Digital Methods for Long Term River History:

The Case of the Yellow River in China

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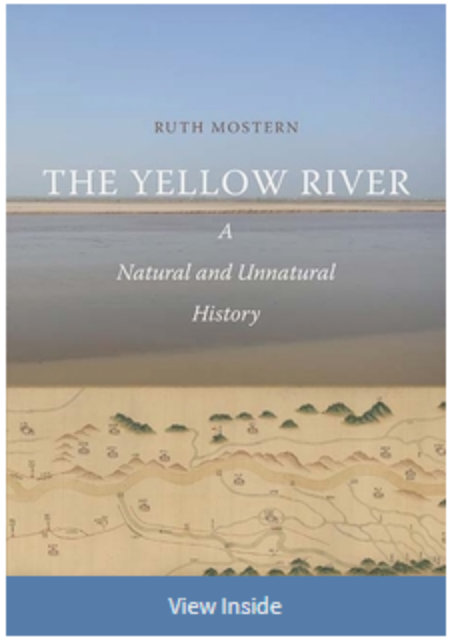
For Presentation at Methods in Sinology

September 1, 2022

The Yellow River

A Natural and Unnatural History

Ruth Mostern; Maps and Infographics with the Assistance of Ryan M. Horne



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Description | Reviews

A three-thousand-year history of the Yellow River and the legacy of interactions between humans and the natural landscape

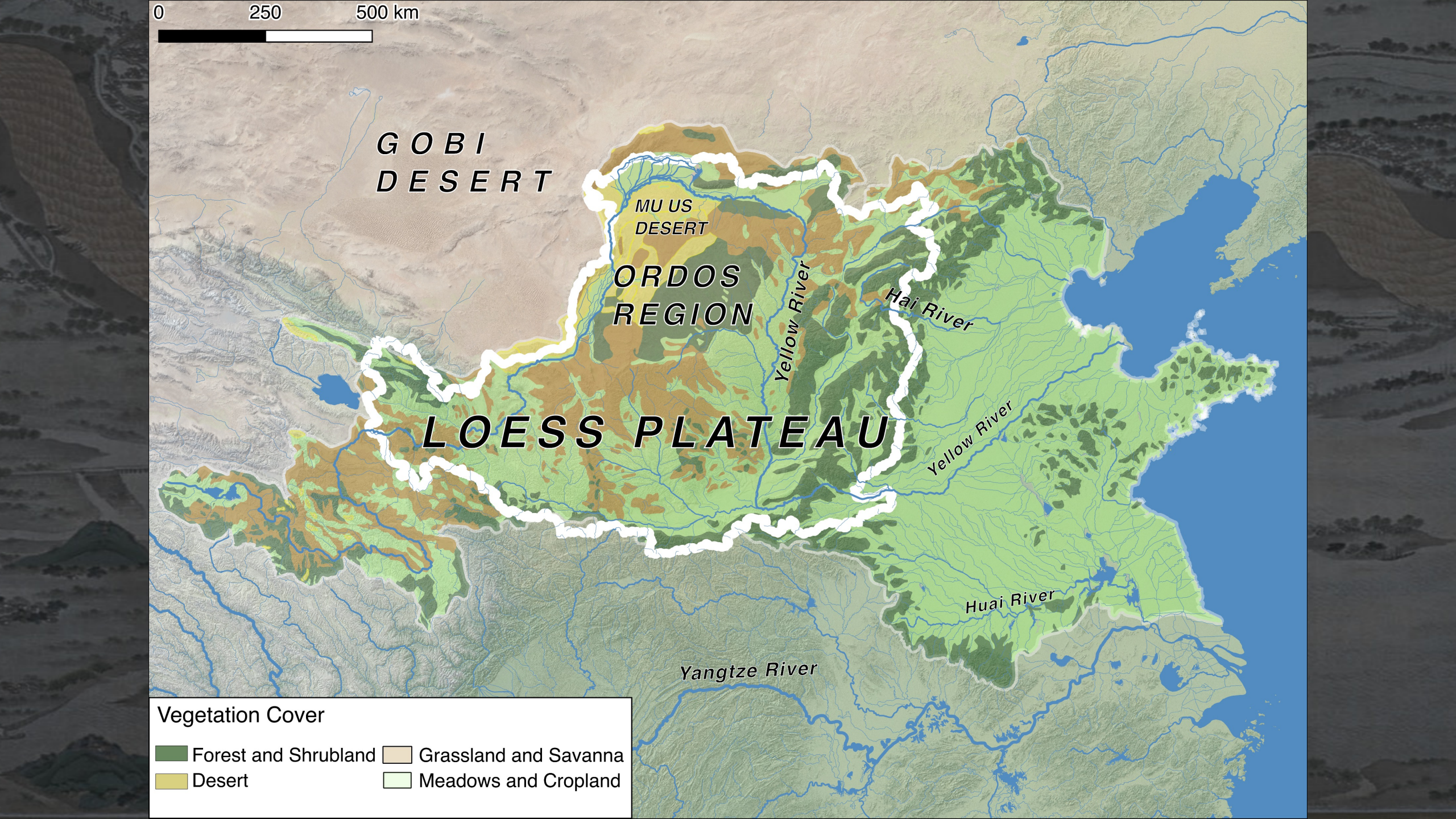
From Neolithic times to the present day, the Yellow River and its watershed have both shaped and been shaped by human society. Using the Yellow River to illustrate the long-term effects of environmentally significant human activity, Ruth Mostern unravels the long history of the human relationship with water and soil and the consequences, at times disastrous, of ecological transformations that resulted from human decisions.

As Mostern follows the Yellow River through three millennia of history, she underlines how governments consistently ignored the dynamic interrelationships of the river's varied ecosystems—grasslands, riparian forests, wetlands, and deserts—and the ecological and cultural impacts of their policies. With an interdisciplinary approach informed by archival research and GIS (geographical information system) records, this groundbreaking volume provides unique insight into patterns, transformations, and devastating ruptures throughout ecological history and offers profound conclusions about the way we continue to affect the natural systems upon which we depend.

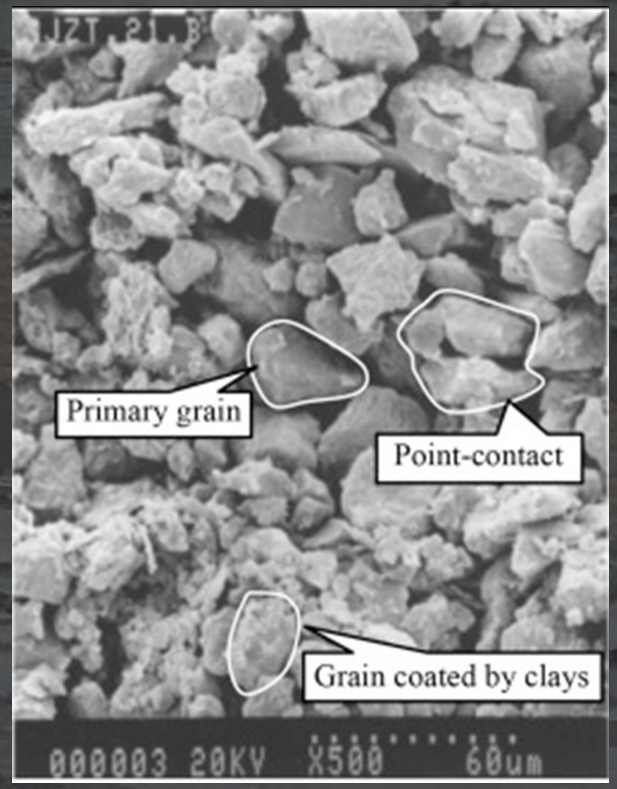
Ruth Mostern is associate professor of history at the University of Pittsburgh, where she is also director of the World History Center.

ISBN: 9780300238334
Publication Date: September 28, 2021

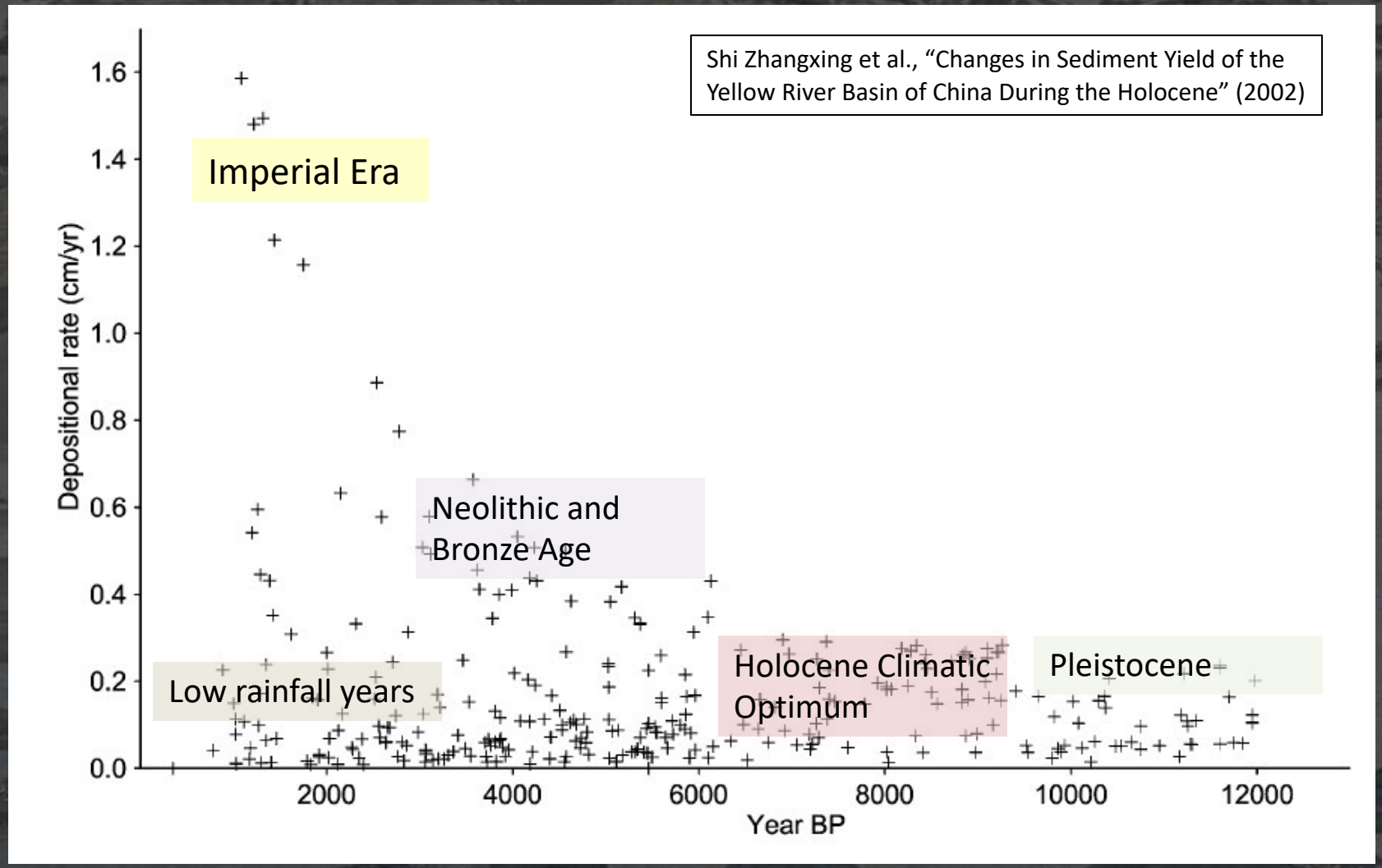
376 pages, 7 x 9
43 color + 120 b/w illus.


0
250
500 km
GOBI DESERT
MU US DESERT
ORDOS REGION
LOESS PLATEAU
Yellow River
Hai River
Yellow River
Huai River
Yangtze River
Vegetation Cover
Forest and Shrubland
Grassland and Savanna
Desert
Meadows and Cropland


0
250
500 km
LOESS
PLATEAU
Yellow River
ALLUVIAL
PLAIN



"Loess is very resistant to erosion under vegetation cover but readily erodible without it. … [U]nder forest or grass cover, slope and rainfall intensity have relatively little effect on soil erosion" (Ren and Zhu, 1994).


Shi Zhangxing et al., “Changes in Sediment Yield of the Yellow River Basin of China During the Holocene” (2002)
Imperial Era
Neolithic and Bronze Age
Low rainfall years
Holocene Climatic Optimum
Pleistocene
Depositional rate (cm/yr)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2000
4000
6000
8000
10000
12000
Year BP

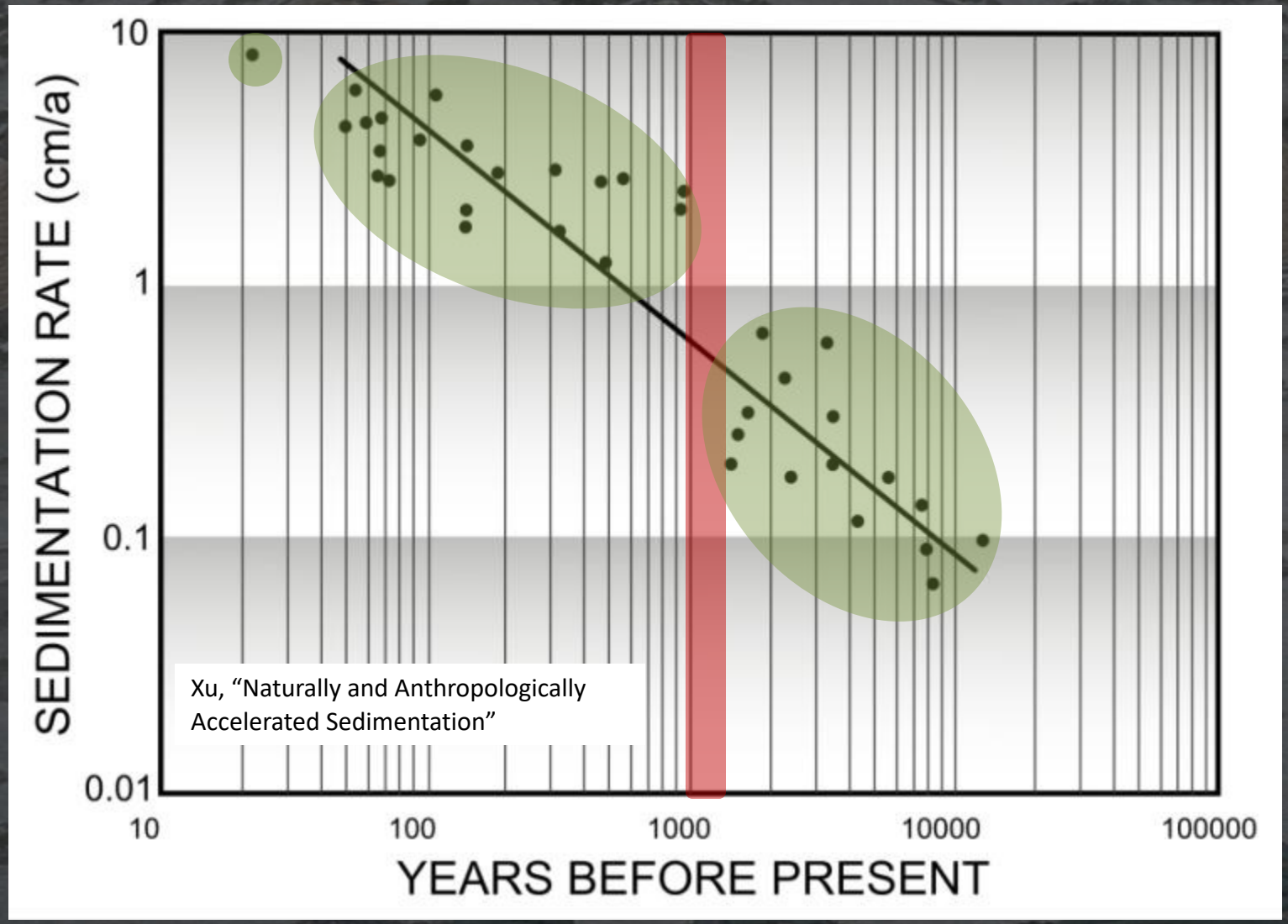
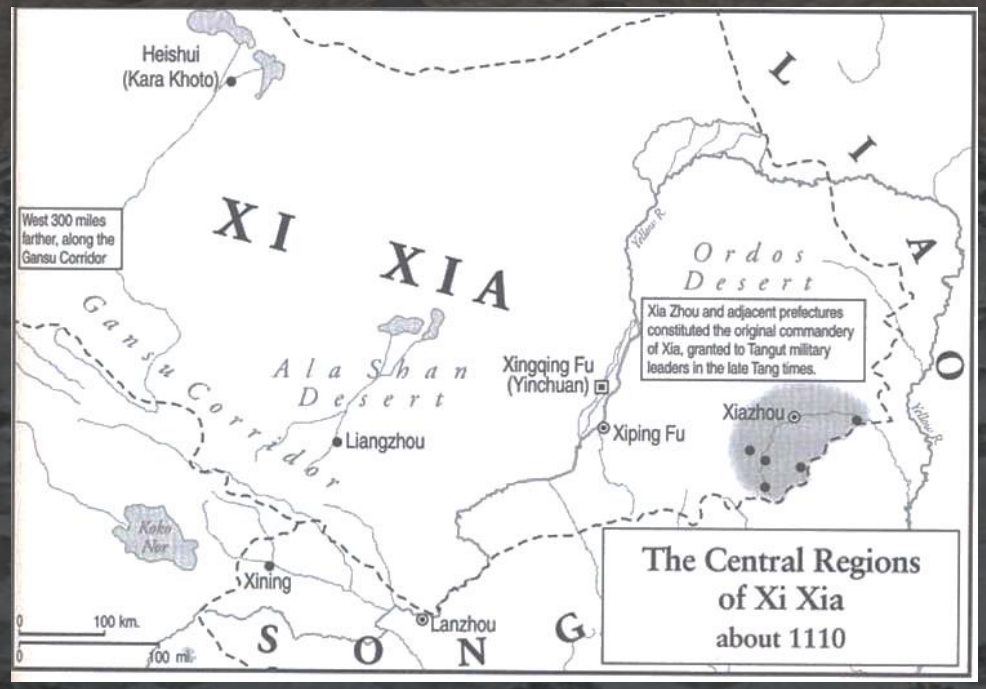

SEDIMENTATION RATE (cm/a)
10
1
0.1
0.01
10
100
1000
10000
100000
YEARS BEFORE PRESENT
Xu, “Naturally and Anthropologically Accelerated Sedimentation”

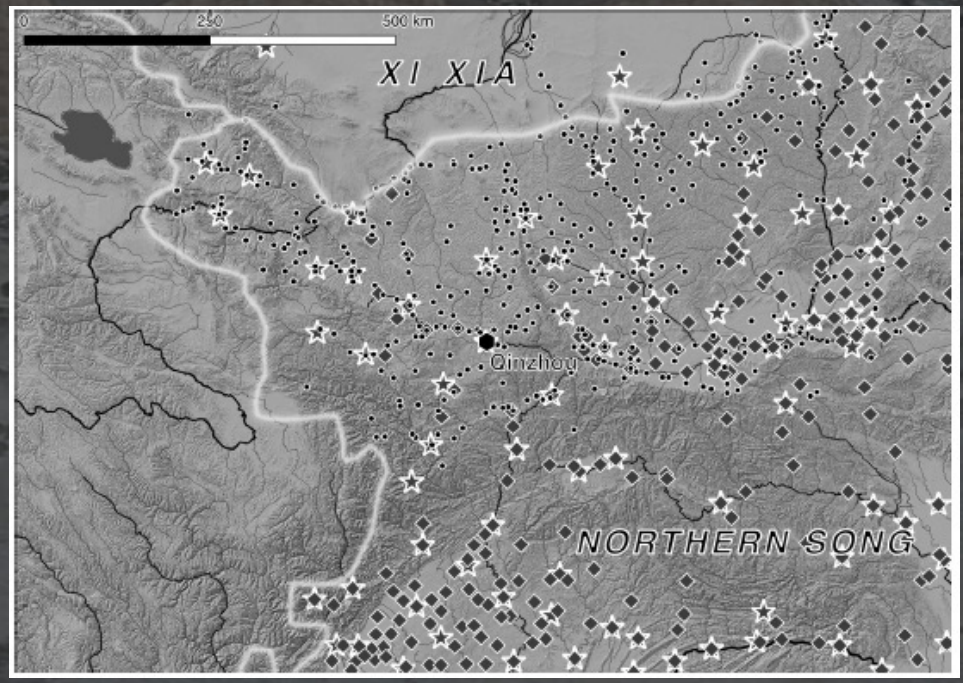
Table 2 – Changes in forest area of the Loess Plateau across time[a]

	Time						
	West-zhou (1066–771 B.C.)	N-S dynasty (420–589 A.D.)	Tang and Song (618–1275 A.D.)	Ming and Qing (1368–1911 A.D.)	1949	1988	1998
Area ($\times 10^6$ ha)	32.0	25.0	20.0	8.0	3.7	4.5	5.9
Coverage (%)	53	40	33	15	6.1	7.2	9.5

[a] About the forest cover, it is a contentious issue. Some of historical literatures, e.g., Shi et al. (1985) as cited by this paper, show a vast forest cover on the Loess Plateau during historical periods. And some geological records, such as pollen (Li et al., 2003), indicate that dense forests have never existed in the loess Yuan area (the plain area) since the late Pleistocene. But both historical literatures and geological records proved that vegetation coverage declined in all ages. Here, we use historical records because we think pollen as evidence is relatively sparse.

He Xiubin: intense loess plateau soil erosion transpired in three phases: starting around 7500 BP with the rise of agriculture, around 200 BCE-0 CE during the Western Han, and starting around 1000 years ago in the Northern Song. “Serious accelerated soil erosion has occurred during the last 2,500 years because of man-induced devastation of vegetation and other anthropogenic disturbance of the environment.”





The Tangut Xi Xia and the Khitan Liao came to power in the tenth century during an era of Chinese disunity. The Song state, established in 960, came to treaty terms with Liao in 1004 and established diplomatic relations and a clear border. That never happened with Xi Xia; war broke out in 1038 and lasted seven years.

Song Strategy on the Loess Plateau

- 1041: 34,000 horses and 155,600 people from 670 tribes. 32,580 imperial soldiers in 20 battalions, 900 additional battalions of provincial troops and militias. 1044: 500 imperial battalions, 500,000 troops. 300,000 Xia cavalry. (McGrath, "Frustrated Empires" in *Battlefields Real and Imagined*)
- A defensive strategy, a massive fort and wall building campaign in 1040, another in 1042 to "fill in the empty spaces." The war ended in a stalemate, cavalry versus forts.

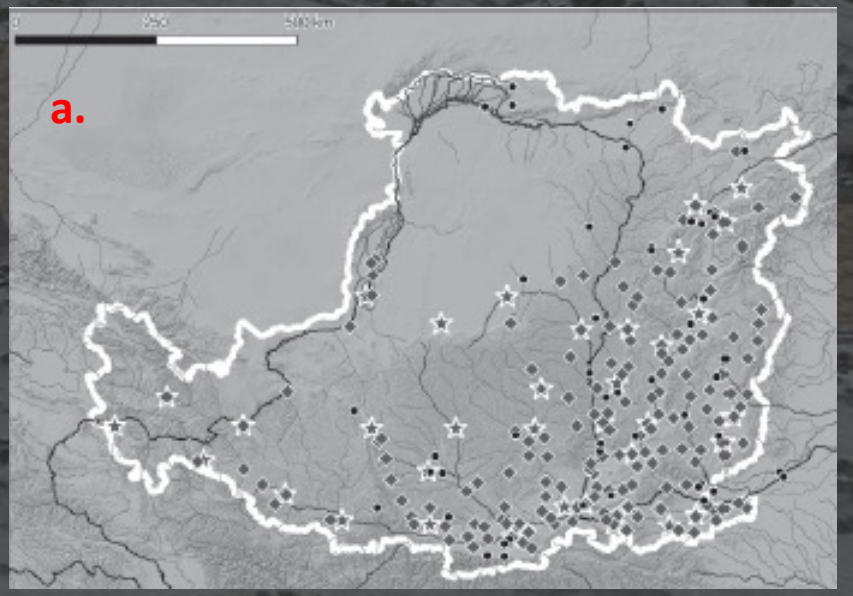
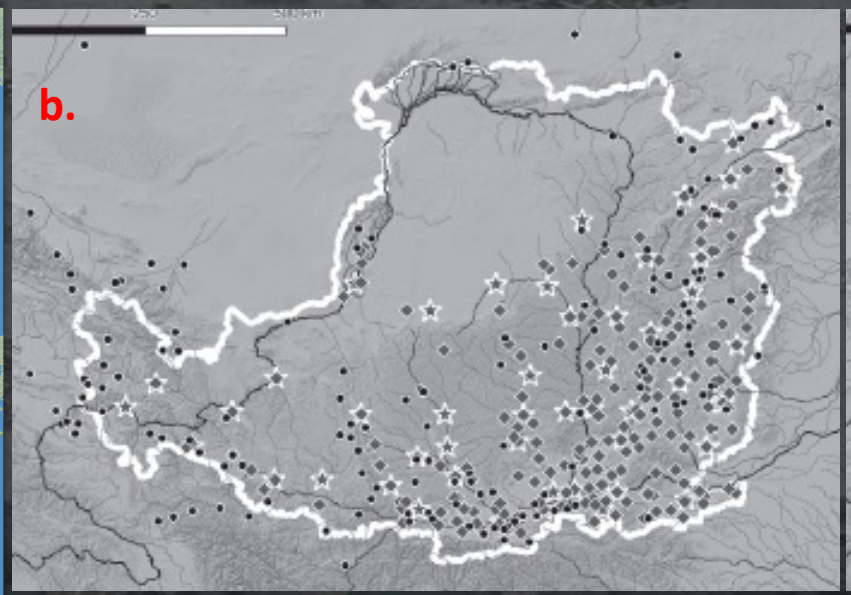
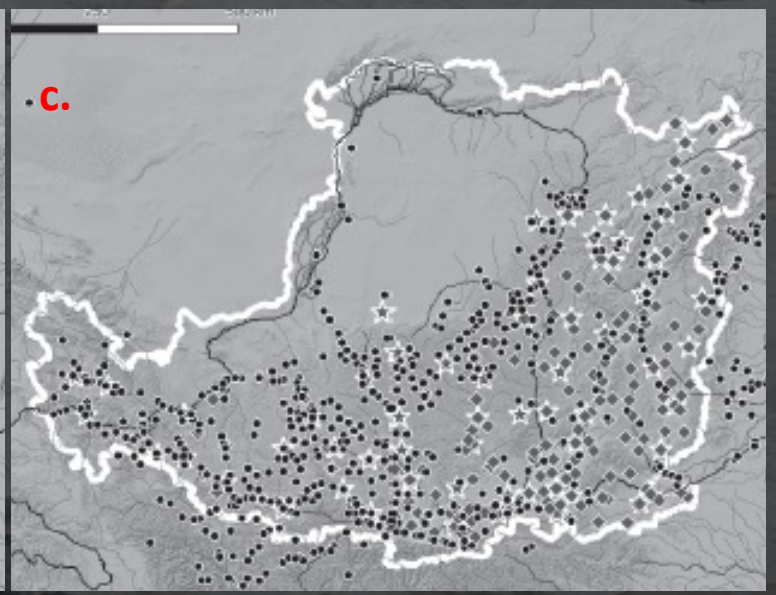


FIGURE 3.6
Loess Plateau Settlement Geography. This series of maps depicts the dramatic expansion of settlement in the Ordos between (a) the middle of the eighth century, (b) the middle of the eleventh century, and (c) the early twelfth century at the conclusion of the fortification campaign on the Xi Xia frontier.





From Wei Huan 魏煥,, *Huang Ming jiu bian kao* 皇明九邊考 (1542)

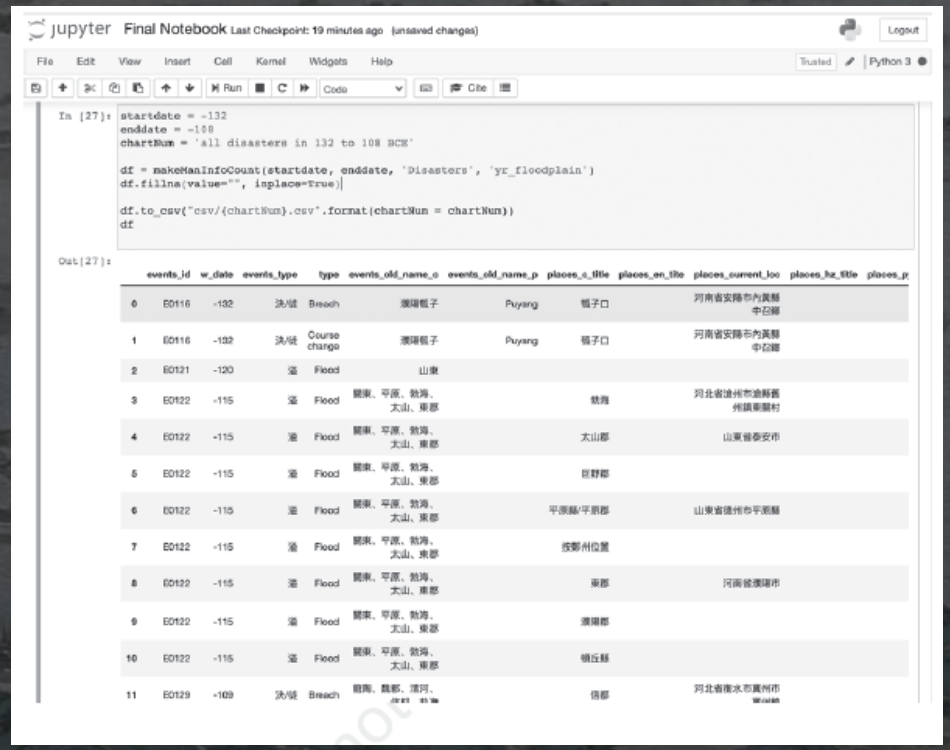
The Song timber industry, Ming Great Wall fortification, and Qing forestry and farming all put additional pressure on Loess plateau landscapes, though Yuan colonization and late Ming droughts and rebellions relieved those pressures.

- Middle Course Data: Units below county rank in the *Historical Atlas of China* (中国历史地图集), units above country rank from the China Historical GIS.
- Floodplain Data: from 62 lists and tables spread across ten Chinese publications such as *The Yellow River Annals* (黄河年表), georeferenced and coded by event type. 3,754 unique events including 1,645 floods and course changes.

TABLE A.1
Contextual Data in the Tracks of Yu Digital Atlas

Category	Source
China Historical GIS	Historical Counties and Prefectures[a]
Lakes and Open Water	Harvard ChinaMap
Rivers	China Rivers Sorted by Basin[b]
Historic Courses of the Grand Canal	Harvard ChinaMap
Basemap	Ancient World Mapping Center, Natural Earth, NASA SRTM[c]
Vegetation	Harvard ChinaMap (2000)
Historical Courses of the Yellow River	Chen Yunzhen[d]
Dynasties and Reigns	Wikipedia
Mountain peaks and passes	Harvard ChinaMap
Ecosystems	World Wildlife Fund
Moisture Index	Monsoon Asia Drought Atlas[e]
Sedimentation Rate	Xu Jiongxin
Historical Census Data	HarvardChinaMap

[a]Fairbank Center et al., "China Historical GIS."
[b]Berman, "China River Basins."
[c]Horne, "Map Tiles"; NASA, SRTM.
[d]Chen, "Course Change Shapefiles." Thank you to Chen Yunzhen for sharing this data with me and allowing me to use it.
[e]Cook et al., "Asian Monsoon Failure and Megadrought." Thank you to Amy Hessl for preparing this data and discussing it with me.



Shen Yi 沈怡 (1901—1980): A prominent civil engineer, Director of the Yellow River Conservancy Commission in the 1930s, Nanjing mayor in the 1940s, editor of the *Yellow River Annals.*

Box A.1

A Query to the Tracks of Yu Digital Atlas

This generic query combines the events, places, places to events, event types, floodplain geography, and an arbitrary point and buffer. It generates all information about places that were affected by an event of a certain type, between an arbitrary number of years, and within a set distance from a point. Users need simply input the years, distance, and point values of interest into a function call. The final notebook contains more than five hundred such queries and calls, with each individual query capable of being styled and adjusted as needed.

```
def makeManInfoCount(startdate, enddate, category, area):
    sql ="""
SELECT
  c.events_id,
  c.w_date,
  c.events_type,
  d.type,
  c.events_old_name_c,
  c.events_old_name_p,
  c.places_c_title,
  c.places_en_tite,
  c.places_current_loc,
  c.places_hz_title,
  c.places_py_title,
  c.places_id,
  c.geom
FROM
  (
    SELECT
      a.events_id AS events_id,
      a.w_date,
      a.type_c AS events_type,
      a.old_name_c AS events_old_name_c,
      a.old_name_p AS events_old_name_p,
      b.c_title AS places_c_title,
      b.en_tite AS places_en_tite,
```

Box A.1 (continued)

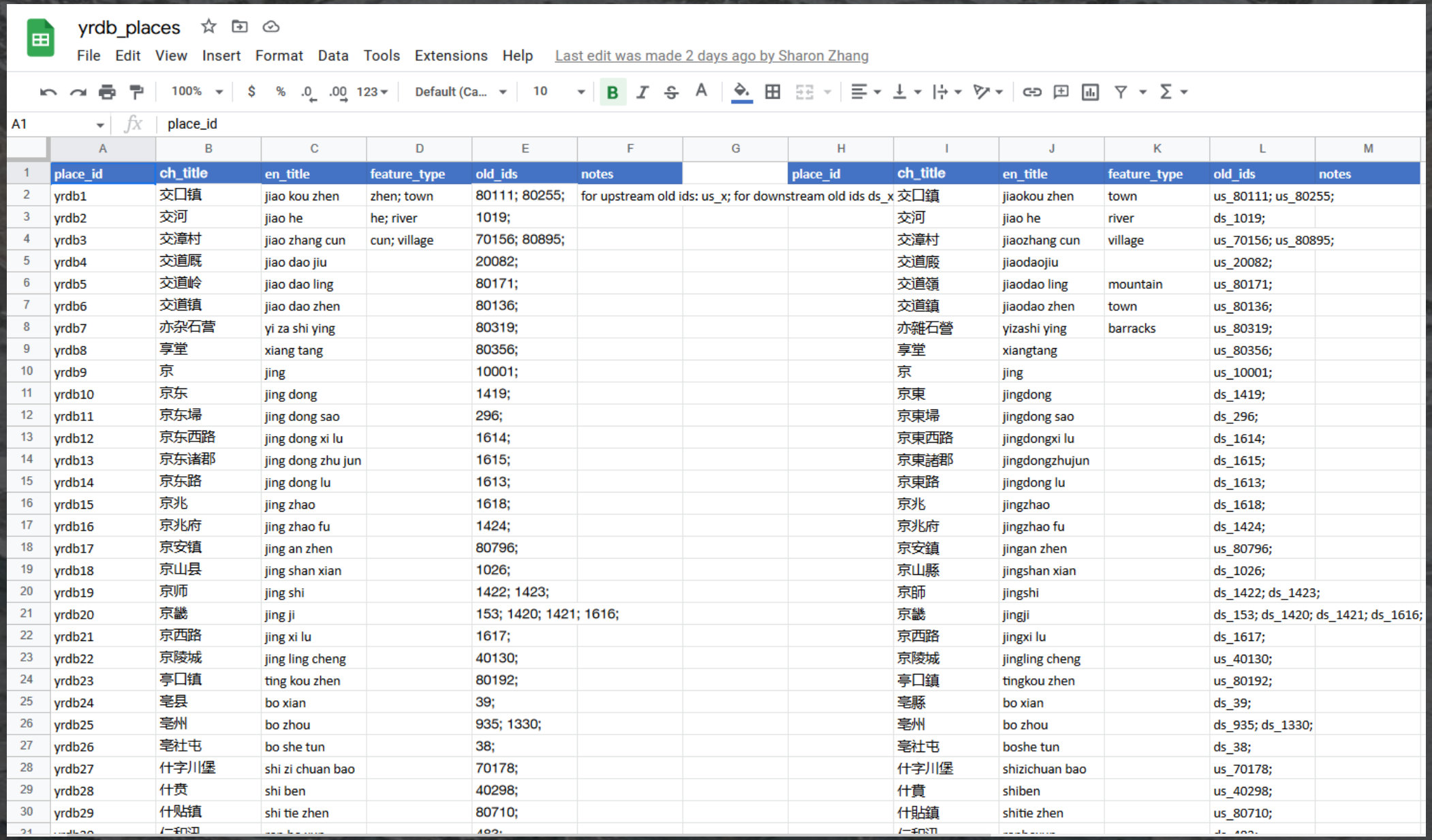
```
      b.current_loc AS places_current_loc,
      b.hz_title AS places_hz_title,
      b.py_title AS places_py_title,
      b.geom AS geom,
      a.place_id AS places_id
    FROM
    (
      SELECT
        events.old_name_c,
        events.old_name_p,
        places_to_events.place_id,
        events.type_c,
        events.w_date,
        events.id AS events_id
      FROM
        events
        LEFT JOIN places_to_events ON events.id = places_
to_events.event_id
      WHERE
        events.id IN (
          SELECT
            events_to_type.id
          FROM
            events_to_type
            JOIN event_types ON event_types.ch_title =
events_to_type.type_c
          WHERE
            event_types.en_cat = {category}
          GROUP BY
            (events_to_type.id)
        )
    ) a
    LEFT JOIN (
      SELECT
        places_to_events.place_id,
        places.c_title,
```

```
        places.en_tite,
        places.current_loc,
        places.hz_title,
        places.py_title,
        places.geom
      FROM
        places
        LEFT JOIN places_to_events ON places.id = places_
to_events.place_id
      WHERE
        st_intersects(
          places.geom,
          (
            SELECT
              ST_Union(
                ST_Buffer({area}.geom :: geography, 180000)::
geometry
              )
            from
              {area}
          )
        ) = true
    ) b ON a.place_id = b.place_id
    WHERE
      a.w_date BETWEEN {startdate}
      AND {enddate}
  ) c
  JOIN (
    SELECT
      event_types.type,
      events_to_type.id AS event_id
    FROM
      events_to_type
      JOIN event_types ON event_types.ch_title = events_to_
type.type_c
    WHERE
      event_types.en_cat = {category}
```

Box A.1 (continued)

```
    ) d ON c.events_id = d.event_id
  GROUP BY
    c.events_id,
    c.places_c_title,
    c.places_en_tite,
    c.places_current_loc,
    c.places_hz_title,
    c.places_py_title,
    c.places_id,
    c.w_date,
    c.events_type,
    c.events_old_name_c,
    c.events_old_name_p,
    d.type,
    c.geom
  ORDER BY
    c.w_date ASC=""".format(startdate = startdate, enddate =
      enddate, category=category, area=area)
      dfManInfo = pd.read_sql_query(sql, cnx)
      return dfManInfo
```

This generic query combines events, places, places-to-events, event types, floodplain geography, and an arbitrary point and buffer. It generates all information about places that were affected by an event of a certain type, between an arbitrary number of years, and within a set distance from a point. The final Jupyter Notebook contains more than 500 such queries. We have reached the limit of relational database logic and we plan to restructure the data into a **graph database** comprised of nodes, edges and properties prior to releasing it publicly. Ryan M. Horne is my collaborator in this work.



yrdb_places

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A1 place_id

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	place_id	ch_title	en_title	feature_type	old_ids	notes		place_id	ch_title	en_title	feature_type	old_ids	notes
2	yrdb1	交口镇	jiao kou zhen	zhen; town	80111; 80255;	for upstream old ids: us_x; for downstream old ids ds_x			交口鎮	jiaokou zhen	town	us_80111; us_80255;	
3	yrdb2	交河	jiao he	he; river	1019;				交河	jiao he	river	ds_1019;	
4	yrdb3	交漳村	jiao zhang cun	cun; village	70156; 80895;				交漳村	jiaozhang cun	village	us_70156; us_80895;	
5	yrdb4	交道厩	jiao dao jiu		20082;				交道廄	jiaodaojiu		us_20082;	
6	yrdb5	交道岭	jiao dao ling		80171;				交道嶺	jiaodao ling	mountain	us_80171;	
7	yrdb6	交道镇	jiao dao zhen		80136;				交道鎮	jiaodao zhen	town	us_80136;	
8	yrdb7	亦杂石营	yi za shi ying		80319;				亦雜石營	yizashi ying	barracks	us_80319;	
9	yrdb8	享堂	xiang tang		80356;				享堂	xiangtang		us_80356;	
10	yrdb9	京	jing		10001;				京	jing		us_10001;	
11	yrdb10	京东	jing dong		1419;				京東	jingdong		ds_1419;	
12	yrdb11	京东埽	jing dong sao		296;				京東埽	jingdong sao		ds_296;	
13	yrdb12	京东西路	jing dong xi lu		1614;				京東西路	jingdongxi lu		ds_1614;	
14	yrdb13	京东诸郡	jing dong zhu jun		1615;				京東諸郡	jingdongzhujun		ds_1615;	
15	yrdb14	京东路	jing dong lu		1613;				京東路	jingdong lu		ds_1613;	
16	yrdb15	京兆	jing zhao		1618;				京兆	jingzhao		ds_1618;	
17	yrdb16	京兆府	jing zhao fu		1424;				京兆府	jingzhao fu		ds_1424;	
18	yrdb17	京安镇	jing an zhen		80796;				京安鎮	jingan zhen		us_80796;	
19	yrdb18	京山县	jing shan xian		1026;				京山縣	jingshan xian		ds_1026;	
20	yrdb19	京师	jing shi		1422; 1423;				京師	jingshi		ds_1422; ds_1423;	
21	yrdb20	京畿	jing ji		153; 1420; 1421; 1616;				京畿	jingji		ds_153; ds_1420; ds_1421; ds_1616;	
22	yrdb21	京西路	jing xi lu		1617;				京西路	jingxi lu		ds_1617;	
23	yrdb22	京陵城	jing ling cheng		40130;				京陵城	jingling cheng		us_40130;	
24	yrdb23	亭口镇	ting kou zhen		80192;				亭口鎮	tingkou zhen		us_80192;	
25	yrdb24	亳县	bo xian		39;				亳縣	bo xian		ds_39;	
26	yrdb25	亳州	bo zhou		935; 1330;				亳州	bo zhou		ds_935; ds_1330;	
27	yrdb26	亳社屯	bo she tun		38;				亳社屯	boshe tun		ds_38;	
28	yrdb27	什字川堡	shi zi chuan bao		70178;				什字川堡	shizichuan bao		us_70178;	
29	yrdb28	什贲	shi ben		40298;				什賁	shiben		us_40298;	
30	yrdb29	什贴镇	shi tie zhen		80710;				什貼鎮	shitie zhen		us_80710;	

yrdb_places

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A1 Event ID

	Event ID	Source ID	ChineseDate	WesternDate	OldPlaceNameChinese	OldPlaceNamePinyin	ModernPlaceNameChinese	ModernPlaceNamePinyin	EventType Chinese	EventType English	EventDescription	PrimarySource1	PrimarySource2
1201	1200	10407029	金章宗明昌五年	1194	南、北清河				议			春正月，尚书省奏：“都水监丞田栎同本监官讲议黄河利害，尝以状上言，前代每遇古堤南决，多经南、北清河分流，南清河北下有枯河数道，河水流其中者长至七八分，北清河乃济水故道，可容三二分而已。今河水趋北，啮长堤而流者十余处，而堤外率多积水，恐难依元料增修长堤与创筑月堤也。可于北岸墙村决河入梁山泺故道，依旧作南、北两清河分流。然北清河旧堤岁久不完。当立年限增筑大堤，而梁山故道多有屯田军户，亦宜迁徙。今拟先于南岸王村、宜村两处决堤导水，使长堤可以固护，姑宜仍旧，如不能疏导，即依上开决，分为四道，俟见水势随宜料理。”（金史河渠志）	四月密旨曰：“如栎所言，筑堤用二十万十日，五年可毕，此役之大，古所未有可知，就使可成，恐难行也。”（金史河
1202	1201	10407030	金章宗明昌五年	1194	北清河州县				议			工部言：“若遽于墙村疏决，缘濒北清河州县二十余处，两岸连互千有余里，其堤防素不修备，恐所屯军户亦卒难徙。今岁先于南岸延津县堤决堤泄水，其北岸长堤自白马以下，定陶以上，并宜加功筑护，庶可以遏将来之患。若定陶以东三埽弃堤则不必修，止决旧压河口，引导积水东南行，流堤北张彪、白塔两河间，碍水军户可使迁徙，及梁山泺故道分屯者，亦当预为安置。”（金史河渠志）	
1203	1202	10407031	金章宗明昌五年	1194	栎梁山				议/治			百官咸谓：“栎梁山泺淤填已高，而北清河窄狭不能吞伏，兼所经州县农民庐井非一，使大河北入清河，山东必被其害。栎所言无可用。”遂寝其议。（金史河渠志）	
1204	1203	10407032	金章宗明昌五年	1194	王村河口				放			六月开道王村河口。（金史河渠志）	
1205	1204	10407033	金章宗明昌五年	1194	阳武、封丘				决			八月，以河决阳武故堤，灌封丘而东。（金史河渠志）	
1206	1205	10407034	金章宗明昌五年	1194	光禄村				议			胥持国、马琪言：“已至光禄村周视堤口。以其河水浸漫，堤岸陷溃，至十余里外乃能取土。而堤面窄狭，仅可数步，人力不可施，虽穷力可以暂成，终当复毁。而中道淤淀，地有高低，流不得泄，且水退，新滩亦难开凿。其孟华等四埽与孟阳堤道，沿汴河东岸，但可施功者，即悉力修护，将于农隙兴役，及冻毕工，则京城不至为害。”（金史河渠志）	
1207	1206	10407035	金章宗明昌五年	1194	孟阳、汴城				议/修/治			十月庚辰，琪自行省还，入见，言：“孟阳河堤及汴堤已填筑补修，水不能犯汴城。自今河势趋北，来岁春首拟于中道疏决，以解南北两岸之危。凡计工八百七十余万，可于正月终兴工。臣乞前期再往河上监视。”上然之（金史河渠志）	
1208	1207	10407036	金章宗明昌五年	1194	延津、封邱、长垣、兰阳、束明、曹州、濮州、郓城、范县、寿张、梁山溪、东平、东阿、平阴、长清、齐河、历城、济阳、齐东、武定、青城、滨州、蒲台、利津、汶上、嘉祥、济				徙			河徒自阳武而束，历延津封邱长垣兰阳束明曹州濮州郓城范县诸州县界中。至寿张注梁山溪分为二派；北派由北清河入海。今大清河自东平历东阿平阴长清齐河历城济阳齐东武定青城滨州蒲台至利津县入海者是也。南派由南清河入淮，郎泗水故道，今会通河自东平历汶上嘉祥济宁合泗水至清河县入淮者是也。（禹贡锥指）	

id	hz	py	name_type	x_coor	y_coor	page	date	regime	parentPref	parentPref	parentProv	parentProv	notes
80522	三岔镇	sancha zhe	zhen	104.2711771	34.84011047	8,28-29	1820	Qing	巩昌府	Gongchang	甘肃	Gansu	
70443	三川寨	sanchuan z	zhai;chuan	106.1230922	36.01456688	7,17-18	1330	Yuan	开成州	Kaicheng Zh	陕西行省	Shaanxi Xingsheng	
70472	三川站	sanchuan z	chuan;zhan	109.2803486	35.76691403	7,17-18	1330	Yuan	延安路	Yan'an Lu	陕西行省	Shaanxi Xingsheng	
70259	三乡镇	sanxiang zh	zhen	106.631212	34.99330944	7,59-60	1582	Ming	平凉府	Pingliang Fu	陕西	Shaanxi	
80184	三河口	san hekou	hekou	110.1357762	34.61676057	8,26-27	1820	Qing	同州府	Tongzhou F	陕西	Shaanxi	
80740	三泉镇	sanquan zh	quan;zhen	111.6944516	37.1905697	8,20-21	1820	Qing	汾州府	Fenzhou Fu	山西	Shanxi	
81101	三甲集	sanjia ji	ji	103.742217	35.55127334	8,30	1820	Qing	兰州府	Lanzhou Fu	甘肃	Gansu	
80064	三皇峁	sanhuang m	mao	109.9486924	37.58719768	8,26-27	1820	Qing	绥德州	Suide Zhou	陕西	Shaanxi	
80408	三眼井堡	sanyanjing b	jing;bu	103.9053283	37.33795553	8,28-29	1820	Qing	兰州府	Lanzhou Fu	甘肃	Gansu	
70253	三营	san ying	ying	106.1500712	36.1278177	7,59-60	1582	Ming	平凉府	Pingliang Fu	陕西	Shaanxi	
80483	三营	san ying	ying	106.1922836	36.25809133	8,28-29	1820	Qing	平凉府	Pingliang Fu	甘肃	Gansu	
80396	三角城	sanjiao che	cheng	104.6603468	36.64759329	8,28-29	1820	Qing	兰州府	Lanzhou Fu	甘肃	Gansu	
80062	三道	sandao		109.110895	37.57433048	8,26-27	1820	Qing	榆林府	Yulin Fu	陕西	Shaanxi	
81027	三道河	sandao he	he	107.0957879	40.27149259	8,57-58	1820	Qing	厄鲁特旗	Elute Qi	内蒙古	Inner Mongolia	
80310	上五庄	shangwu zh	zhuang	101.2244552	36.83821485	8,28-29	1820	Qing	西宁府	Xining Fu	甘肃	Gansu	
80504	上关	shang guan	guan	106.7887899	35.12556355	8,28-29	1820	Qing	平凉府	Pingliang Fu	甘肃	Gansu	
20115	上虒亭	shangsi ting	ting	112.778216	36.57934571	2,17-18		Western Han	上党郡	Shangdang	并州刺史部	Bingzhou Cishi Bu	
80353	上川口司	shangchuar	si1	102.7138335	36.30430551	8,28-29	1820	Qing	西宁府	Xining Fu	甘肃	Gansu	

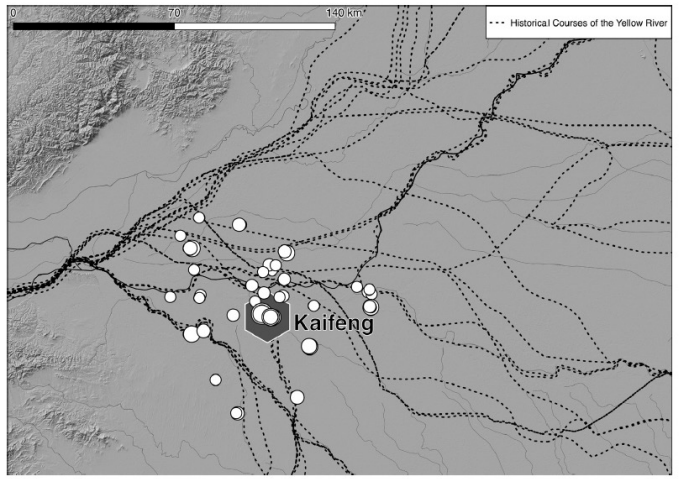


FIGURE 1.11
Historical Floods around Kaifeng. Kaifeng, the major city of the floodplain and sometimes an imperial capital, lay in the middle of the flood region.

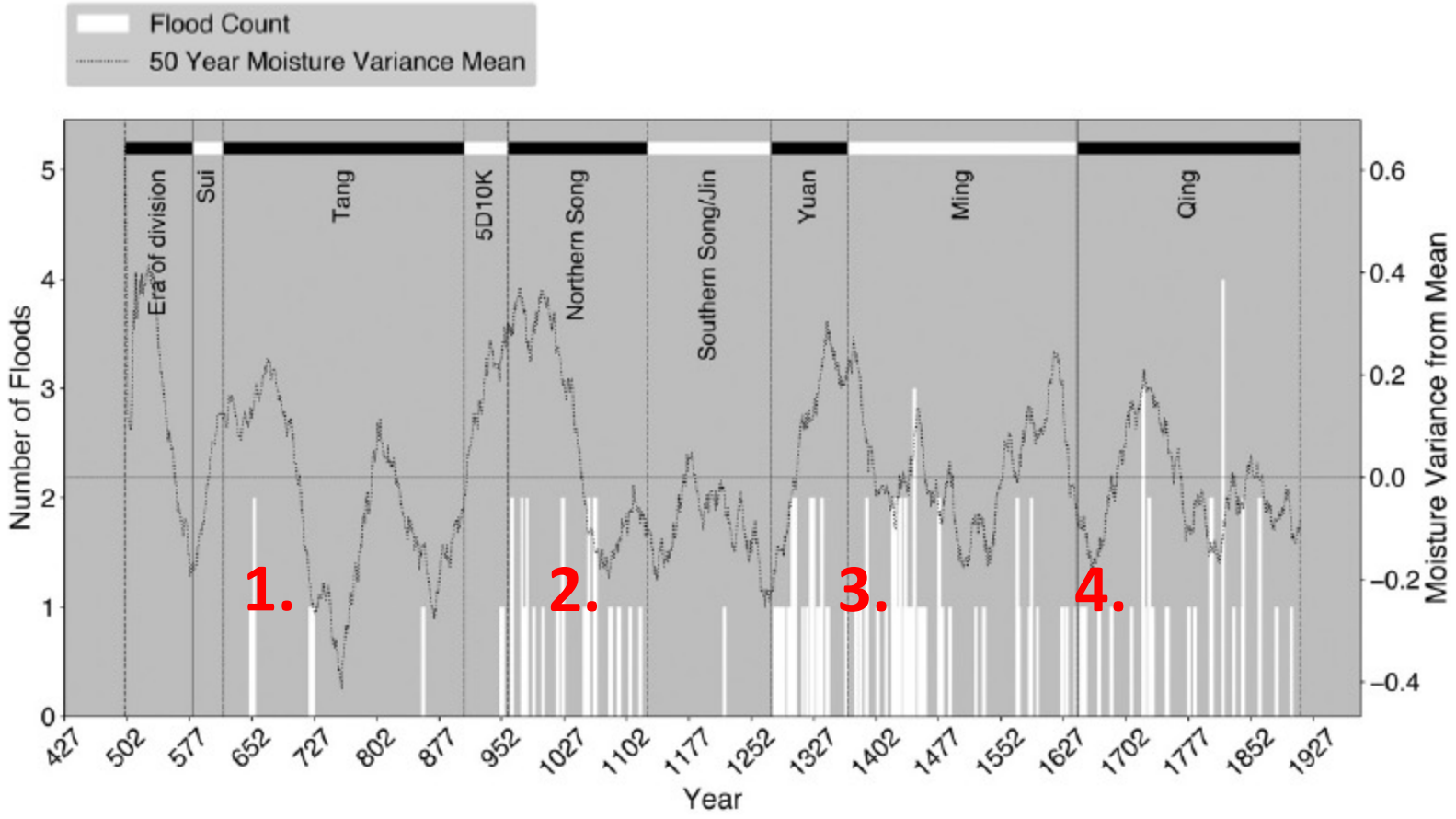
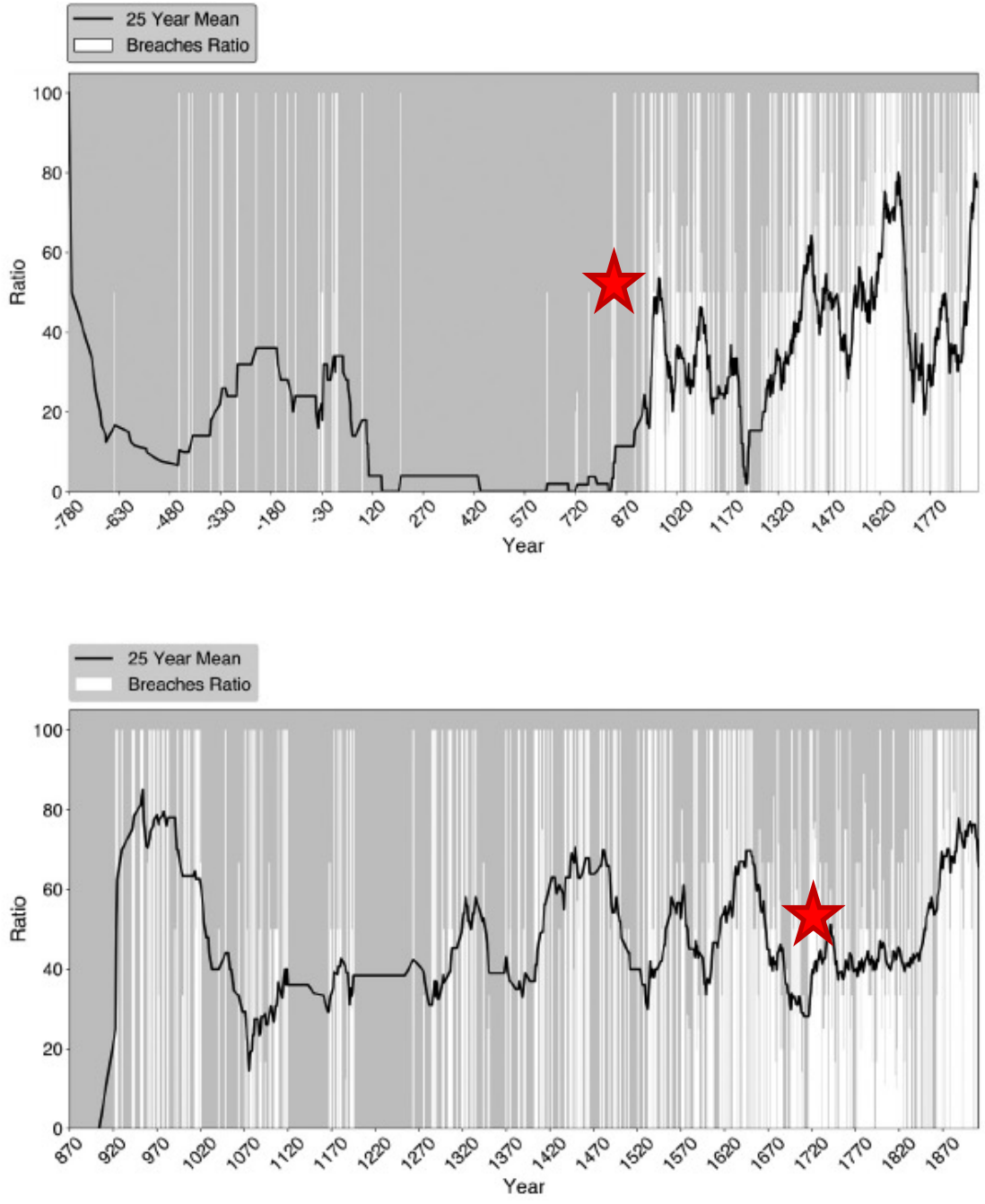


FIGURE 1.12
A Timeline of Historical Floods around Kaifeng. Around Kaifeng, as everywhere else on the floodplain, the turn of the first millennium of the Common Era marked the beginning of the disaster era.

FIGURE I.2

Breaches as a Percentage of Disasters. Until the tenth century, when levee building began in earnest, there were few disasters on the floodplain, and few of those that did occur were recorded as levee breaches. From the tenth century onward, historical sources report disasters on a near-annual basis, and half or more of all reported disasters were breaches. Figure (a) depicts attested levee breaches on the Yellow River as a percentage of all recorded disasters. Waterworks management was rare until the ninth century, and it increased to near-annual frequency only in the seventeenth century. Figure (b) depicts repairs as a percentage of all recorded events of waterworks management.



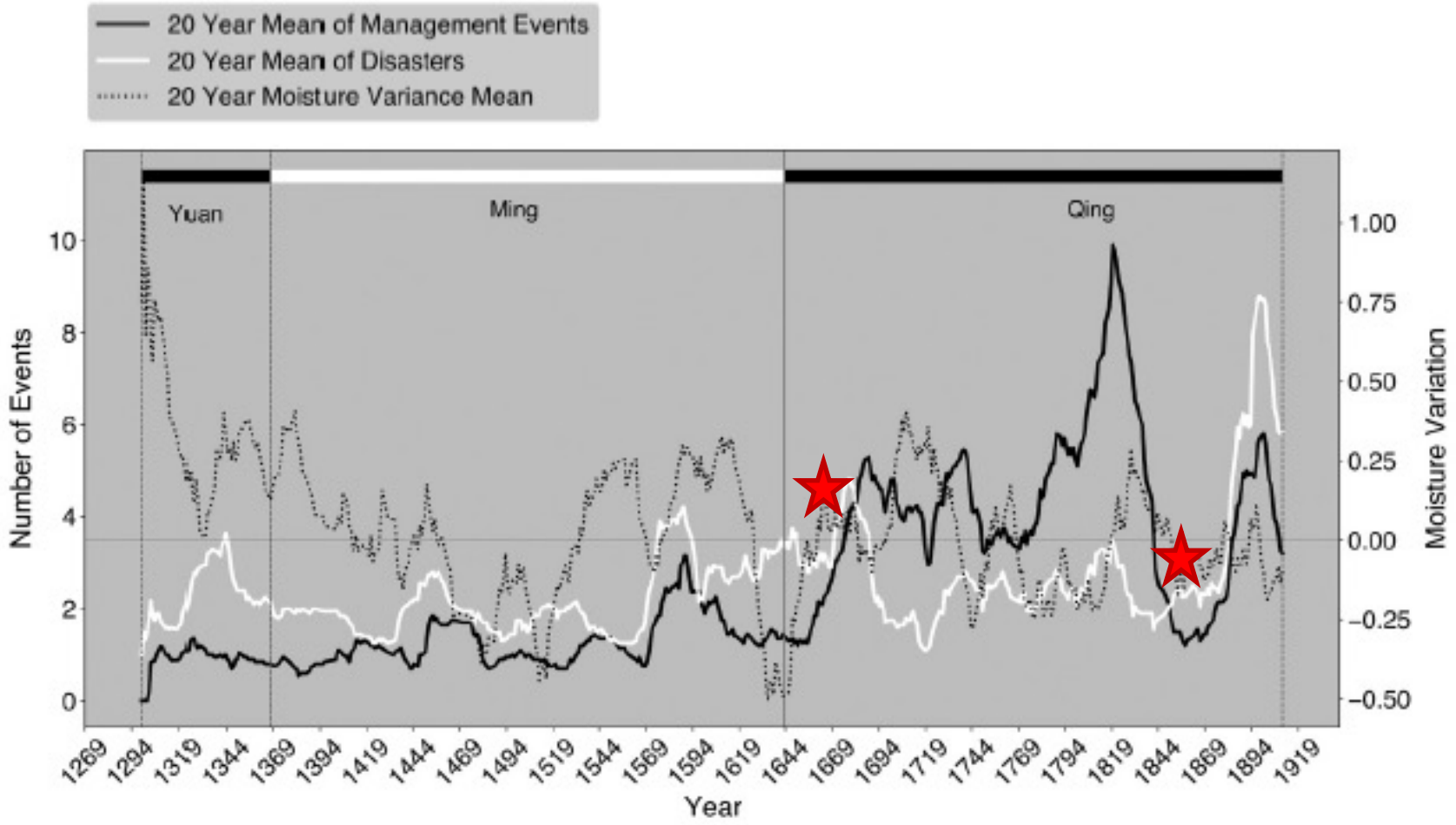
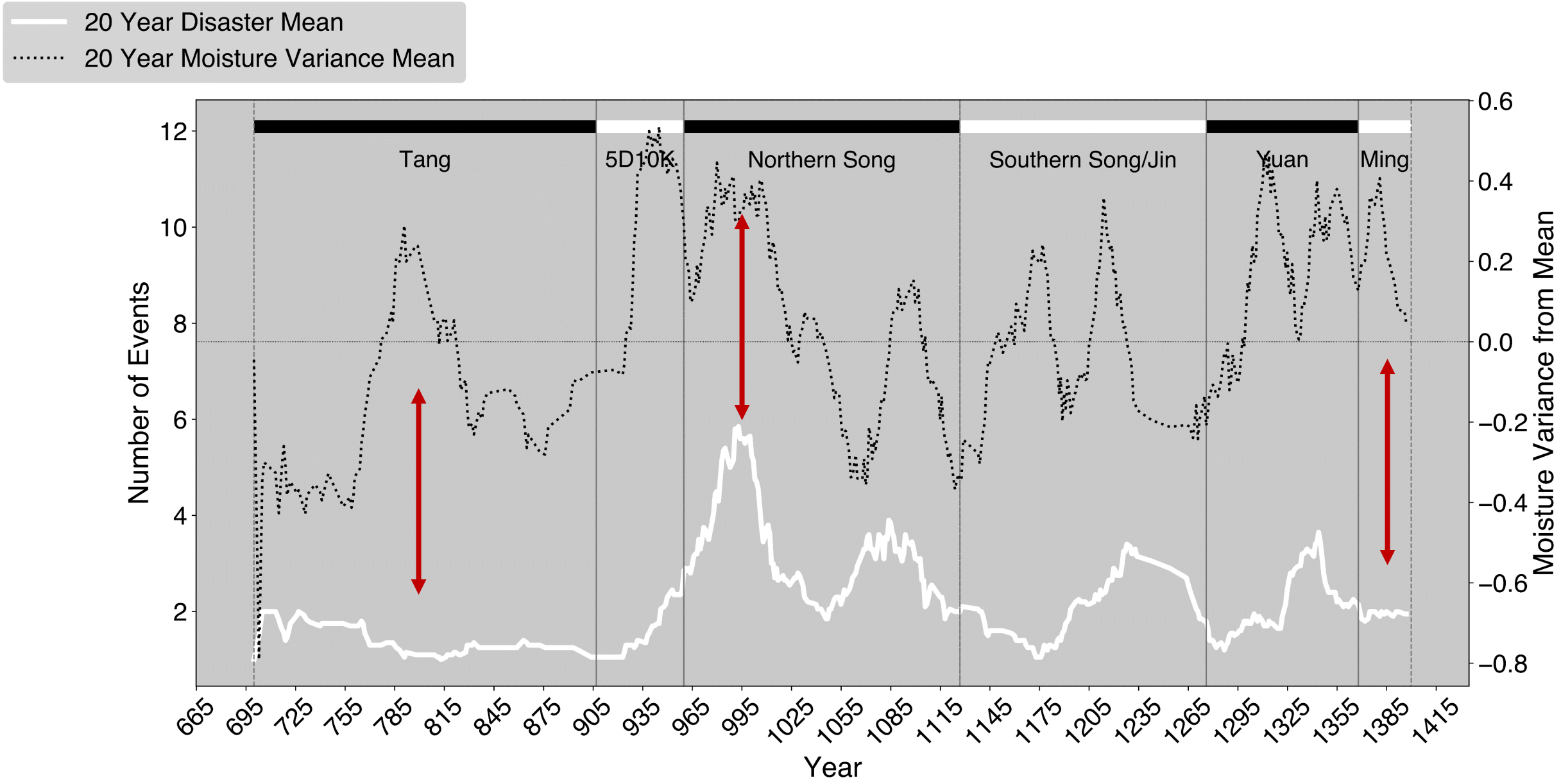


FIGURE 4.2
Events and Moisture Levels, 1300 to 1911. Until the seventeenth century, the rate of attested management events and the rate of reported disaster events tracked fairly closely to one another, with the number of management events consistently below the number of disaster events. That relationship changed dramatically in the late seventeenth century, the beginning of more than a century of vigorous infrastructure development that successfully suppressed flood rates. The moisture timeline and the event timeline are not related during these centuries.


20 Year Disaster Mean
20 Year Moisture Variance Mean
Tang
5D10K
Northern Song
Southern Song/Jin
Yuan
Ming
Number of Events
Moisture Variance from Mean
Year
12
10
8
6
4
2
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
665
695
725
755
785
815
845
875
905
935
965
995
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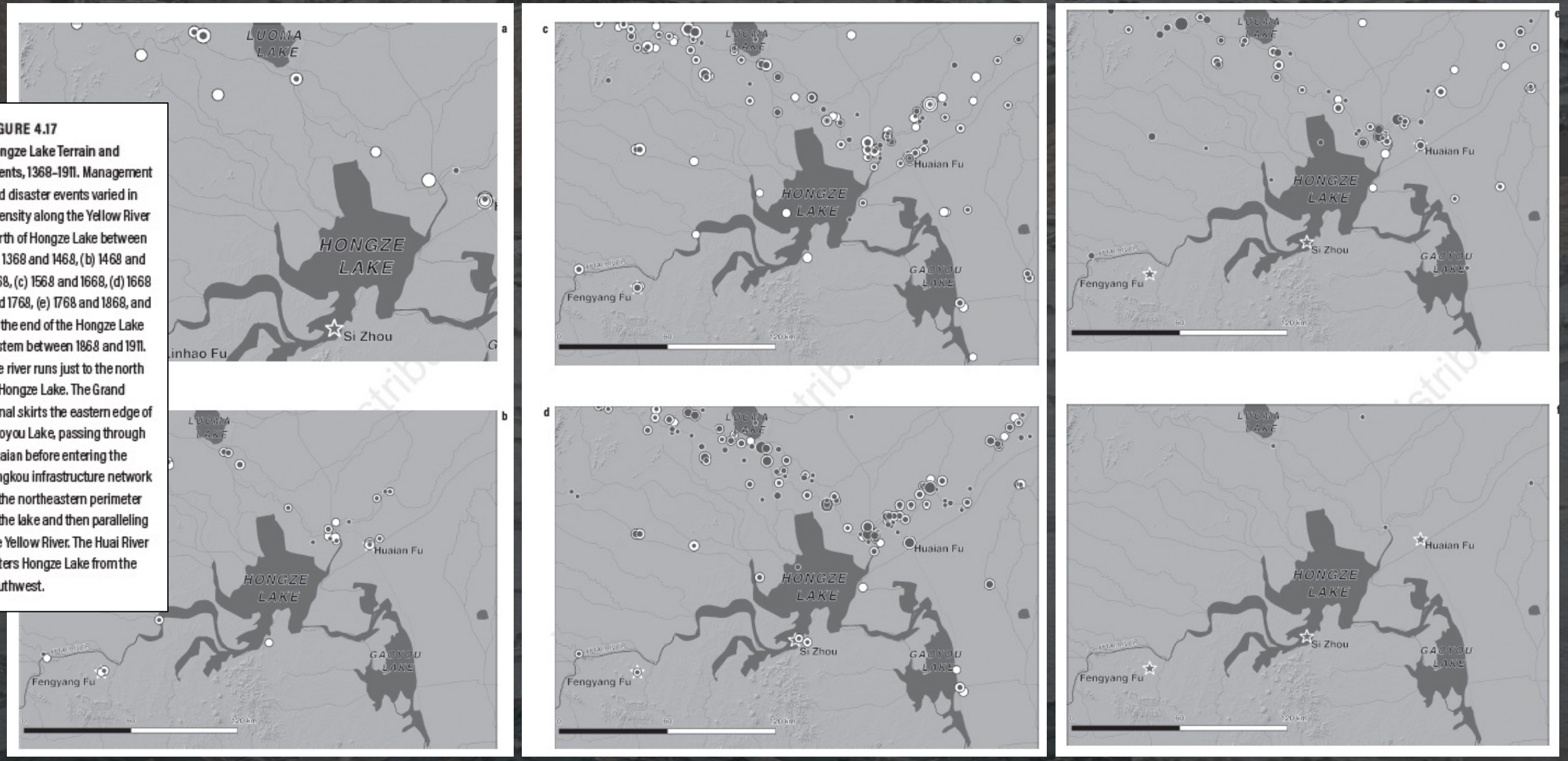


FIGURE 4.17
Hongze Lake Terrain and Events, 1368–1911. Management and disaster events varied in intensity along the Yellow River north of Hongze Lake between (a) 1368 and 1468, (b) 1468 and 1568, (c) 1568 and 1668, (d) 1668 and 1768, (e) 1768 and 1868, and (f) the end of the Hongze Lake system between 1868 and 1911. The river runs just to the north of Hongze Lake. The Grand Canal skirts the eastern edge of Gaoyou Lake, passing through Huaian before entering the Qingkou infrastructure network at the northeastern perimeter of the lake and then paralleling the Yellow River. The Huai River enters Hongze Lake from the southwest.

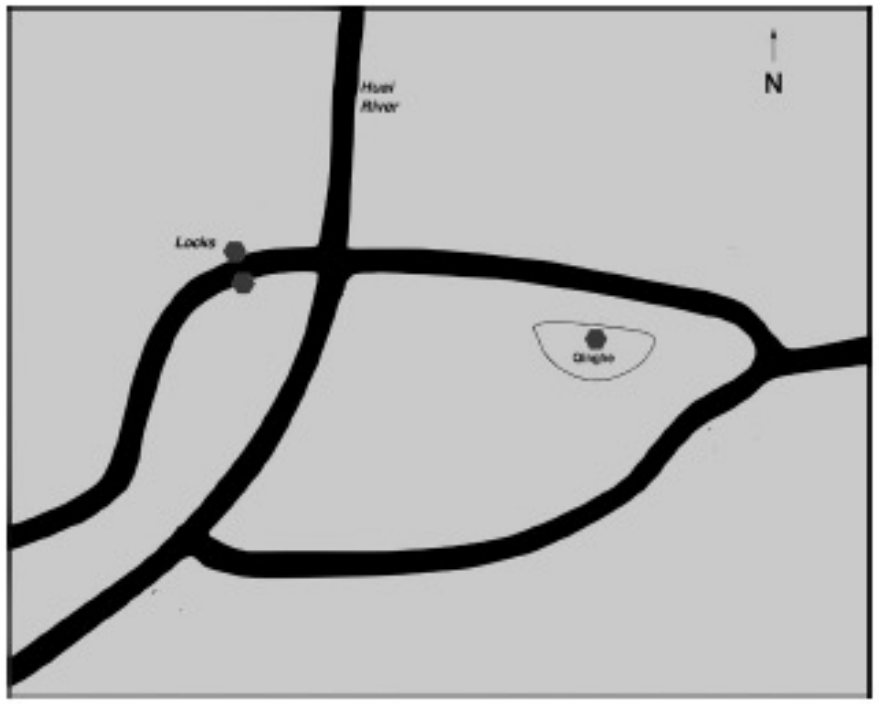
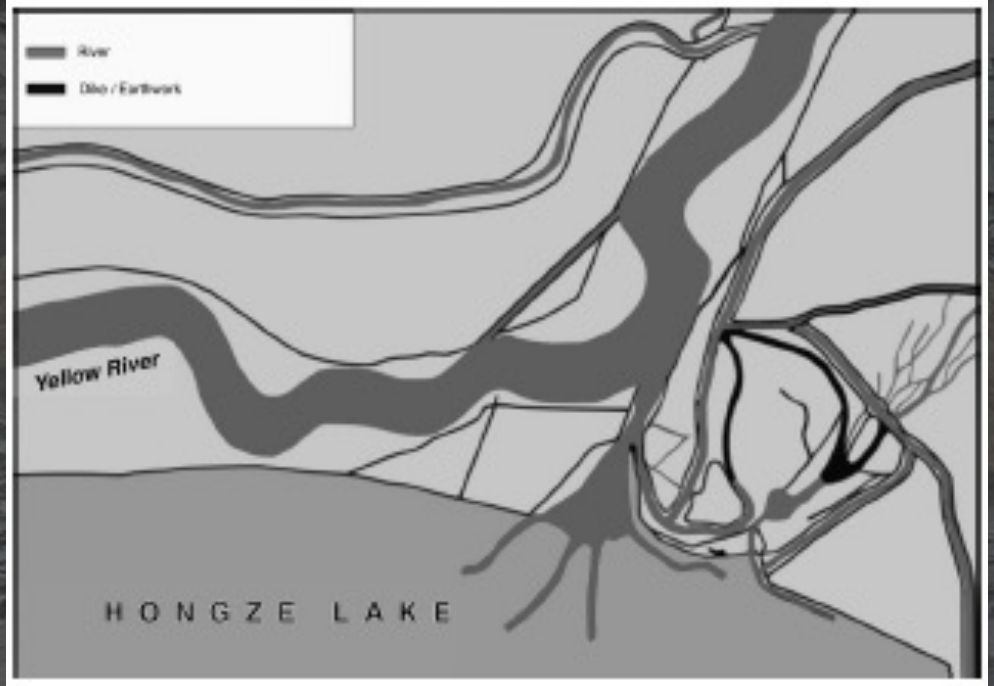
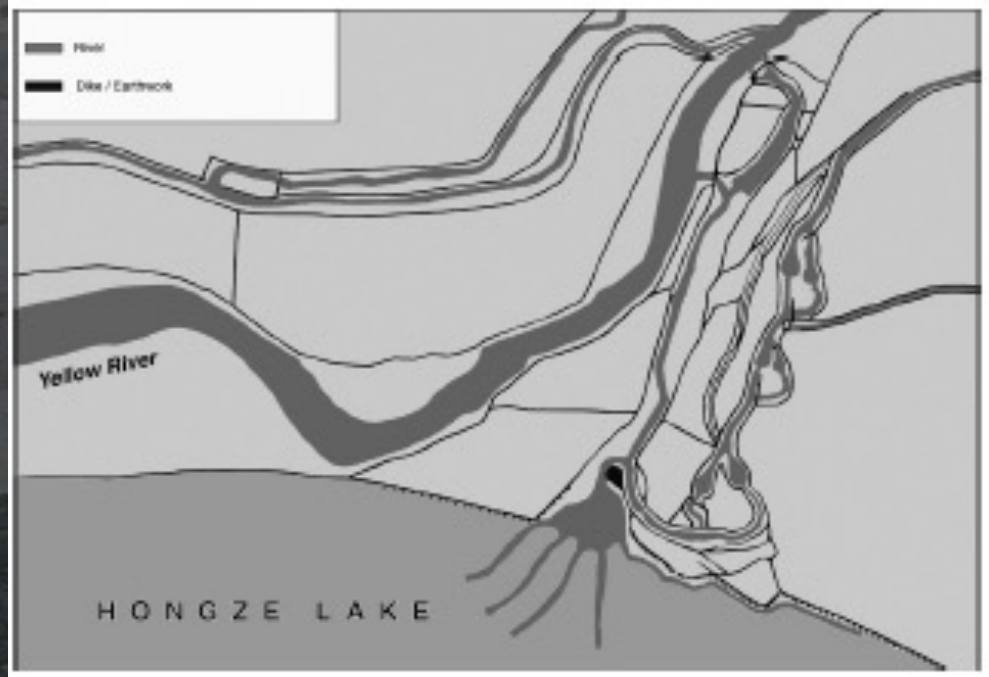


FIGURE 4.18
The Evolution of Hydrological Architecture around the Qingkou Confluence. The major features of the confluence of Hongze Lake, the Yellow River, and the Grand Canal were the Qingkou passage, Gaojiayan Dam, and various watercourses. Although construction of the Qingkou system began in the Ming era, it did not reach full buildout until the eighteenth century. These images depict the Qingkou confluence at (a) prior to the fourteenth century, (b) 1776, and (c) 1854. Based on Zhang et al., "Qingkou Complex."





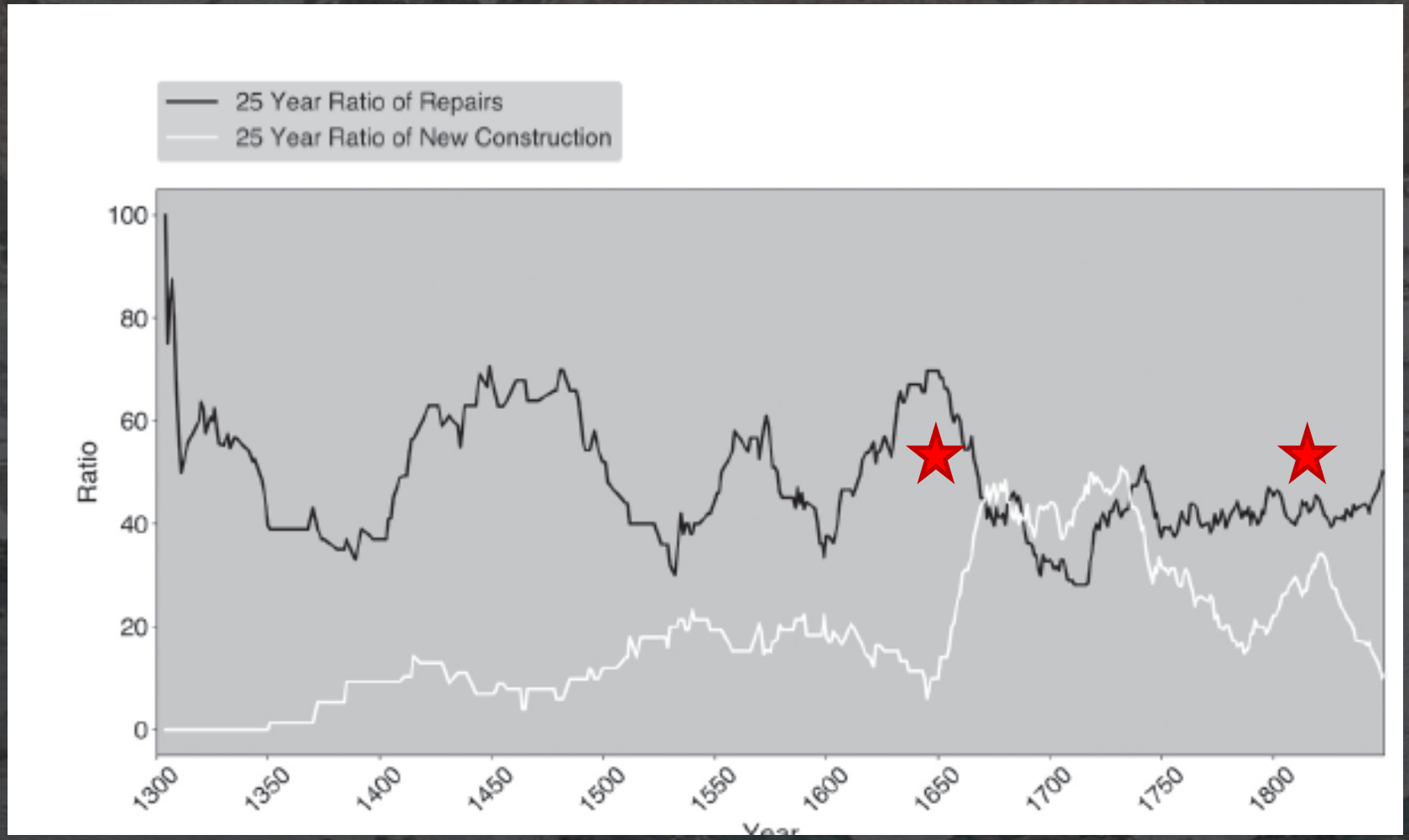
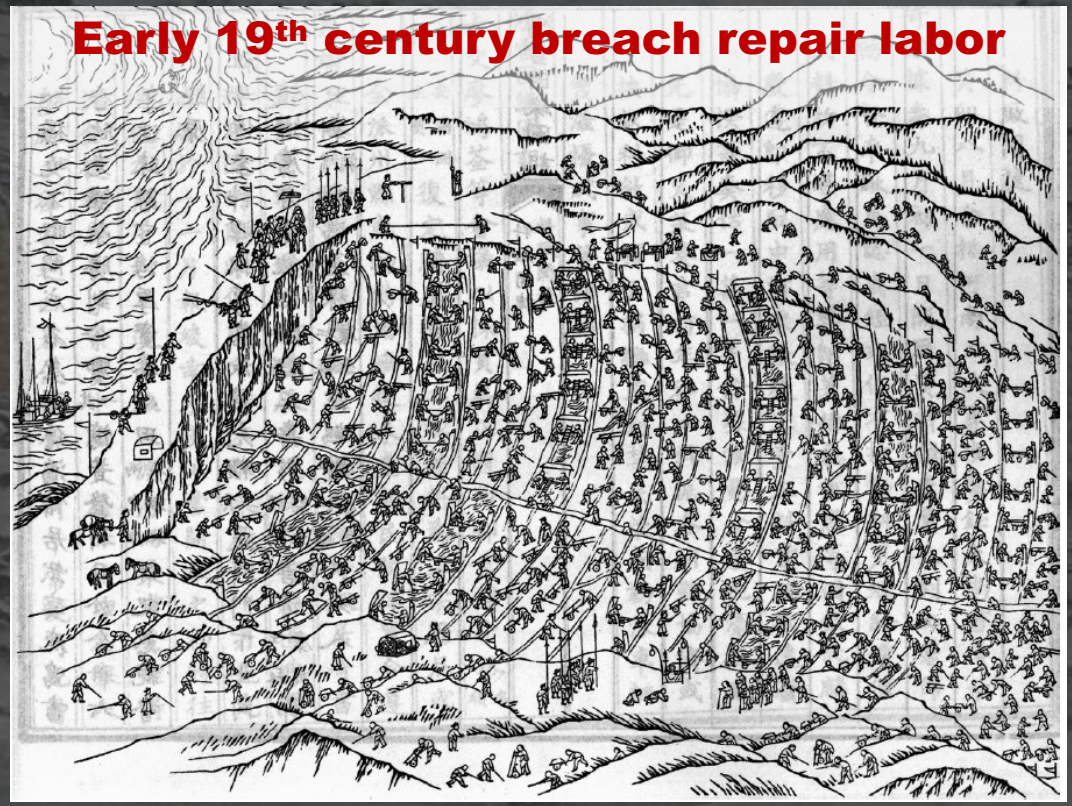


FIGURE 4.22
Ratio of Repairs to New Construction, 1300–1850. Watershed management not only changed in magnitude during the final centuries of river management; the characteristic activities evolved as well. During its first century in power, from the mid-seventeenth century to the mid-eighteenth century, the Qing regime promoted new construction more intensively than repairs to existing structures.

- Gilbert F. White (1942): "floods are 'acts of God,' but flood losses are largely acts of man."
- Intensive management of the imperial floodplain only began in the eighteenth century, and it ended in the middle of the nineteenth century.

1887 Yellow River Flood

Early 19th century breach repair labor



2021 Zhengzhou flood

Thank you for your time!

Thank you to my collaborators and assistants, especially Ryan Horne, Kaiqi Hua, Shen Zhifeng, and Shaobai Xiong