Agriculture 1500 CE—Arboriculture and Horticulture, Floodwater and Irrigated, Rainfed, Terrace and Wetland Cultivation

Revision of 7.6.16 by Andrew Sluyter.

For the agricultural map of Middle America for 1500 CE, the starting point was Whitmore and Turner (2001), for the following reasons.

- It is rigorously conceived and exceptionally well executed.
- It is based on a thorough, systematic synthesis of relatively recent scholarship in geography, anthropology, archaeology, and history.
- It includes 32 detailed maps of Middle America, broken down into four subregions and the Basin of Mexico. Some of the subregions have more maps than others because they had more types of agricultural land use:
    - 2 maps of the Antilles (approximate scale of 1:15,000,000).
    - 5 maps of Central America (approximate scale of 1:10,000,000).
    - 9 maps of Eastern Mesoamerica (approximate scale of 1:10,000,000).
    - 11 maps of Western Mesoamerica (approximate scale of 1:10,000,000).
    - 5 maps of the Basin of Mexico (approximate scale of 1:500,000).
- The maps represent different types of agricultural land use as polygons and point symbols. The polygons of different land-use types overlap, as they do with actual land use. And the authors indicate the level of confidence for each polygon on the basis of the type of evidence available, using the terms “sparse evidence,” “inference,” “logic,” “indirect evidence,” “strong indirect evidence,” “strong evidence,” and “confirmed” depending on the type of agriculture and evidence involved.
- It focuses on a fairly brief time period roughly centered on the 1500 CE target year. Much of Middle America was conquered and colonized by the Spaniards between the first voyage of Christopher Columbus to the Caribbean in 1492, the conquest of Tenochtitlan (now Mexico City) in 1521, and that of considerable parts of Central America over the rest of the 1520s. Colonization focused on areas with dense population and agriculture, and the conquistadors were aided by introduced epidemic diseases that resulted in dramatic depopulation, contraction of agriculture, and expansion of pastoralism over the sixteenth century. Areas that remained largely beyond the colonial frontier by the 1520s, albeit not always beyond the devastation of epidemic diseases, included northern Mexico, the Yucatan Peninsula, and most of the Caribbean beyond the four Greater Antilles and the group of small islands off the coast of Venezuela (Margarita, Coche, and Cubagua) colonized for their pearl beds, including all of the Lesser Antilles and other small islands. Relative to the areas where the Spaniards focused conquest and colonization, many of the unconquered areas had sparse populations and little agriculture in 1500 CE.
- It provides detailed explanation of each type of agricultural land use and discussion of the evidence for mapping the respective polygons.
- The authors are willing to answer question about their interpretation of the evidence to supplement the already detailed discussion in the text and provide the original files for the maps, drafted in Canvas.

Typology

One issue with using this source, however, is the use of a large number of agricultural land-use types, some of them pertaining to only one of the four subregions or to the Basin of Mexico, one of the most densely settled and intensively cultivated areas in 1500 CE. The 47 types of land use the authors employed to organize the book are as follows:

1. Sparse evidence for agroforestry
2. Sparse evidence for orchards and orchard-gardens
3. Strong evidence for orchards and orchard-gardens
4. Confirmed orchards and orchard gardens
5. Confirmed and sparse evidence for swidden
6. Confirmed and sparse evidence for conuco
7. Sparse evidence for swidden and temporal
8. Strong evidence for swidden
9. Sparse evidence for swidden
10. Sparse evidence for temporal
11. Inference and sparse evidence for swidden
12. Inference and sparse evidence for temporal
13. Inference and sparse evidence for swidden and temporal
14. Indirect evidence for sloping-field terraces
15. Sparse evidence for sloping-field terraces
16. Confirmed bench terraces
17. Indirect evidence for bench terraces
18. Sparse evidence for bench terraces
19. Confirmed cross-channel terraces
20. Indirect evidence for cross-channel terraces
21. Sparse evidence for cross-channel terraces
22. Confirmed subsurface and wetland irrigation
23. Strong evidence for subsurface and wetland irrigation
24. Sparse evidence for subsurface and wetland irrigation
25. Confirmed floodwater irrigation
26. Strong evidence for floodwater irrigation
27. Strong indirect evidence for canal irrigation
28. Logic and sparse evidence for canal irrigation
29. Confirmed canal irrigation
30. Strong evidence for canal irrigation
31. Sparse evidence for canal irrigation
32. Confirmed wetland irrigation
33. Indirect evidence for wetland irrigation
34. Indirect evidence for canal irrigation
35. Sparse evidence for recessional cultivation
36. Strong indirect evidence for recessional and subsurface wetlands cultivation
37. Sparse evidence for recessional and subsurface wetlands cultivation
38. Strong evidence for intensive wetlands cultivation
39. Sparse evidence for intensive wetlands cultivation
40. Confirmed intensive wetland and chinampa cultivation
41. Strong evidence for intensive wetland and chinampa cultivation
42. Sparse evidence for intensive wetland and chinampa cultivation
43. Confirmed wetlands and chinampa cultivation
44. Indirect evidence for wetlands and chinampa cultivation
45. Logic and sparse evidence for wetlands and chinampa cultivation
46. Indirect evidence for recessional and subsurface cultivation
47. Logic and sparse evidence for recessional and subsurface cultivation

Because LandCover6k involves a global mapping of a relatively limited number of land-use types, the 47 types used by Whitmore and Turner were consolidated and otherwise reduced to 24. The first step toward consolidation involved combining “sparse evidence,” “indirect evidence,” “inference,” and “logic” into a

single type for each land use, designated by the qualifier “probable”; and combining “strong indirect evidence,” “strong evidence,” and “confirmed” into another single type for each land use, designated by the lack of any qualifier at all. In the single case (Antilles swidden and *conuco*) when a map conflates “sparse evidence” and “confirmed” for a single polygon, no qualifier was used because although the evidence is sparse, the logic underlying the inference is sound. That first step toward consolidation resulted in a reduction from 47 to 31 types. The second step involved lumping “*chinampa*,” “wetland irrigation,” and “wetlands and *chinampa* cultivation” into the more generic “intensive wetland fields,” reducing the types from 31 to 24. The third step eliminated conjoined types such as “probable swidden and temporal” that occur only because of overlapping polygons, since in a GIS they can be mapped and viewed as separate polygons even were they overlap, unlike on the printed maps in the book. In addition, the type “recessional and subsurface cultivation” was eliminated because it was synonymous with “recessional and subsurface wetland cultivation.” And the “subsurface wetlands cultivation” portion of that type was eliminated as a detail that could be added to the Comments field for polygons where it occurred, such as some of the intensive wetland cultivation of the Basin of Mexico (*chinampas*). As part of the process of consolidation, some terms were changed to more globally recognized ones: “shifting cultivation” instead of “swidden,” and “short-fallow cultivation” instead of “*temporal”* and “*conuco* cultivation,” thereby combining those two regional variants with similar properties. The fact that some types only appear with the qualifier “probable” testifies to the difficulty of identifying and dating them compared to other types, for example, agroforestry versus bench terraces. The resulting 21 types represent 12 types of agriculture, with 9 having both probable and unqualified types, 2 only probable types only, 1 only an unqualified type. To that, I added unqualified and probable designations so that each type of agriculture has both an unqualified and probable type because new evidence might emerge that prompts revision of the map by assigning those categories to some of the polygons. The result is 12 types of agriculture with an unqualified and a probable version of each, for a total of 24 types of polygons:

1. Probable agroforestry
2. Agroforestry
3. Probable orchards and orchard gardens
4. Orchards and orchard gardens
5. Probable shifting cultivation
6. Shifting cultivation
7. Probable short-fallow cultivation
8. Short-fallow cultivation
9. Probable sloping-field terraces
10. Sloping-field terraces
11. Probable bench terraces
12. Bench terraces
13. Probable cross-channel terraces
14. Cross-channel terraces
15. Probable subsurface irrigation
16. Subsurface irrigation
17. Probable floodwater irrigation
18. Floodwater irrigation
19. Probable canal irrigation
20. Canal irrigation
21. Probable recessional cultivation
22. Recessional cultivation
23. Probable intensive wetland fields
24. Intensive wetland fields

The descriptions that follow better specify each of the twelve types of agriculture as well as issues related to evidence, interpretation, and level of confidence (unqualified presence versus probable presence). For fuller discussion of each type of agriculture, refer to the cited pages in Whitmore and Turner (2001). In general, documentary evidence preserves direct observations of agricultural practices, although they often pertains to periods after the depopulation and other major disruptions associated with colonization following the immediate contact period, dating from 1492 through the 1520s for most of Middle America. Archaeological evidence records numerous botanical remains from domesticates and non-domesticates in many settlements that imply particular agricultural practices in the environs of those settlements. Landscape vestiges preserve field forms such as terrace walls, some still in use. Paleoecological and vegetation studies reveal species compositions that similarly imply particular agricultural practices. And ethnographic and ethnohistoric studies provide more detailed understandings of more recent historical and present-day agricultural and horticultural practices that act as analogs for those of the contact period.

Because including all the types on one layer would have resulted in visual confusion, they were mapped on five layers, each including 2-5 subtypes: Agriculture—Wetland Cultivation 1500 CE; Agriculture—Floodwater and Irrigated Cultivation 1500 CE; Agriculture—Arboriculture and Horticulture 1500 CE; Agriculture—Rainfed Cultivation 1500 CE; and Agriculture—Terrace Cultivation 1500 CE.

Agriculture—Arboriculture and Horticulture 1500 CE

Agroforestry. Whitmore and Turner (2001, 77) define this type of agriculture as "the selective preservation or cultivation of multiple tree and shrub species in the context of local flora" involving "the use, management, or modification of a forest ecosystem to augment production needs by providing wood, fruits, nuts, dyes, latex, fibers, medicinal products, and other foodstuffs." They explicitly distinguish agroforestry from hunting, fishing, and gathering because agroforestry, as they define and map it, unlike gathering, involves deliberate management and modification of forests through such practices as culling and selective propagation and preservation of select, albeit mainly non-domesticated, species. Often that management takes place in concert with shifting cultivation, with fallowed fields continuing to produce a sequence of products through a managed succession back to forest. The evidence for agroforestry remains sparse for all of Middle America in 1500 CE. Despite suspecting agroforestry throughout much of the humid and mesic tropical forests of the region, therefore, Whitmore and Turner (2001, 79-86) remain careful to map only several areas of probable agroforestry on the mainland and none at all on the islands. Their evidence derives from a mix of ethnographic and ethnohistoric analogy as well as limited, direct observations recorded in contact-period documents.

Orchards and orchard gardens (with a discussion of gardens). Whitmore and Turner (2001, 78) define orchards as intensively managed plots near settlements focused on monocultures or near monocultures of tree or shrub species, including succulents such as *nopal* and *maguey*; gardens as intensively managed plots within settlements focused on the cultivation of non-staple annuals; and orchard gardens as the mixing of those land uses on a single plot typically within settlements. Unlike agroforestry, the emphasis in orchards, gardens, and orchard-gardens was on domesticated species. The evidence in some cases is sparse, allowing mapping of probable instances only, but in other cases is strong or confirmed, allowing mapping of unqualified instances (Whitmore and Turner 2001, 86-106). The evidence does not typically permit distinguishing among orchards, orchard-gardens, and gardens because of the prevalence of polyculture in the region as well as limited details provided by the evidence. Probable instances of orchards and/or orchard-gardens occur on Hispaniola, Puerto Rico, and Trinidad based on a mix of archaeological remains and limited, direct observations recorded in contact-period documents. On the mainland, similar evidence as well as ethnographic and ethnohistoric analogy allows mapping of instances of probable orchards and/or orchard-gardens; in addition, however, a relative wealth of direct observations recorded in contact-period documents allows mapping of many unqualified instances, particularly related to cacao orchards because of their value as the source of chocolate and occurrence as monocultures, but also related to other crops. Based on similar types of evidence, gardens were grown

immediately around residential structures and differentiated from orchard-gardens by a higher proportion of domesticated annuals relative to trees and shrubs; but the sources do not permit gardens to be distinguished from orchard-gardens; they were likely plentiful, small in area, and ubiquitous in settlements throughout Middle America; and they cannot therefore be mapped as a distinct category.

Agriculture—Rainfed Cultivation 1500 CE

Shifting cultivation. Whitmore and Turner (2001, 112) use the term swidden, but in the context of a global project such as LandCover6k I prefer shifting cultivation as a more widely applicable, descriptive term. They define it as characteristic of tropical lowland forests as well as having a fallow period lasting for years that exceeds the period of active cultivation, burning of regrowth to release nutrients prior to cultivation, and minimal tillage (Whitmore and Turner 2001, 113). Shifting cultivation is a form of rainfed agriculture and therefore widespread throughout the tropical lowlands of Middle America but limited by arid climates in the north, rain shadows throughout, and high elevations. The evidence for shifting cultivation consists of sparse contact-period accounts as well as ethnographic and ethnohistoric analogy but tends to be general, pertaining to broad areas rather than specific locales. Whitmore and Turner (2001, 116-17) note how problematic the use of ethnographic and ethnohistoric analogy is in this particular case because the dramatic depopulation and introduction of steel axes might have expanded shifting cultivation at the expense of more intensive, short-fallow cultivation. Nonetheless, those sources allow Whitmore and Turner (2001, 114-23) to map broad, general areas of shifting cultivation throughout the Caribbean, limited to the windward, wetter sides of the Lesser Antilles and to areas not used more intensively for short-fallow cultivation on Hispaniola, Jamaica, and Puerto Rico; Central America except for extensive areas of wetlands along the Caribbean coast; and much of southern Mexico except for more temperate elevations, with an elevation cutoff of 9,000 feet (converted and rounded to the 2,800 m contour).

Short-fallow cultivation. Whitmore and Turner (2002, 113-129) identify two types of short-fallow cultivation: *temporal* and *conuco*. Both are forms of rainfed cultivation and therefore widespread. *Temporal* is distinguished from shifting cultivation by having annual or near annual cropping, with fallow restricted to the dry or cold season; characteristic of higher, temperate elevations of parts of mainland Middle America; and involving substantial tillage to manage soil fertility. *Conuco* occurred in the tropical lowlands of some of the Greater Antilles and Trinidad and involved intensive tillage and soil mounding (as high as 70 cm) to manage fertility and allow sustained cropping. The evidence for short-fallow cultivation consists of sparse contact-period accounts as well as ethnographic and ethnohistoric analogy but tends to be general, pertaining to broad areas rather than specific locales. Nonetheless, those sources allow Whitmore and Turner (2001, 123-30) to map broad, general areas of short-fallow cultivation on Hispaniola, Jamaica, and Puerto Rico; higher, more temperate elevations of Central America; and much of the temperate elevations of the mountains of southern Mexico up to an elevation of 9,000 feet (converted and rounded to the 2,800 m contour).

Agriculture—Terrace Cultivation 1500 CE

Bench terraces. Whitmore and Turner (2001, 145) define bench terraces as contouring walls of earth or rock high enough to create level planting surfaces on steep slopes, thus deepening soils, reducing soil erosion and runoff, increasing infiltration and soil moisture, and facilitating irrigation. The evidence for this type of agriculture involves vestiges of rock walls and other landscape modifications, some currently in use, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of many instances of this type of agriculture, mostly unqualified but some probable, throughout what are now the Mexican and Guatemalan parts of Middle America up to an elevation of 9,000 feet (converted and rounded to the 2,800 m contour), although some claims of bench terraces on Puerto Rico also exist (Whitmore and Turner 2001, 145-54).

Sloping-field terraces. Whitmore and Turner (2001, 136-37) define sloping-field terraces as modifications to landscapes that reduce but do not eliminate shallow slopes, consisting of contouring rock alignments, low walls, earthen embankments, or rows of perennial vegetation that collect and deepen soil upslope, slow runoff, and increase infiltration and soil-moisture storage. The evidence for this type of agriculture involves vestiges of rock alignments and other landscape modifications, some currently in use, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of many instances of this type of agriculture, albeit qualified as probable because of the relatively minimal landscape modifications this type of terracing entails compared to bench terraces, throughout what is now the Mexican part of Middle America as well as northern Guatemala up to an elevation of 9,000 feet (converted and rounded to the 2,800 m contour) (Whitmore and Turner 2001, 136-45).

Cross-channel terraces. Whitmore and Turner (2001, 154) define this type of terracing as weirs or dams built across ephemeral stream channels to capture sediments and moisture for cultivation in a series of small, wedge-shaped fields. The evidence for this type of agriculture involves vestiges of rock walls and other landscape modifications, some currently in use, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of many instances of this type of agriculture, albeit qualified as probable in many instances because they leave less landscape evidence than bench terraces, throughout what are now Mexico and northern Central America (Whitmore and Turner 2001, 154-61).

Agriculture—Floodwater and Irrigated Cultivation 1500 CE
Subsurface irrigation. Whitmore and Turner (2001, 170) define this type of irrigation as the excavation of shallow holes to create sunken fields that accessed the water table, often in the channels of ephemeral streams with low gradients. The evidence for this type of agriculture involves landscape vestiges, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of the incidence of this type of agriculture along the channels of streams that drain into the Pacific Ocean, up to an elevation of 900 m, as well as other scattered locations in what is now Mexico, with unqualified instances in the Río Balsas drainage and southward and probable ones to the north (Whitmore and Turner 2001, 167, 170-71).

Floodwater irrigation. Whitmore and Turner (2001, 171) define this type of irrigation as involving the construction of cross-channel weirs or dams, similar to the walls of cross-channel terraces, across the narrow channels of ephemeral streams or broader valley bottoms to collect, spread, and direct floodwaters in combination with systems of ditches. They thereby distinguish it from “recessional cultivation” (also “floodwater farming”), which does not employ weirs or ditches and occurs in places where the unmodified topography distributes adequate water to fields, but at the same time note that areas of floodwater irrigation and recessional cultivation (floodwater farming) likely occurred in close proximity. The evidence for this type of agriculture involves landscape vestiges, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of unqualified instances of this type of agriculture generally along the channels of streams that drain into the Pacific Ocean as well as other scattered locations in what is now Mexico (Whitmore and Turner 2001, 171-74).

Canal irrigation. Whitmore and Turner (2001, 174) define this type of irrigation as employing canals, meaning artificial channels, to deliver water from a perennial source such as a reservoir or spring to agricultural fields in a highly controlled manner, thus distinguishing it from floodwater irrigation systems that rely on ephemeral and unpredictable flows that are difficult to control. The evidence for this type of agriculture involves vestiges of canals, dams, and other structures, some currently in use, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of probable and unqualified incidences of this type of agriculture

throughout the Mexican and northern Central American parts of Middle America, although some claims of canal irrigation on Cuba and Hispaniola also exist (Whitmore and Turner 2001, 174-91).

Agriculture—Wetland Cultivation 1500 CE

Recessional cultivation. Whitmore and Turner (2001, 199-200) define this type of agriculture (also "floodwater farming") as planting crops in the moist soils of the seasonally exposed margins of wetlands and floodplains as flood waters recede, for example, at the beginning of the dry season around backswamps on the backslopes of levees. In some cases, ditches aligned with slope hastened drainage and/or provided access to shallow water tables longer into the dry season, a variant termed "subsurface wetlands cultivation" that merges into the subsurface irrigation category but is largely indistinguishable in terms of the ditches from ones dedicated to drainage in recessional fields (Whitmore and Turner 2001, 200). The evidence for this type of agriculture involves vestiges of ditches and other landscape modifications, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of probable and unqualified incidences of this type of agriculture throughout much of mainland Middle America (Whitmore and Turner 2001, 199-207).

Intensive wetland fields. Whitmore and Turner (2001, 207) define this type of agriculture as permanently altering the elevation of the cropping surface relative the water table by digging ditches in wetlands and using the spoil to elevate fields or, in the most intensive form of this type of agriculture, the *chinampas* of the Basin of Mexico, raising fields from the bottom of shallow lakes to create artificial islands separated by canals. Some *chinampas* were even irrigated, what Whitmore and Turner (2001, 167, 182, 191-92) refer to as "wetland irrigation," meaning that canals delivered fresh water to them from springs and streams in order to reduce the salinity of the surrounding lake waters, as indicated in the Comments field of the attribute table. The evidence for this type of agriculture involves vestiges of ditches, raised fields, and other landscape modifications, some currently in use, archaeological excavations, scattered references in contact-period documents, and ethnographic and ethnohistoric analogy. That evidence allows mapping of probable and unqualified incidences of this type of agriculture throughout the Mexican and northern Central American parts of Middle America (Whitmore and Turner 2001, 207-24).

Northern Mexico

Whitmore and Turner (2001) do not cover that part of Middle America that is now northern Mexico. For that area, I used Doolittle (2000), which includes it as a southward extension of the US Southwest. Like Whitmore and Turner (2001), Doolittle (2000) is rigorously conceived and exceptionally well executed; based on a thorough, systematic synthesis of relatively recent scholarship in geography, anthropology, archaeology, and history; includes 17 maps showing the location of various agricultural types relevant to northern Mexico; provides detailed explanation of each type of agricultural land use and discussion of the evidence used for mapping; and the author is willing to answer question about his interpretation of the evidence to supplement the already detailed discussion in the text. Some issues with using this source involve differences in the types of agriculture relative to Whitmore and Turner (2001); use of different qualifiers such as "suspected," "inferred," and "confirmed"; the greater use of point symbols rather than polygons; the much smaller scale of the maps (approximately 1:50,000,000); and the later contact period in that part of Middle America, meaning that the direct observations recorded in contact-period documents date not to 1492 through the 1520s, but to the late 1520s (by Álvar Núñez Cabeza de Vaca) through the eighteenth century, much more recent than the target date of 1500 CE.

The issue of different agricultural types can be resolved relatively well. Some of the agricultural types used in Doolittle (2000) simply do not pertain to northern Mexico: "Husbandry of small herbaceous plants" is known there only from twentieth-century ethnographies; "Shifting cultivation" likely did not occur anywhere north of the tropics (Doolittle 2000, 174-190); and "Ridged fields in cool environments," "Dry farming," and "Draining and ridging" did not occur in northern Mexico. "Gardens," as for Middle

America more generally, were likely plentiful, small in area, and ubiquitous within settlements but therefore cannot be mapped as a category distinct from "Orchards and orchard-gardens." Most of the agricultural types used in Doolittle (2000) that do pertain to northern Mexico correspond directly to agricultural types used in Whitmore and Turner (2001), as tabulated below. In the case of "Terracing," the use of "Cross-channel terraces," "Sloping-field terraces," and "Bench terraces" all pertained to northern Mexico by are known by various terms that were converted to the three standard ones used for the rest of the map (Doolittle 2000, 287-88, table 8.1; Donkin 1979, 58-61).

Doolittle 2000	Equivalents in Turner and Whitmore 2001
Husbandry of large, and woody plants	Orchards and orchard-gardens
Plain fields in warm environments	Short-fallow cultivation
Various terrace forms	Sloping-field; Bench; and Cross-channel terraces
Water harvesting	Floodwater irrigation
Canal irrigation	Canal irrigation
Flood recessional farming	Recessional cultivation

The maps in Doolittle (2000), in general, are based on four general types of evidence: direct observations in contact-period documents, analogy based on later ethnohistoric accounts and ethnographic observations; archaeology and paleobotany; and landscape vestiges of fields such as terraces walls and canals (Doolittle 2000, 7-14). All were mapped as unqualified instances rather than probable.

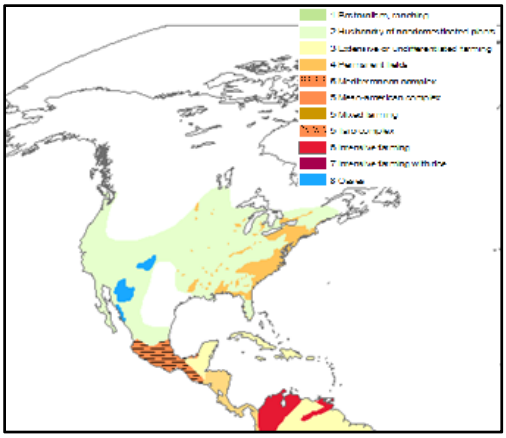
Another issue with Doolittle (2000) is that it uses mainly square point symbol maps rather than polygons, except in a few cases such as Figure 5.17. Each point symbol indicates an instance of that type of agriculture based on documentary, archaeological, or ethnographic evidence. In other words, Doolittle (2000) does not infer polygons from evidence that relates to a point location. Each point was therefore mapped as a polygon in order to make this source commensurable with Whitmore and Turner (2001).

Digitization

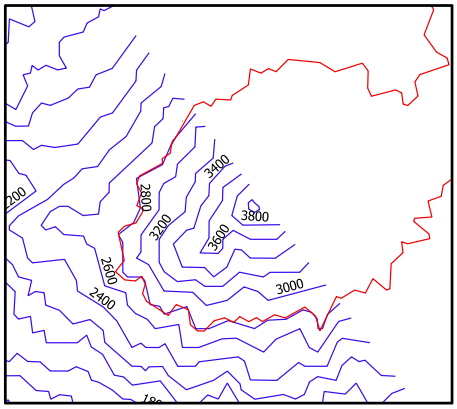
As each respective polygon was digitized onto the five Agriculture 1500 CE layers, generally at a scale of 1:1,000,000, "Agriculture" was entered into the Type field of the attribute table, one of the 24 types of agriculture was entered into the Subtype field, relevant local terms (e.g., *conuco*, *temporal*, *chinampa*) and other details or observations (e.g., the occurrence of subsurface wetlands cultivation) were entered into the Comments field, the name of the georeferenced map layer (e.g., AgroforestryCentralAmerica_modified.tif) was entered into the Source field, and the citation for that map (e.g., Whitmore and Turner 2001, map 3.1) was entered into the Citation field.

The georeferenced images do not, in the case of Whitmore and Turner (2001), derive from scans of the published maps. Instead, Tom Whitmore kindly proved the original Canvas files in the updated Canvas 15 format. Canvas 15 can export to shapefile and DXF (Drawing Interchange Format) formats, both of which QGIS can import, shapefiles directly and DXF via a plugin. But after several tests of those options, considering that the maps were produced in a previous version of Canvas that lacked GIS integration, and many issues with compatibility, a more direct approach was developed that involved saving them as 32 raster images (TIF format) and georeferencing them in the GIS using predetermined control points to make the process faster, more precise, and more consistent. Georeferencing was set to Projective transformation, Nearest neighbor resampling, the project CRS, Full histogram stretch, and no compression. The polygons were then transferred to the five Agriculture 1500 CE layers using heads-up digitizing.

In contrast, the maps from Doolittle (2000) have such a small scale (approximately 1:50,000,000) and use point symbols. Each relevant map was scanned, georeferenced in the same manner as those from Whitmore and Turner (2001), and the point symbols digitized onto the relevant Agriculture 1500 CE layers as square polygons of the same size as on most of the maps published in Doolittle (2000). Clusters of point-polygons were then merged into single polygons and the types of source data (ethnographic, documentary, and so on) they were based on were added to the attribute tables. In addition, an unpublished map of areas of dominant types of agriculture in North America designed by Doolittle and provided by Mats Widgren (Doolittle n.d.; Widgren personal communication June 16, 2016) was georeferenced and the two areas of "oases agriculture" (blue) in northwestern Mexico were digitized and used to constrain and locate the polygons for recessional cultivation, canal irrigation, and floodwater irrigation.



In cases were elevation limits required use of the Difference tool to geoprocess holes in polygons, the relevant contours (2,800 m) for Mexico were extracted from the 1:1,000,000 shapefile downloaded from www.inegi.org.mx and copied onto a vector polygon working layer. For Central America and the Dominican Republic (the only country in the Caribbean with elevations that reach 2,800 m), ASTER DEMs (a product of NASA [National Aeronautics and Space Administration] and METI [Japanese Ministry of Economy, Trade and Industry]) were downloaded from earthexplorer.usgs.gov, contours extracted at an interval of 100 m, the 2,800 m contours isolated, copied onto a vector polygon working layer, and simplified with the Simplify Feature tool to a tolerance of 50.00 layer units to achieve a near match with the level of generalization of the 1:1,000,000 contours for Mexico. The good correspondence of the 2,800 m contours from those two sources is evident along the Mexico-Guatemala border, with the contours of the Mexican shapefile in blue and the one extracted from the ASTER DEMs in red.



Similarly, lakes were extracted from the 1:1,000,000 shapefile of waterbodies downloaded from www.inegi.org.mx and copied onto a vector polygon working layer. Reservoirs were deleted on the basis of the presence of dams, extracted from the 1:1,000,000 shapefile of dams downloaded from www.inegi.org.mx. The lakes of the Basin of Mexico, which were drained after 1500 CE, were derived from Whitmore and Turner (2001, fig. 5.1). Lakes for Central America and the Caribbean were digitized from the OCM Landscape base map.

In cases where Whitmore and Turner (2001) represent specific types of agriculture as line symbols instead of polygons, such as cross-channel terraces along the Balsas River or recessional cultivation, the 1:1,000,000 shapefile of streams was downloaded from www.inegi.org.mx, irrelevant stream segments deleted, buffers as thick as the lines in Whitmore and Turner (2001, figs. 5.8, 6.1, 6.2, 7.1) geoprocessed using the Buffer tool, and relevant buffers merged using the Merge Features tool to create polygons that followed each stream. For recessional cultivation in the Caribbean lowlands of Central America, the streams were acquired from OpenCycleMap using the BBBike shapefile extraction tool (extract.bbbike.org).

Point symbols were digitized as points, either round (Turner and Whitmore 2001) or square (Doolittle 2000). Whitmore and Turner (2001, e.g., fig. 5.6) rarely use point symbols, but Doolittle (2000) characteristically does.

In addition, the Difference tool and the Urban, Extractive 1500 CE layer were used to geoprocess holes in polygons that overlapped urbanized areas.

Once all polygons were digitized, an area field was added to the attribute table to check that all polygons are equal to or greater than 500 ha. An area of 500 ha is approximately 8% the size of the grid cells of 8,000 m by 8,000 m (64 km2/6,400 ha) used to judge the level of generalization appropriate for the project. So even an area of 500 ha, which, if a square, would have sides about 2.25 km (2,250 m) long, is not particularly significant and serves as an absolute lower threshold. All polygons attained that threshold, and none were deleted.

References

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