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# Channel and island change in the lower Platte River, Eastern Nebraska, USA: 1855–2005

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ABSTRACT

The lower Platte River has undergone considerable change in channel and bar characteristics since the mid-1850s in four 20–25 km-long study stretches. The same net effect of historical channel shrinkage that was detected upstream from Grand Island, Nebraska, can also be detected in the lower river but differences in the behaviors of study stretches upstream and downstream from major tributaries are striking. The least relative decrease occurred downstream from the Loup River confluence, and the stretch downstream from the Elkhorn River confluence actually showed an increase in channel area during the 1940s. Bank erosion was also greater downstream of the tributaries between ca. 1860 and 1938/1941, particularly in stretch RG, which showed more lateral migration. The cumulative island area and the ratio of island area to channel area relative to the 1938/1941 baseline data showed comparatively great fluctuations in median island size in both downstream stretches. The erratic behavior of island size distributions over time indicates that large islands were accreted to the banks at different times, and that some small, newly-stabilized islands were episodically "flushed" out of the system. In the upstream stretches the stabilization of mobile bars to create new, small islands had a more consistent impact over time. Channel decrease by the abandonment of large, long-lived anabranches and by the in-place narrowing resulting from island accretion were more prominent in these upstream stretches. Across all of the study area, channel area appears to be stabilizing gradually as the rate of decrease lessens. This trend began earliest in stretch RG in the late 1950s and was accompanied by shifts in the size distributions of stabilized islands in that stretch into the 1960s. Elsewhere, even in the easternmost study stretch, stabilizing was occurring by the late 1960s, the same time frame documented by investigations of the Platte system upstream of the study area. Comprehensive management plans for the lower Platte River should account, at least in theory, for the observed differences in stream behavior upstream and downstream of the major eastern tributaries.

## 1. Introduction

At the beginning of the twenty-first century, land, water, and wildlife management issues in the Platte River Basin (~220 000 km$^2$) clearly have major significance in the central United States and in North America as a whole (National Academy of Sciences, 2004; Condon, 2005). An understanding of geomorphic change along the river should be a critical aspect of integrated understanding of the Platte River ecosystem. Historical geomorphic change is particularly relevant in the case of the Platte River because of emerging concerns about threatened and endangered species, whose life histories are intimately tied to the physical condition of the river's bed, mobile bars, and banks (National Academy of Sciences, 2004). Long before the strongest concern about habitat change on the Platte River emerged, benchmark studies of historical change (Williams, 1978; Eschner, 1983; Eschner et al., 1983; Kircher and Karlinger, 1983) documented dramatic channel narrowing, the stabilization of mobile bars and banks by woody vegetation, and extensive island-to-bank accretion since the 1860s. These studies focused on the river west of Grand Island, Nebraska, and on the tributaries North and South Platte River even farther west, relying on serial measurements of channel width at single stations. More recent studies of the Platte employed improved techniques (including examinations of change in channel area using GIS) and greatly enhanced the understanding of riparian dynamics and recent environmental history (e.g., Johnson, 1994, 1997; Currier and Davis, 2000; Johnson and Boettcher, 2000), but they still tended to concentrate on short stretches of the central to western Platte River.

Despite the weight of previous studies, the historical dynamics of the Platte River remain far from completely characterized. Our study, in contrast to earlier ones, concentrates on the lower Platte River (Central City to near Plattsmouth, NE: Fig. 1) and employs geographic information systems (GIS) technology to generate area measurements of both channel and stabilized in-channel island area in long (~20–25 km) stretches of the river (Figs. 1–3). The reasons for concentrating on the lower Platte River are fourfold. First, the understanding of historical change in that area is very incomplete. Second, patterns of change can be contrasted upstream and downstream of two major tributaries, the Loup and Elkhorn Rivers (Fig. 1), which together have discharges equivalent to

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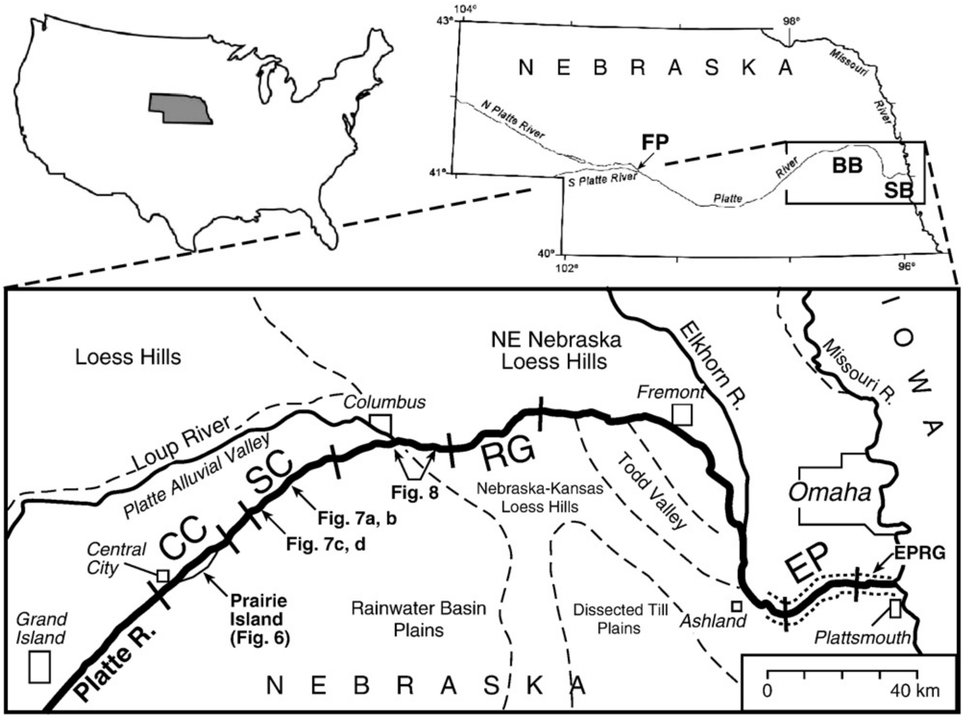

**Fig. 1.** Location of study area and study stretches CC, SC, RG, and EP. Also depisted are Forks of the Platte (FP), Big Bend (BB) and South Bend (SB).

about 30% of the total discharge of the Platte at its mouth. Third, the study area is environmentally distinct from central and western Nebraska. For example, there is maximum difference in mean annual precipitation of nearly 200% (415 mm at Scottsbluff versus 788 mm at Plattsmouth). Fourth, the study area overlaps the rapidly growing 800,000-population Omaha metropolitan area, wherein concerns about human–river interactions and management should only increase in the future. The goal of this study is to address some fundamental geomorphic underpinnings of the lower Platte River ecosystem by seeking a robust assessment of change and by understanding that change in terms of processes.

## 2. Regional setting

The lower Platte River flows through multiple physiographic subregions (Fig. 1). It flows in a broad valley cut through rolling, loess-mantled plains between Grand Island and Fremont, NE, through its Big Bend or North Bend (Fig. 1). From Ashland, NE, the river turns abruptly eastward in its lowermost 35 km to flow through a shallow gorge eroded into Pennsylvanian sedimentary rocks (Lugn, 1935, p. 19), hereafter referred to as the Eastern Platte River Gorge (Fig. 1: EPRG). The EPRG includes the much smaller but still prominent South Bend (Fig. 1). The EPRG is a geologically young feature, dating to the Wisconsinan stage

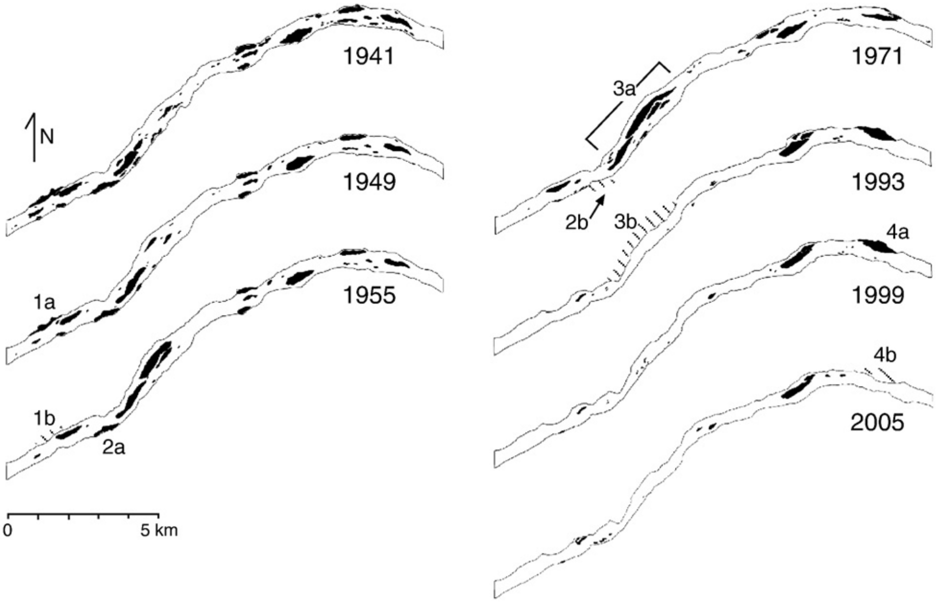

**Fig. 2.** Stretch EP showing time series of the development of stabilized islands (black). Numbers and subordinate letter pairs indicate islands or groups of islands (e.g., 1a) that are gradually accreted to the banks (e.g., 1b: hatched pattern). Small “functional” anabranches created by the isolation of braid channels after the stabilization of islands (e.g., landward side of island 1a) are too small to be depicted at scale of diagram.

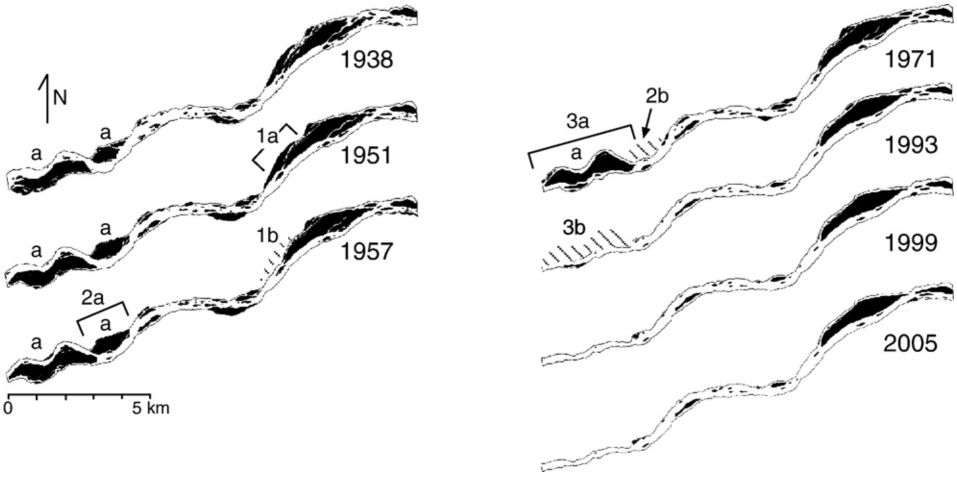

**Fig. 3.** Stretch RG showing time series of the development of stabilized islands (black). Numbers and subordinate letter pairs indicate islands or groups of islands (e.g., 1a) that are gradually accreted to the banks (e.g., 1b: hatched pattern). Short anabranches (a) are abandoned in the process of island accretion between 1957 and 1993 (2b and 3b).

and records the capture by the Platte of the lowermost Elkhorn River (cf. Condra, 1903). The Platte River must have captured a major part of the Loup River as it shifted its course northward after the earliest Pleistocene (cf. Swinehart et al., 1994).

Study stretch EP lies within the EPRG. Stretches CC, SC, and RG (in contrast to stretch EP) are characterized by broad valley widths and a lack of bedrock constrictions.

We employ the standard use of the term “anabranch” to describe subsidiary channels that divert from the main channel belt and rejoin downstream. Likewise, we consider “braid channels” to be smaller channels within the main channel belt, but our general usage of the term “channel” hereafter refers to the entire belt of braid channels as a whole. We have observed that changes in island stabilization and bank accretion eventually convert some braid channels into “functional” anabranches by isolating them from the main river channel.

From the forks of the Platte (the confluence of the North and South Platte Rivers; Fig. 1) eastward into the study area, however, much larger anabranches a few kilometers to a few tens of kilometers in length have been prominent from at least the time of first Euramerican contact (early eighteenth century), and presumably much earlier. Large, long-lived anabranches such as these are particularly prominent between the present towns of North Platte and Grand Island, NE. Stabilized tracts of braidplain between anabranches are considered, for the purposes of discussion but not statistical analyses, to be large to very large islands even though their origins are clearly different from those of stabilized in-channel bars. The most conspicuously large and long-lived anabranches are located near Grand Island, 32 km upstream from study stretch CC, where seven major anabranches exist within a 29-km-long stretch. Downstream from Grand Island, Nebraska ca. 1860, anabranches on the Platte River become much shorter and much less numerous. In the twentieth century, however, every study stretch included anabranches of some kind, whether the short-lived “functional” ones isolated during the process of island stabilization and accretion or the

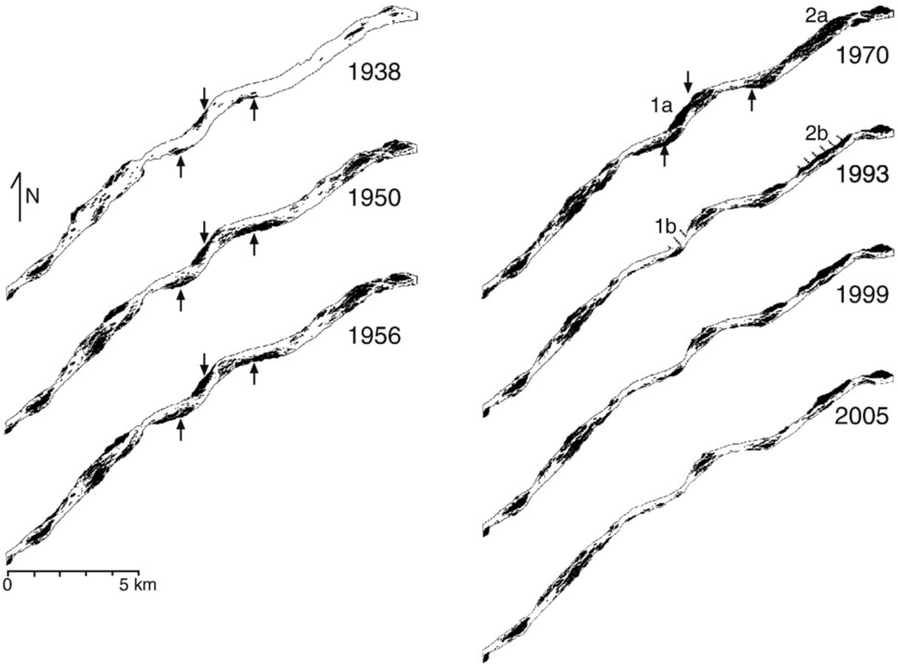

**Fig. 4.** Stretch RC showing time series of the development of stabilized islands (black). Numbers and subordinate letter pairs indicate islands or groups of islands (e.g., 1a) that are gradually accreted to the banks (e.g., 1b: hatched pattern). Arrows indicate positions at which groups of islands have stabilized downstream of open bends.

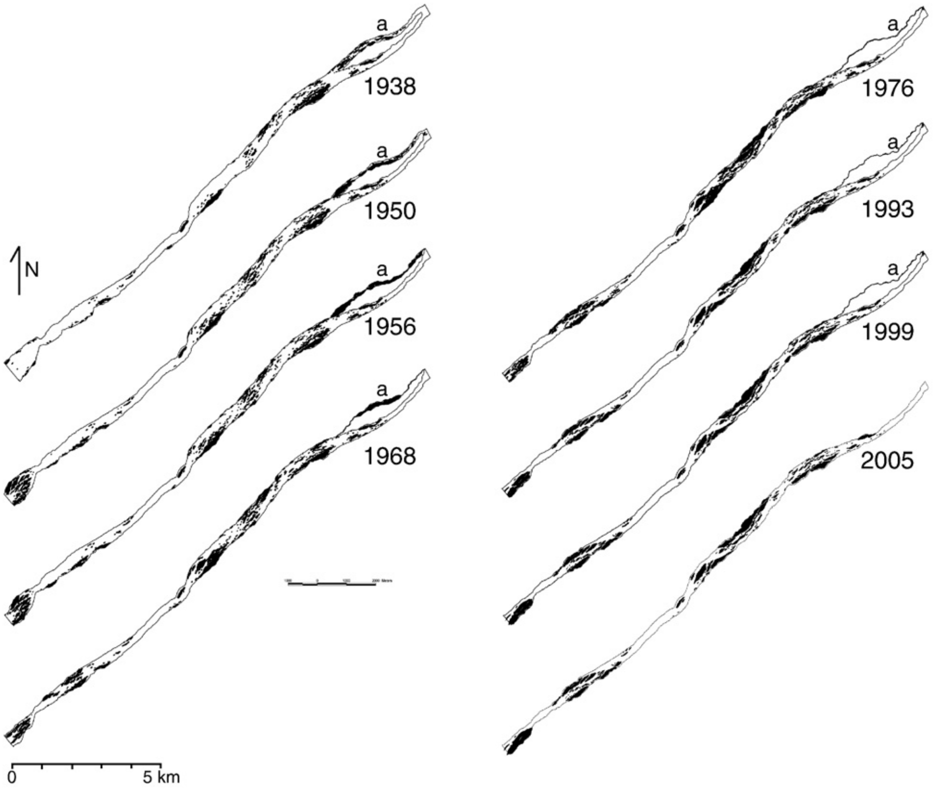

**Fig. 5.** Stretch CC showing time series of the development of stabilized islands (black). A long-lived anabranch (a) has gradually dwindled since 1938.

much rarer, larger, long-lived ones that had been present since at least the mid-nineteenth century, and probably much earlier.

## 3. Materials and methods

Manually georeferenced sets of historical aerial stereophotographs and digital orthophoto quadrangles dating from 1938 to 2005 are the principal data sources for our assessment of historical channel change. U.S. General Land Office (GLO) surveys (see Cazier, 1977) from the 1850s and 1860s (Nebraska State Surveyor's Office, undated), although constituting a very different kind of documentation, are nonetheless the earliest reliable maps of the Platte River and therefore provided ancillary baseline data. Four stretches of the lower Platte River (Figs. 1–5) were selected for analysis: (i) stretch EP near Louisville, selected because of its position downstream from the mouth of the Elkhorn River (Fig. 2); (ii) stretch RG, immediately downstream from the Loup-Platte confluence (Fig. 3); (iii) stretch SC, in the vicinity of Silver Creek, Nebraska, just upstream from the Loup-Platte confluence (Fig. 4); and (iv) stretch CC, near Central City (Fig. 5), which extends eastward from the point at which recent analyses of the river by Johnson (1997) ended.

Scanned and adjusted stereophotograph images were georeferenced in ArcMap™. Image data were layered over Landsat TM images in ArcView™ GIS. Channels and stabilized islands of the Platte River were rendered onscreen over these layers at a scale of 1:20 000. A fundamental distinction was made between what appeared to be islands stabilized by woody vegetation (dark photograph tones, with discernible trees in the highest resolution imagery) and temporarily emergent bars. Only stabilized islands were rendered (Figs. 2–5). After an initial onscreen rendering at a scale of 1:20 000, resultant channel and stabilized island surface area data were scrutinized for potential anomalies by the examination of plots and the comparison of statistics from a given stereophotograph series with those from the next series in time sequence. Subsequently, each rendering was carefully edited at 1:10 000 and was assessed for continuity of selection criteria for groups of individual stabilized islands and for active channel segments in successive aerial stereophotograph series (Figs. 2–5). Resultant data were once again examined, rendered features were re-examined in time sequence, and a third edit of rendered features was made at a scale of 1:10 000. Point-to-point measurements of channel width were also carried out at four or five equally spaced positions along each of the four stretches in the GIS project at a scale of 1:10 000. Width-measurement points were selected to avoid obvious and immediate interference by bridges and other manmade structures. A single operator performed all activities for the purposes of consistency and overall precision. Unfortunately, serial measurements of stream depth and surveyed cross sections (the “third dimension” of change) are unavailable, but earlier studies (e.g., Williams, 1978; Eschner, 1983; Eschner et al., 1983; Kircher and Karlinger, 1983) demonstrated that these constraints do not negate the value of examining river planform change over decadal timescales. Moreover, no *a priori* reasons exist to assume that channel depths have increased dramatically as planform

**Table 1**
Sinuosity of study stretches ca. 1860 and in 2005

| Year | EP | RG | SC | CC |
|---|---|---|---|---|
| ca. 1860 | 1.00 | 1.04 | 1.02 | 1.00 |
| 2005 | 1.01 | 1.05 | 1.03 | 1.01 |

**Table 2**
Apparent bank erosion ($m^2/km$) between GLO survey (ca. 1860) and first aerial stereophotograph year (1938 or 1941) in four study stretches

| Stretch | Erosion ($m^2/km$) |
|---|---|
| EP | 65 260 |
| RG | 149 760 |
| SC | 32 980 |
| CC | 17 270 |

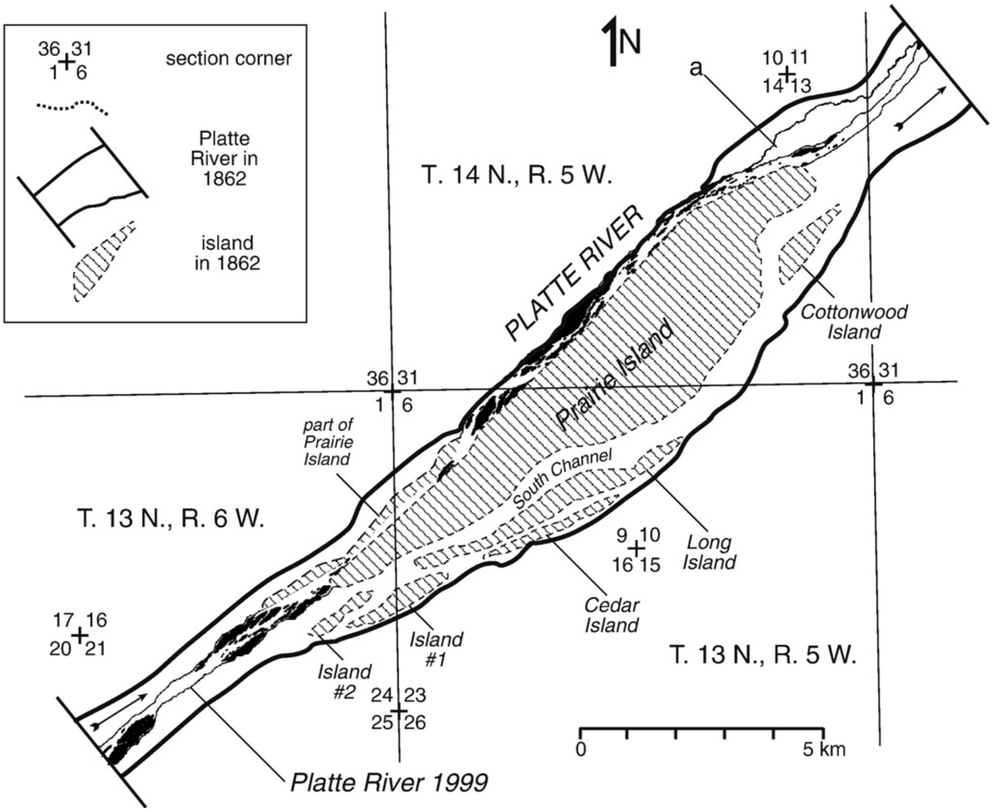

**Fig. 6.** Stretch CC in 1999 (including smaller anabranch "a"; see Fig. 5) relative to same stretch from early-1860s GLO surveys of different townships (e.g., T. 14 N., R. 5 W.). Named and numbered (e.g., Prairie Island, "Island No. 2") islands did not exist as islands per se by 1938 because the South Channel anabranch had already dwindled. See Fig. 1 for location.

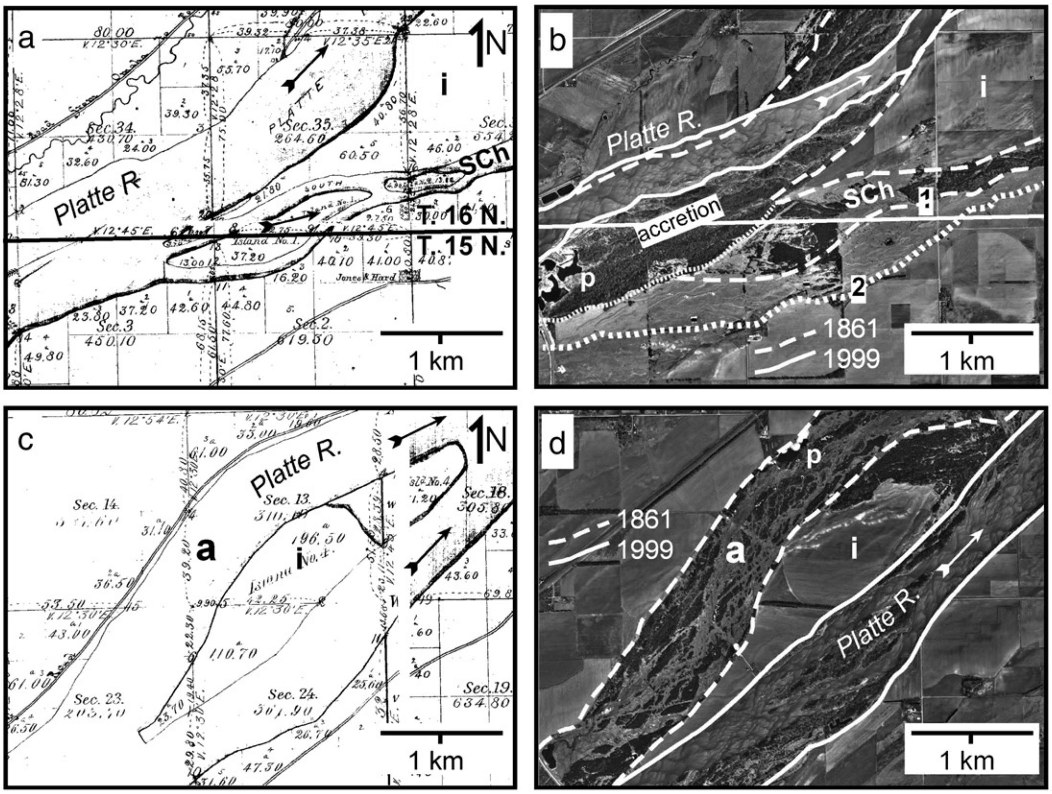

**Fig. 7.** Major changes in Platte River planform since GLO mapping of early 1860s along boundary between T. 15 N., R. 3 W. and T. 16 N., R. 3 WE in stretch SC. (aa) Divergence of South Channel anabranch (SCh), which is entirely separate entity from "South Channel" in Fig. 6, from main channel of Platte River around large island of stabilized braidplain (i) in 1861 GLO survey. (b) Same area in 1999; abandonment of SCh occurred prior to 1938; "1" represents south bank of SCh as taken from 1861 survey and "2" represents prominent break between smooth terrain and bar-and-swale topography that may represent an even earlier south bank position of SCh, potentially indicating shrinkage in width and diminution of flow in the anabranch prior to 1861. Post-1938 accretion of stabilized islands has grown across the opening of SCh. (c) and (d) fate of short anabranch around island of stabilized braidplain (i). In both areas, the appearance of gravel pits (p) which begins prior to 1938, indicates that anabranches had long been abandoned and that accretion lands are already relatively stable. See Fig. 1 for locations.

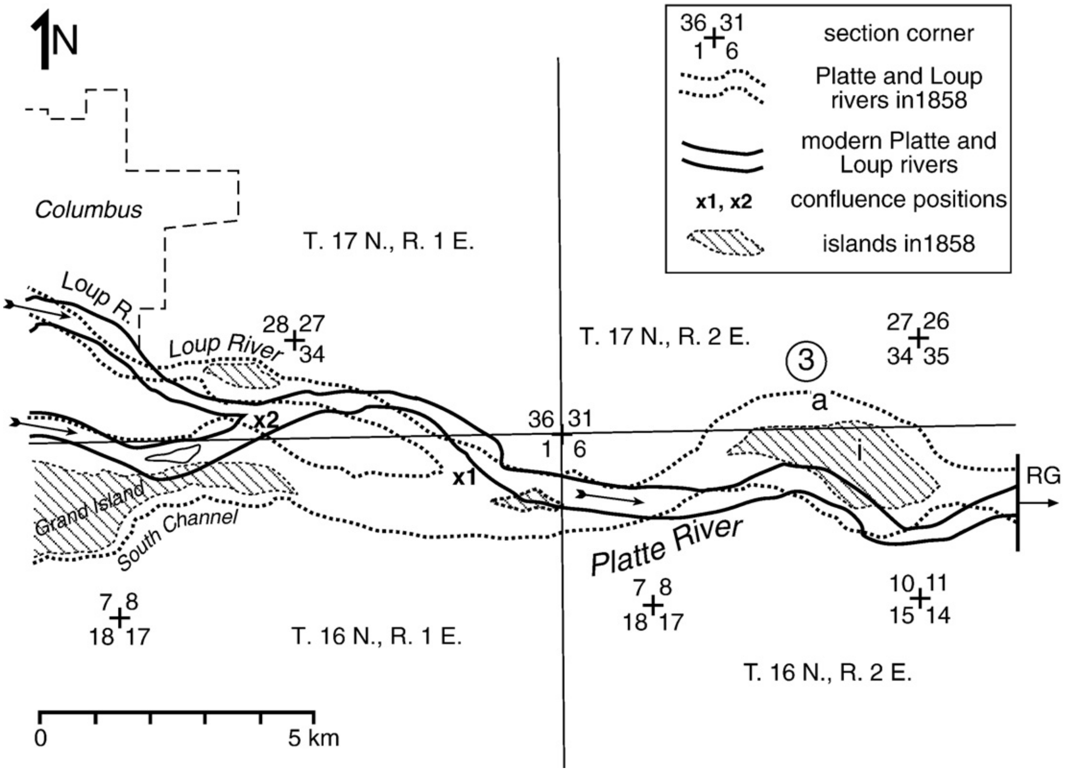

**Fig. 8.** Change since late 1850s around the Loup-Platte confluence near Columbus, Nebraska westward from upstream end of stretch RG (indicated at right). "Grand Island" is term used in GLO survey of T. 16 N, R. 1 E. for stabilized tract of braidplain between South Channel anabranch (same anabranch as in Fig. 7a, b) and does not seem to equate to other historical uses of the place name for intra-anabranch tracts near the present city of Grand Island, farther upstream. Confluence has moved from point ×1 to point ×2 since 1858. A short anabranch (a) and smaller tract of stabilized braidplain (i) at right are also abandoned after 1858. Note slight lateral migration of Platte b associated with bank erosion. See Fig. 1 for location.

changes have occurred. Sparse anecdotal data exist for some level of channel downcutting at some sites on the lower river.

## 4. Channel and island change

### 4.1. General observations

Channel area in the lower Platte River has decreased since the mid-1800s, and this decrease can be well documented from the date of the first aerial stereophotography in the area (1938) onward. The decrease in channel area resulted from the stabilization of mobile bars by woody vegetation (i.e., the production of new islands), the accretion of islands to the river's banks, and the abandonment of braid channels and anabranches (Figs. 2–5). Upstream from the study area, marked woodland expansion on the North Platte, South Platte, and upper to middle Platte River involved the widespread growth of cottonwoods and willows in formerly active channels and on formerly mobile bars, mostly between 1900 and the 1930s (Johnson, 1994). Woodland expansion on the lower Platte is less easily contrasted with pre-Euramerican settlement conditions because wooded islands were present upstream to the mouth of the Loup River long before intense Euramerican interaction with the river (Secretary of War, 1836; Auerbach and Alter, 1940; Rollins, 1995). Surveyor's notes from the GLO surveys of the mid-1850s to early 1860s (Appendix) implied that riparian and valleyside woodlands had always been better developed in the EPRG. GLO survey notes from the mid-1850s (Appendix) described at least nine large wooded islands in the Platte in the EPRG, similar to those visible in aerial imagery in stretch EP from 1941 onward. Some of these islands were prominent enough to receive place names, such as "Cedar Island," which are still in use. Even in the lowermost Platte River, however, woody vegetation has stabilized additional in-channel bars (creating new islands) and proliferated on pre-existing islands since at least 1938, and probably decades earlier. In stretch SC, groups of islands have tended to stabilize, grow, and begin to accrete to the banks downstream of large, open bends in the river (Fig. 4); whereas in the other study stretches, such a pattern is not readily apparent (Figs. 2, 3, 5).

The lower Platte has remained more or less within the braid belt delineated by late-1850s and early-1860s GLO surveys, and the sinuosities of the four study stretches have not changed significantly since ca. 1860 (Table 1), but apparent bank erosion per kilometer between the date of the GLO survey (ca. 1860) and the first aerial stereophotograph year in each stretch (1938 or 1941) varies considerably among the stretches. Stretch RG experienced the most bank erosion during that early period of historical change, EP the second most, followed by SC, and finally CC, which experienced very little bank erosion (Table 2).

The fate of anabranches and large to very large islands (as opposed to in-channel bars gradually stabilized after 1938 by vegetation or joined groups of smaller, stabilized bars) is especially noteworthy. Prairie Island, a 13 km-long and 2.5 km-wide area of stabilized braidplain between the main (current) channel of the Platte River and an abandoned anabranch (the South Channel), appears in an 1862 GLO survey upstream along study stretch CC (Fig. 6). Although the place name "Prairie Island" persists today, the South Channel in this area had been abandoned by 1938 and an island per se no longer exists. Several other islands named in the GLO survey of the area have since been accreted through the abandonment of the South Channel anabranch (Fig. 6).

In stretch SC, a much longer (~28 km) anabranch also called the "South Channel" (but distinct from the anabranch of the same name that flowed around Prairie Island) also diverged from the main channel of the Platte in the area; this anabranch has since dwindled and islands within it have been accreted (Fig. 7a, b; SCh). In the same stretch, an unnamed 3.6-km-long and 0.7-km-wide island mapped in the early 1860s was accreted when the river narrowed by the abandonment of a short anabranch north of the island sometime before 1938 (Fig. 7c, d; a). Downstream near Columbus, Nebraska, the same South Channel (Fig. 8) is uniquely referred to as a "bayou" in the late 1850s GLO survey, suggesting that flow was already more sluggish there than in the main channel and that abandonment had already begun. Furthermore, a short, broad anabranch existed immediately upstream from stretch RG in the early 1860s (Fig. 8), but it too has since been abandoned. This anabranch (Fig. 8; a) was separated from the main channel by a large tract or "island" (Fig. 8; i) of stabilized braidplain.

### 4.2. Channel width and area statistics

Change in channel widths is not consistent between all stations in the four stretches. Width at individual stations has increased very slightly, decreased slightly, or decreased precipitously at particular stations since 1938 (Fig. 9a–d). Some individual stations show as much as a 233% difference between minimum and maximum widths attained during the period 1938–2005 (Fig. 9b), but the difference between minimum and maximum channel width attained is <8.0% for at least one station in all four stretches (Fig. 7). Overall, stretch CC (Fig. 9d) is the least variable stretch in terms of channel width, with the exception of an abrupt apparent narrowing between 1999 and 2005 (a period of significant regional drought) that relates to the abandonment of a long-lived anabranch, which (on the basis of serial aerial photographic observations) had nonetheless been dwindling for decades (Fig. 9d, no. 4; aa). Channel widths in stretch RG varied the most because of the abandonment of two larger, long-lived anabranches (Fig. 7b, nos. 1 and 2; aa) during the study period. In the other stretches (EP and SC), small, "functional" anabranches (produced through the isolation of former braid channels and the stabilization of large islands after 1938) were subsequently abandoned. When the GLO surveys are used as ancillary data sources for the period 1855–1862 and when width is viewed relative to the baseline data set at 1860, the overall trend is also one of decreasing channel width (Fig. 10). Through this exercise, the abandonment of large anabranches is identified as a significant contributor to overall channel narrowing over time (Fig. 10c, d).

Channel surface area (Fig. 11a, b) decreased consistently during the period 1938–1999 in stretches CC, SC, and RG, regardless of any other changes. Channel area decreases in these stretches proceeded through a succession of three phases: (i) sustained decreases in channel area between 1938 and the late 1960s; (ii) stabilization of channel area, commencing first in stretch RG in the late 1950s, and then occurring in SC and CC by the late 1960s; and (iii) relatively slight change in channel area after the late 1960s. Stretch EP, downstream from the Elkhorn River (Fig. 11a, b), shows a slightly different pattern of (i) a slight increase in channel area during 1941–1949, followed; (ii) a very

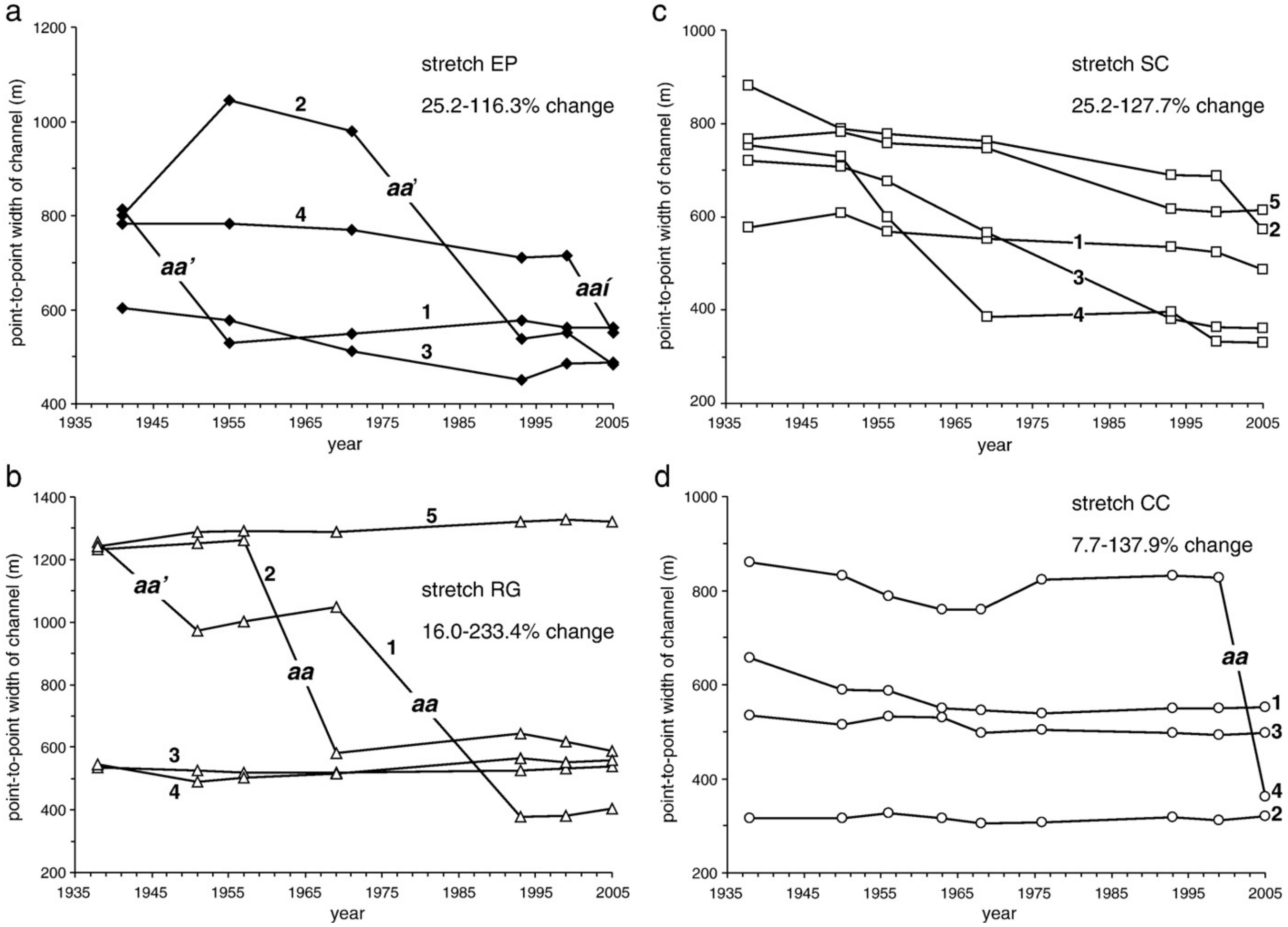

**Fig. 9.** Station-to-station channel widths for stretches EP (a), RG (b), SC (c), and CC (d). Abandonments of large, long-lived anabranches (aa) and small, "functional" anabranches formed by isolation of channels through island stabilization and growth (aa') are indicated.

slight decrease during 1949–1955; (iii) a more pronounced decrease in area during 1971–1993, followed by (iv) very slight, and perhaps insignificant, fluctuations in channel area during 1993–2005. The net trend in stretch EP is still a decrease in channel surface area after 1941, although the relative decrease is lesser in comparison with other stretches (Fig. 11b). Overall, stretches CC and SC (the stretches lying upstream from the two major tributary confluences in the study area) show the most marked absolute decreases in channel area since 1938 (Fig. 11).

### 4.3. Island statistics

Statistics were compiled for small to large islands that appeared to have grown more or less *de novo* after ca. 1860 in each of the study stretches, but only aerial imagery (1938–2005) was employed as data sources. From 1938/1941 to 2005, the number of islands per river kilometer was low in stretches EP and RG but considerably higher in stretches CC and SC upstream of the major tributary confluences (Fig. 12a). The number of islands per kilometer in stretches CC and SC increased from 1938 to the end of the 1940s, remained high through the mid-1970s, and then decreased precipitously until the early 1990s (Fig. 12a).

The cumulative area of stabilized islands in each stretch during 1938–2005 shows different patterns of progression over the studied time interval compared to channel surface area (Fig. 12b, c). Stretches EP and CC had relatively low cumulative areas of stabilized islands during the study period, but EP also consistently contained fewer islands overall (Fig. 12a) and showed an overall decrease in cumulative island area (Fig. 12b). Stretch CC, in comparison, experienced a slight *increase* in cumulative island area until the late 1960s, followed by a long period of comparative stability (Fig. 12b). Stretch RG showed an increase in cumulative island area until the end of the 1940s, followed by a precipitous decline until the early 1990s, and then a state of comparative stability (Fig. 12b, c). Relative change in cumulative island areas since 1938/1941 is greatest in SC and CC and least in RG and EP. A significant change in conditions with respect to cumulative island area in the late 1960s is more evident in both SC and CC than in the downstream study stretches (Fig. 12c).

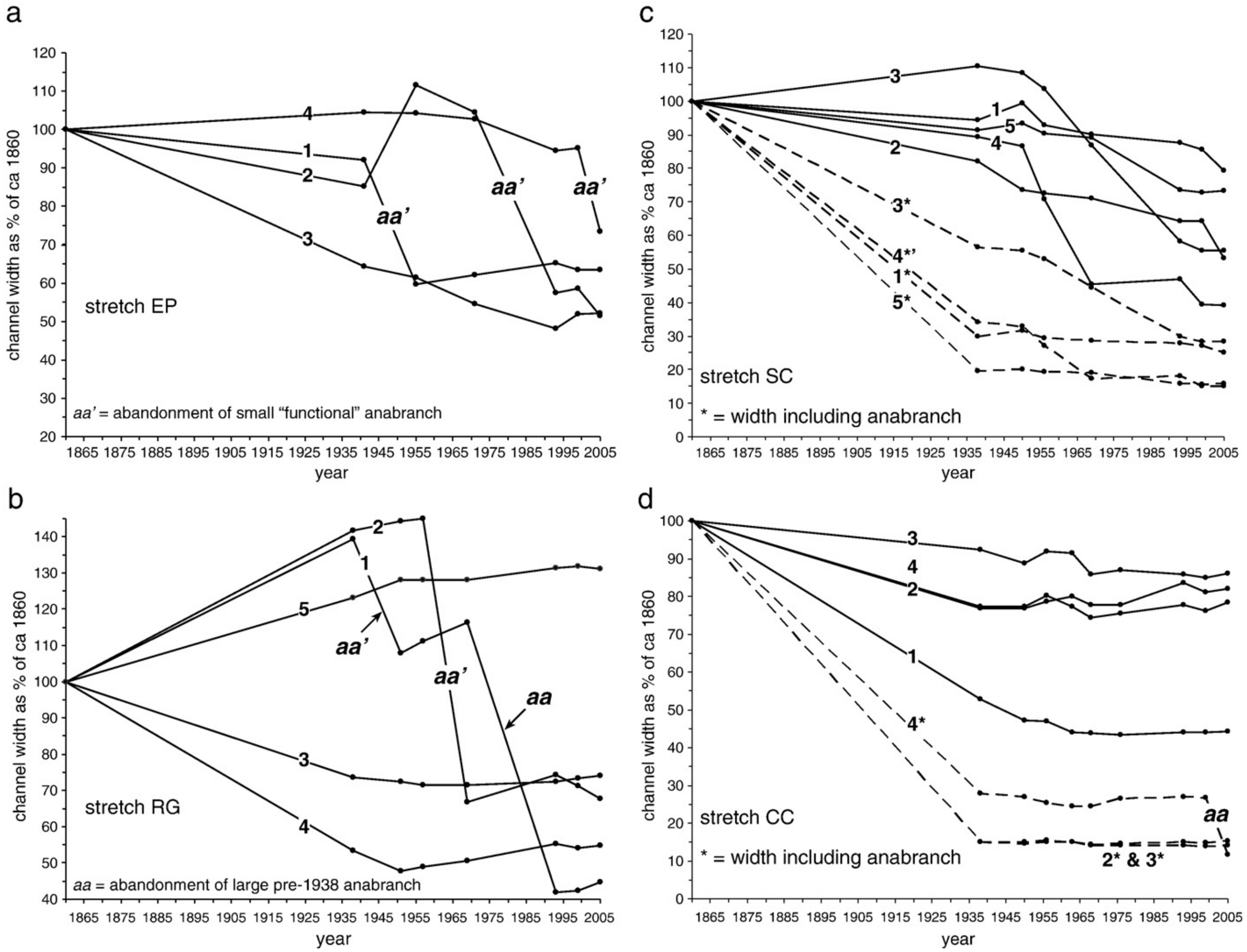

**Fig. 10.** Examination of station-to-station channel widths for four study stretches. (a) Stretch EP, where several small "functional" anabranches produced by isolation of channels as islands stabilized and grew, are abandoned over time (aa') at three stations. (b) Stretch RG, where both small (aa') and large (aa) anabranches are abandoned. (c) Stretch SC, showing effects of abandonment of large anabranches between 1858 and 1938 at stations 1, 3, 4, and 5: plain numbers and solid lines (e.g. 3) represent width of main channel alone at stations, whereas numbers with asterisk (e.g., 3*) represent widths including large anabranches and including large stabilized islands between anabranches; stations 3, 4, and 5 include Prairie Island (Fig. 6). (d) Stretch CC, also showing effects of abandonment of large anabranches between prior to 1938 at stations 2, 3, and 4; large, gradually dwindling anabranch mapped in original GLO survey is abandoned between 1999 and 2005 at station 4, probably because of prolonged drought donditions. 1858–1862 GLO survey baseline widths are all set at 1860 for ease of comparison. Individual stations are identified by same numbers as in Fig. 9.

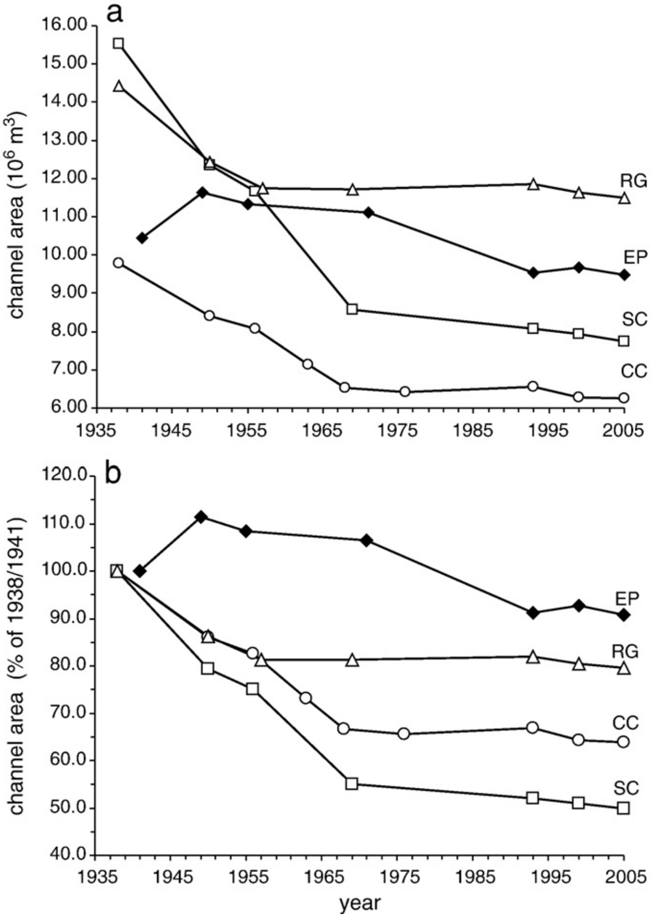

**Fig. 11.** (a) Cumulative channel area over time in study stretches. (b) Cumulative channel area as a percentage of baseline values from first aerial photograph year in each stretch, either 1938 or 1941.

Furthermore, the median area of stabilized islands during the period 1938–2005 changed least in stretches CC and SC (Fig. 12d). Median island area increased in both of these upstream stretches after the late 1960s. Stretch CC shows a slightly greater increase in median island size between the late 1960s and the early 1980s than does SC (Fig. 12d). Median island size changed more, and indeed erratically, during the period 1938/1941–2005 in stretches EP and RG. The greatest changes appear as sharp increases in median stabilized island sizes in EP during the mid-1950s and in RG during the late 1960s (Fig. 12d). The total size range of stabilized islands observed in all four study stretches spans five orders of magnitude (Fig. 13). The size distribution of stabilized islands shifted least through the period 1938–2005 in stretch CC (Fig. 13D). In stretch EP, the size distribution of islands appears to have shifted erratically over time (Fig. 13A), but temporal patterns can be surmised from size distributions in the other stretches (Fig. 13B–D). In RG, a general increase in area occurred in the part of the island size range below the 40th percentile and above the 85th percentile (Fig. 13B). Shifts in the size distribution occurred in the years 1957 and 1969, the period in which channel surface area was stabilizing (Fig. 13B). In stretches SC and CC the surface areas of islands above the 80th percentile also increase over time (Fig. 13C,D), although in stretch CC the surface areas of islands below the 40th percentile generally *decrease* over time, indicated by an overall downward shift in the plotted size distribution below this percentile between 1938 and 2005 (Fig. 13D).

Plots of the ratio of cumulative stabilized island area to channel area during 1938–2005 (Fig. 14A) and of the same ratio presented in terms of change relative to 1938/1941 baseline values are nearly identical to the corresponding plots of cumulative island area (Fig. 12b,c).

## 5. Discussion

Early studies, predominantly concentrating on stretches west of the study area (e.g., Williams, 1978; Eschner, 1983; Eschner et al., 1983; Kircher and Karlinger, 1983), demonstrated striking decreases in channel width since the 1860s. Johnson (1994), in a singularly important study, examined decreases in channel area and increases in island stabilization over small stretches of the upper and middle Platte and related them to the expansion of cottonwood- and willow-dominated woodland, which was regulated by patterns of (i) June flows, (ii) summer droughts, and (iii) wintertime conditions in the channel belt. These factors are particularly relevant to the life histories of cottonwood and willow trees, specifically in their effects on seedling survivorship (Johnson, 1994). Reductions in June flow related to upstream impoundments and diversions (mostly upstream of the present study area) during the twentieth century "exposed much of the riverbed and elevated recruitment and seedling survivorship" (Johnson, 1994). Seedling survivorship and flow reduction, however, have probably had ever more diminished importance eastward on the Platte River. From the Loup River downstream, yearly rainfall increases, major tributaries enter the river, and woody vegetation has, by all accounts, always more abundant.

Our results show a general decrease in channel surface area in the study stretches over time, similar to that detected in earlier studies farther upstream in the Platte system. The farthest downstream reach in our study, however, actually shows a slight *increase* in channel area in the 1940s. Width measurements of the four study stretches of the lower Platte River vary over time between individual stations on the same stretch, underscoring the robustness of serial channel area measurements. Nonetheless, the comparison of both width and area measurements over time remains an important means of characterizing the nature of change, particularly anabranch abandonment, which may contribute relatively little to area measurements but greatly to decreases in width. In addition, the distinction between "functional" and long-lived is prompted by scrutiny of width measurement changes.

Throughout the aerial stereophotograph study period, the number of stabilized islands per river kilometer in the study stretches was, overall, greater upstream from the major tributary confluences than it was downstream of them. Stretches SC and CC, which lie upstream from the Loup-Platte confluence, both show overall increases in the number of islands per river kilometer from the mid-1950s to the late 1960s. These trends strongly separate the upstream stretches from stretches EP and RG downstream of major tributary confluences (Fig. 12a). The relatively small median island sizes in stretches CC and SC (Fig. 12d), when interpreted in conjunction with the islands-per-kilometer data (Fig. 12a) and, even more importantly, with qualitative observations from serial aerial photographs (Figs. 4, 5), reflects the continual stabilization of many small, in-channel bars even as older, stabilized bars were joined with each other to form large, vegetated islands (Fig. 13C,D).

In stretch EP (Fig. 2), at the far downstream end of the study area, qualitative observations indicate a very different history with respect to islands. Both large and small islands were already present in stretch EP in 1941, and an examination of the GLO survey for the area indicates at least one of these large islands was a tract of stabilized floodplain excised from the bank by the river after 1855. By 1955, however, many of the smaller islands (individual, stabilized in-channel bars) in stretch EP had disappeared, while most of the large islands from 1941 generally remained in the same form. New, smaller islands appeared in subsequent years, but by 1971, several of the large islands present in earlier aerial photo years had been accreted to the banks by the abandonment of channels and, presumably, by some amount of sand deposition in those channels (Fig. 2). Similarly, in stretch RG, large islands were accreted to the banks; and anabranches were abandoned

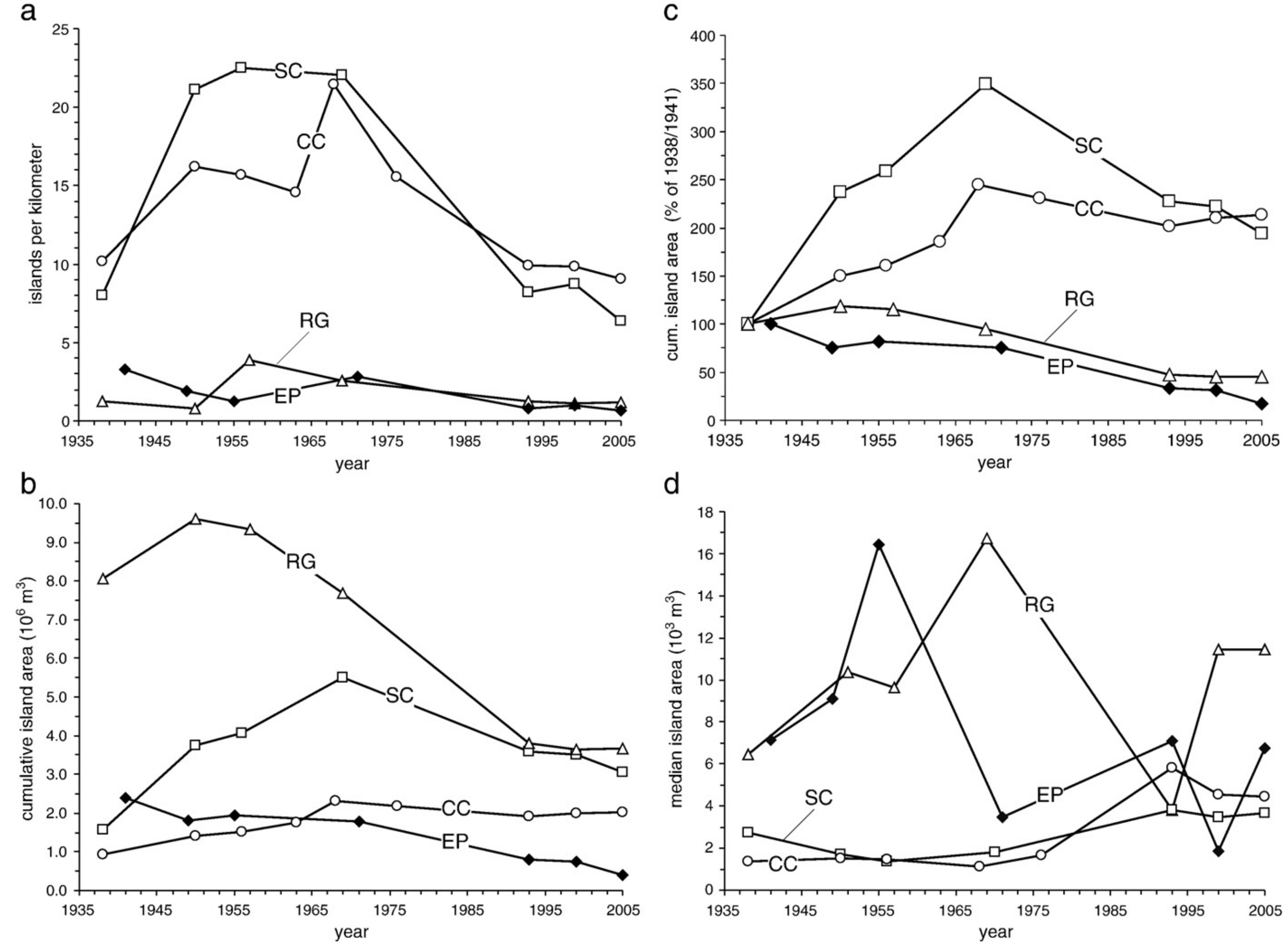

**Fig. 12.** (a) Number of islands per kilometer over time in study stretches. (b) Cumulative area of stabilized islands over time in study stretches. (c) Cumulative area of stabilized islands as a percentage of baseline values from first aerial photograph year in each stretch, either 1938 or 1941. (d) Median island size over time in study stretches.

as channel width decreased over much of the reach after the late 1960s (Fig. 3).

The very strong similarities in cumulative stable island area and the ratio of island area to channel area in all stretches (Figs. 12B, 14Bb) indicate that, since 1938, the Platte River underwent change dominantly by the growth and accretion of islands and only to a much lesser extent by the abandonment of anabranches. Nonetheless, estimates of pre-1938/1941 bank erosion (Table 2) also demonstrate that the two downstream stretches, and particularly stretch RG, underwent more lateral migration than the two upstream stretches. Conversely, relatively little bank erosion occurred in stretches SC and CC during the same period (Table 2). In stretches SC and CC station widths decreased considerably after ca. 1860 (Fig. 10C,D). These decreases in width certainly corresponded to decreases in channel surface area as well, but comparing GLO survey data and aerial stereophotography with respect to exact values of island and channel surface area would be highly questionable considering the fundamental differences between the two data sets. In any case, anabranch abandonment likely played a bigger role in hypothetical decreases in channel area between ca. 1860 and 1938 because, originally, multiple, large anabranches existed in stretches SC and CC. Nonetheless, when the effect of the abandonment of large anabranches is removed from consideration and all stretches are compared, the relative width of the "main" channel (i.e., the one that consistently contains flow from the mid-1850s forward) is actually the most stable in stretch CC, even though that channel was gradually narrowed over time by island accretion. Although in all of the study stretches the Platte has largely stayed within its ca. 1860 channel belt, the combination of observations outlined above indicate an increasing, upstream tendency of in-place narrowing of the channel. Downstream of the major tributaries where discharge was higher and more consistent, though, more lateral migration by bank erosion took place.

## 6. Conclusions

Channel area stands out as a very robust and consistent measurement of historical change on the lower Platte River. Channel shrinkage is prominent, as has been demonstrated upstream (e.g., Johnson, 1994). Even within the lower Platte River, however, the difference in behavior between stretches upstream and downstream from major tributaries (Loup and Elkhorn Rivers) is striking. The least relative decrease in channel area and the most bank erosion occurred in the two stretches of the lower Platte River that lie downstream of major tributary confluences. The farthest downstream stretch (EP) actually showed an initial *increase* in channel area during the 1940s. Channel area has been stabilizing gradually across in the study area since the 1950s.

Measurements of island area greatly expand the assessment of historical change. The overall decrease in cumulative island area and the ratio of island area to channel area in stretches EP and RG relative to 1938/1941 baseline data, the comparatively great fluctuations in median island size in both stretches, and the erratic behavior of island

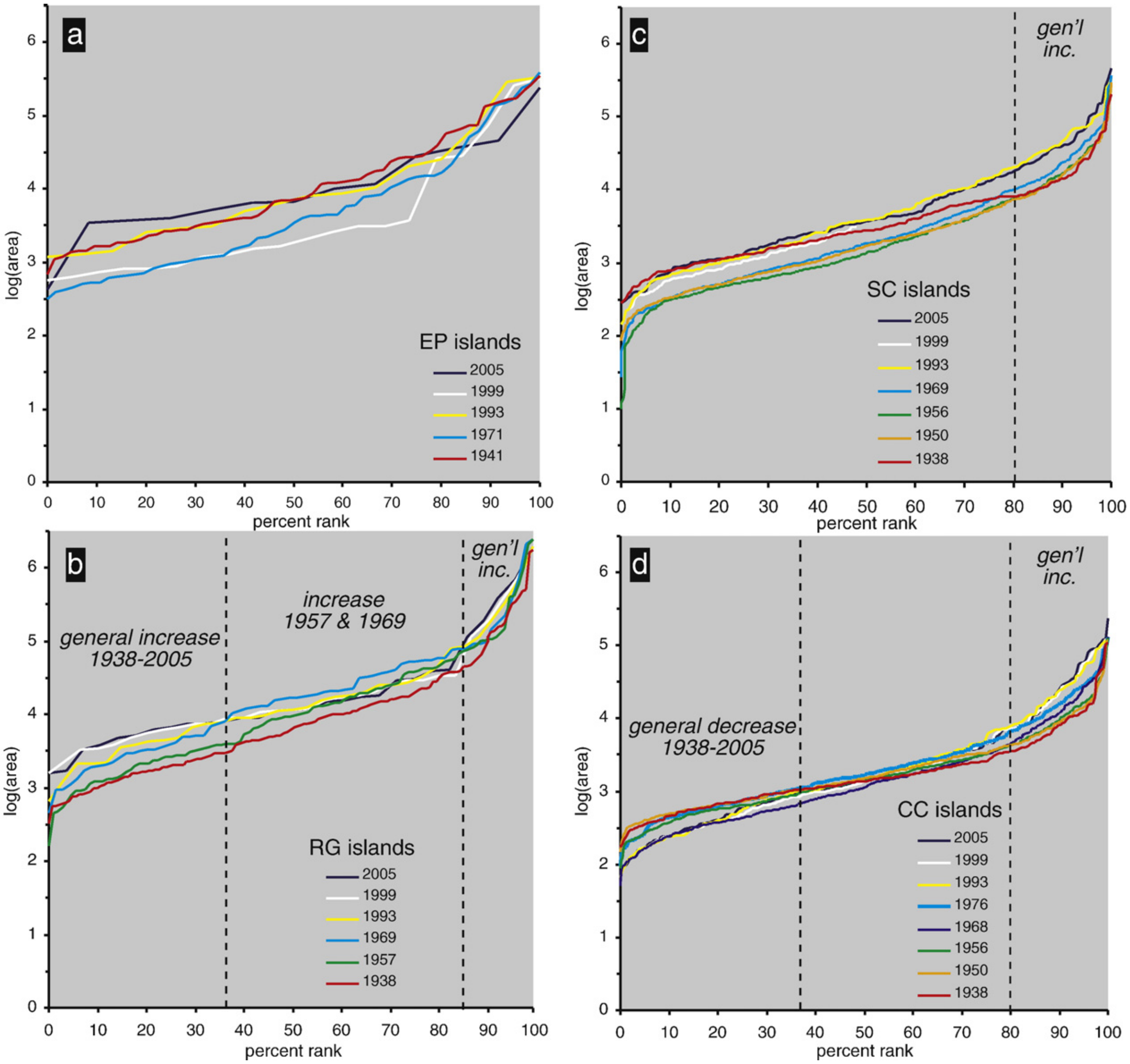

**Fig. 13.** Size distributions of stabilized islands in stretches EP (a), RG (b), SC (c), and CC (d).

size distributions over time in stretch EP indicate two processes. First, large islands were accreted to the banks at different times in the subsequent 150 years. Second, some small stabilized in-channel bars were episodically "flushed" out of the system in these stretches, probably as a part of an overall mechanism of dynamic equilibrium that maintains a certain range of channel width under conditions of comparatively higher discharge. The upstream stretches (SC and CC), in comparison, showed a more consistent impact from the creation of new small islands by bar stabilization.

We conclude that a comprehensive management plan for the Platte River downstream from the Elkhorn and Loup Rivers should differ from the management philosophy proposed by Johnson (1994) for the river upstream from Grand Island, and also that monitoring changes in bar elevation, channel grade, and sediment supply would greatly improve the assessment of future changes by providing the "third dimension" of change related to human activities. The observation of apparently dwindling anabranches of the lower Platte in 1850s GLO survey notes, however, provides a glimpse of longer term changes essentially unconnected to human activities. Therefore, knowledge about the river's characteristics in the recent geologic past is equal in relevance to monitoring programs in the formulation of management policies. The establishment of river characteristics relative to major tributary confluences in this study suggests that it may be possible to interpret the sedimentary record of the ancient Platte River in the context of the putative captures of major tributaries (Loup and Elkhorn Rivers). Moreover, precise channel-belt and ground-penetrating radar surveys, detailed soil and shallow stratigraphic studies, extensive radiocarbon and luminescence dates also have the potential to document a record of riparian change during early historic (~1700 to 1854) and late prehistoric times. Such a record would provide a legitimate means by which hypotheses about the "natural" condition of the Platte River could be tested.

## Acknowledgement

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## Appendix A

Field notes of 1850s government land survey in Eastern Platte River Gorge (EPRG) and vicinity, archived as unpublished typescripts at

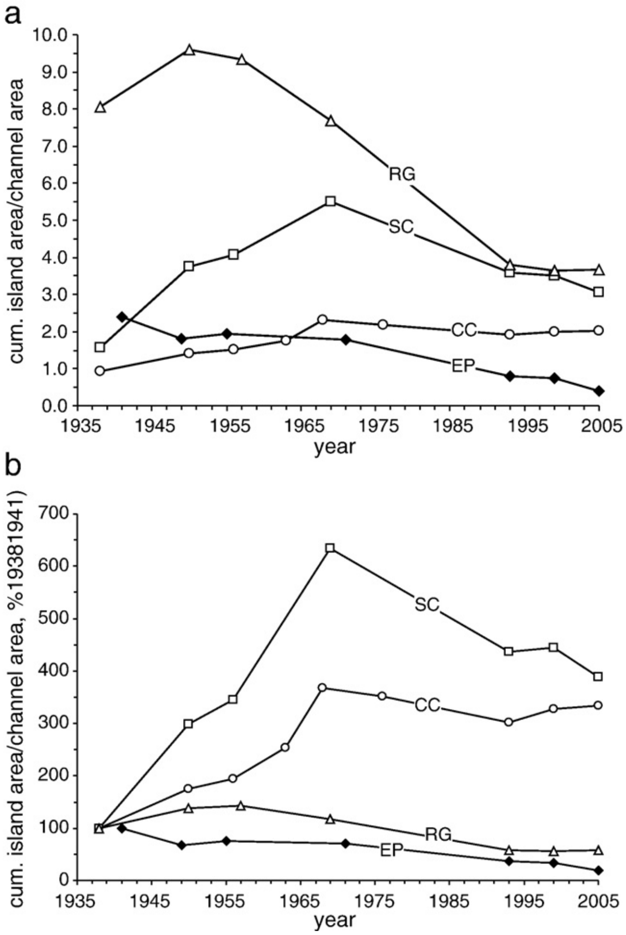

**Fig. 14.** (a) Ratios of cumulative stabilized island area to channel area over time in study stretches. (b) Changes in ratios of cumulative stabilized island area to channel area over time, expressed as percentages relative to value from first aerial photograph year in each stretch, either 1938 or 1941.

Sarpy County, NE Surveyor's Office (Papillion, USA). Typescripts were generated from transcripts of original surveyors' notes made at the U.S. Surveyor General's Office, Plattsmouth, 1882.

"Field Notes of the Subdivision Lines and Meanders of Platte River in Township 12 North, Range 10 East of the 6th Principal Meridian of Nebraska by Philander C. Patterson, Deputy Surveyor."

"Field Notes of the Survey and Establishment of the Third Standard Parallel North of Base Line through Ranges 10, 11, 12, 13, and 14 East of 6th P.M. Executed by Charles A. Manners U.S. Deputy Surveyor"

"Field Notes of the Survey of Exterior Township Lines of Fractional Townships 13 and 14 North of Base Line of Ranges 10, 11, 12, 13, and 14 East of 6th P.M. and Fractional Township 12 North of Ranges 10 and 11 East of 6th P.M. in Nebraska Executed by W.N. Byers, Joseph H. Wagner, and Merriwhether Thompson U.S. Deputy Surveyors"

"Field Notes of Survey of 3rd Standard Parallel along North Boundary Section 6 and North and South Quarter Line and Meanders of Missouri and Platte Rivers in Sarpy County Nebraska"

"Field Notes of Township 12 North, Range 11 East of Sixth Principal Meridian in Nebraska As Surveyed by I.H. Wagner Deputy Surveyor."

"Field Notes of the Subdivision and Meander Lines of Township 13 North, range 10 East of the 6th Principal Meridian in Nebraska as Surveyed by Charles E. Watson Deputy Surveyor"

"Field Notes of the Subdivision Lines of Township 13 North, Range 11 East of 6th Principal Meridian in Nebraska as Surveyed by John I. Paynter Deputy Surveyor"

"Field Notes of the Subdivision and Meander Lines of Township 13 North, Range 12 East of the 6th Principal Meridian in Nebraska as Surveyed by John I. Paynter Deputy Surveyor"

"Field Notes of the Subdivision Lines and Meanders of Township 13 North, Range 13 East of the 6th Principal Meridian in Nebraska as Surveyed by John I. Paynter Deputy Surveyor"

"Field Notes of the Subdivision and Meander Lines of Township 13 North, Range 14 East of the 6th Principal Meridian in Nebraska as Surveyed by William N. Byers Deputy Surveyor"

"Field Notes of the Subdivision and Meander Lines of Township 14 North, Range 10 East of the 6th Principal Meridian in Nebraska as Surveyed by Charles E. Watson Deputy Surveyor"

"Field Notes of the Subdivision Lines of Township 14 North, Range 11 East of the 6th Principal Meridian in Nebraska as Surveyed by John I. Paynter Deputy Surveyor"

"Field Notes of the Subdivision Lines of Township 14 North, Range 12 East of the 6th Principal Meridian in Nebraska as Surveyed by John I. Paynter Deputy Surveyor"

"Field Notes of the Subdivision and Meander Lines of Township 14 North, Range 13 East of the 6th Principal Meridian in Nebraska Executed by John I. Paynter Deputy Surveyor"

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