

It is sometimes assumed in population genetics that patrilocal residence and patrilineal descent are the norm (Cavalli-Sforza 2000), but there are significant numbers of matrilineal societies in the world (Murdock 1967). If the Austronesian ancestors of the Polynesians were patrilineal, one would expect to find Polynesian Y chromosomes of predominantly Asian origin and mtDNA of mixed Asian and Melanesian non-Austronesian origin, the frequency of the latter depending on the frequency with which Austronesian-speaking men married indigenous non-Austronesian-speaking women. The predominance of Asian mtDNA and the high frequency of Mel-

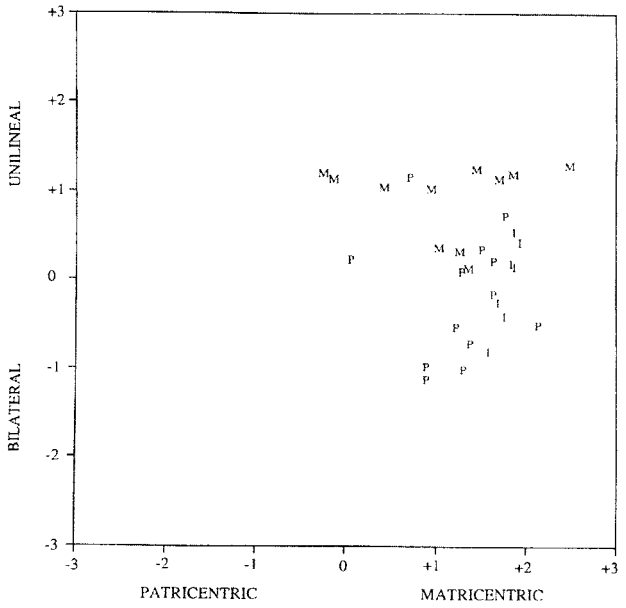

FIG. 2. *Social structural traits of Oceanic-speaking societies based on Burton et al. (1996).* M, *Melanesia;* P, *Polynesia;* I, *Micronesia (from Hage 1998, courtesy of the Polynesian Society).*

anesian Y chromosomes in Polynesian DNA imply the presence of matrilocal residence and matrilineal descent in Proto-Oceanic society. While founder effects in Polynesia and at various points along the way from the northwestern Melanesian Proto-Oceanic homeland could skew the actual level of Melanesian contributions to the Y-chromosome situation amongst Proto-Oceanic-speakers, it would be unlikely for the mitochondrial DNA to be so profoundly skewed in the *opposite* direction by early Polynesian settlement times. The founding population of Polynesia was dominated by Southeast Asian mitochondrial DNA and Melanesian non-Austronesian Y-chromosome DNA, and such a skewed sex-based difference is more likely the result of the long-term systematic effects of ancestral marital patterns than the chance result of compounded founder effects from the Proto-Oceanic homeland along the route to Western Polynesia. The genetic data are consistent with the linguistic and comparative ethnographic data supporting a hypothesis of matrilineal descent in the early Oceanic ancestors of the Polynesians. It would not have taken many generations to reach a high level of Melanesian Y-chromosome admixture in Polynesian DNA. If 10% of the Y-chromosome DNA in each generation came from outsiders, in 300 years (12 generations) the proportion of original DNA would have been (.9) ^ 12~ 28%.

Two studies of matrilineality and genetic diversity lend further support to our model. Oota et al. (2001) have shown that genetic diversity varies with residence rules. In a comparison of six closely related groups—three patrilocal and three matrilocal—from northern Thailand, mtDNA diversity was higher in all the patrilocal than in any of the matrilocal groups. Conversely, Y-STR haplotype diversity was higher in all the matrilocal than in any of the patrilocal groups. According to these researchers, the linguistic, cultural, regional, and economic similarities among the six groups make it unlikely that some factor other than residence could account for these differences.

An analogue to our model of the Oceanic settlement of Polynesia is provided by the Herero (Henry Harpending, personal communication). The Herero, pastoralists who represent the southwestern arm of the Bantu expansion (Pennington and Harpending 1993), are self-consciously ethnic, and group membership is determined exclusively by the mother. There are many liaisons with non-Herero, and offspring of these liaisons are Herero only if their mothers are Herero. One manifestation of this mating pattern is reduced genetic diversity compared with that of other Bantu-speaking people in southern Africa (Harpending and Chasko 1976). Another is lack of mitochondrial diversity, indicating bottlenecking and a restricted maternal ancestry. Vigilant et al. (1991) describe mitochondrial DNA sequences of a world sample of 189 people including 27 Herero. Whereas the sample of 162 non-Herero had 125 distinct sequences the sample of 27 Herero had only 10. An expanding group with strong matrilineal ideology like that of the Herero would show, centuries later, a restricted and geographically specific origin of mitochondrial DNA but a diverse and widespread origin of Y-chromosome and nuclear DNA. This is the pattern that we propose to account for the discrepant origins of Polynesian mitochondrial and Y-chromosome DNA.

It has been put to us that the significant presence of Melanesian non-Austronesian Y chromosomes in Polynesian DNA could be more simply explained by a skewed sex ratio—more males in the boats than females. We would argue that sex ratios in colonizing expeditions were not markedly skewed. As Kirch (1997) observes, the Lapita expansion favored a high rate of population growth. The vulnerability to extinction of small colonizing "propagules" would have favored more nearly balanced sex ratios. If the social motivation for the Lapita expansion was primogeniture (Kirch 1997; Hage 1999*a*, *b*), the colonizing expeditions were probably led by junior, polygynous collaterals of chiefs. It is hard to imagine that men would have set off without women. Further, there is no need to assume that women would have been in the way on colonizing expeditions; they could well have been part of the crew. Lum et al. (1998) have suggested the possibility of male-biased gene flow after initial colonization in the context of predominantly male interisland voyaging and matrilineal descent. The details of this scenario are not given. In our view matrilineal descent and voyaging networks were part of the colonization process itself.

Not all population geneticists are in agreement with the analysis of genetic data in Kayser et al. (2000), Underhill et al. (2001), and Hagelberg et al. (1999). Su et al. (2000) found that one Y-chromosome haplotype, M4G/MST/M9G, is present in Melanesia but not in Polynesia and concluded that "the contribution of Melanesian Y-chromosomal haplotypes to the Polynesian expansion is very low or negligible" (p. 8227), but they did not include in their analysis the DYS 390.3 del/RPS4Y711T haplotype. Hurles et al. (2002) found that two lineages account for 81% of nonadmixed Polynesian Y chromosomes. Lineage 26.4 is found in Polynesia and Southeast Asia; lineage 10.2 is found only in Polynesia and Melanesia, but "it appears that 10.2 owes its ancestry, much like that of its phylogenetic predecessor, the DYS390.3 chromosomes (Kayser et al. 2000), to a source population in Melanesia and/or eastern Indonesia" (p. 300). Oppenheimer and Richards (2001*a*, *b*) believe that a subgroup of the mitochondrial haplotype with the intergenic 9-base-pair deletion called "the Polynesian motif" originated in Wallacea in eastern Indonesia 17,000 years B.P. (95% credible region: 5,500–34,500 years). They also suggest a possible eastern Indonesian origin of the Y-chromosome haplotype DYS 390.3. They argue that Austronesian origins lie within tropical Southeast Asia, but with the exception of Dyen (1965) and Terrell, Kelly, and Rainbird (2001), no linguists and few archaeologists credit this idea. As Diamond (2001) has written, they overlook the linguistic, archaeological, and genetic evidence that locates Austronesian origins in Taiwan and ultimately China.

Oppenheimer and Richards (2001*a*, *b*) and other geneticists are now making regular but unreferenced claims

that the "linguists," "linguistics," or "the standard archaeo-linguistic model" do not allow much "mixing" of Austronesian-speakers with populations they encountered in their journey through time and space to Remote Oceania. While Oppenheimer and Richards contrast this with Terrell's (1998, Terrell et al. 2001) "entangled bank" model, neither Oceanic linguists nor theoretical linguists have actually made anything resembling a "no-mixing" claim. In this and his Wallacea homeland "model" of Austronesian origins, Terrell has simply created "linguistic" models with no foundation in linguistics.

The "express-train" and "slow-boat" terminologies refer, in current parlance amongst biological scientists, not to the speed with which Austronesian dispersal/encroachment into the Pacific occurred but to the character of the social interactions along the way. The amount of time it took was already known to be about 500 years in Oceania. This figure will change if the archaeology changes, not if the biological science changes. Neither the linguists nor the archaeologists have said or implied that the apparent speed of dispersal meant that Austronesian-speakers were not interacting with non-Austronesian-speakers along the way. The contrast between express trains and slow boats, although convenient for geneticists' (Lum et al. 1998; Kayser et al. 2000; Oppenheimer and Richards 2001*a*, *b*; Underhill et al. 2001) purposes, is misleading. Most archaeologists, if forced to use catch phrases, would prefer some form of Green's (1990) Triple I—intrusion, innovation, and integration—model of Austronesian (Oceanic) and non-Austronesian interaction. The question is, how did these populations interact? Here we have suggested an answer: they interacted as most matrilineal societies do.

CONCLUSION

We propose that the predominance of maternally transmitted mtDNA of Asian origin and the significant presence of paternally transmitted Y chromosomes of Melanesian non-Austronesian origin in Polynesian ancestry can be accounted for as an effect of matrilineal institutions of residence and descent in Austronesian Proto-Oceanic society. The matrilineal hypothesis is supported by abundant linguistic, ethnographic, and cross-cultural evidence, and the genetic data are consistent with this evidence.

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