RIPARIAN HABITATS OF THE SOUTHEAST SIERRITA MOUNTAINS: VANISHED PERENNIAL HABITATS

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Introduction

The area of study can be seen on plate 1, which is a black-and-white copy of a color-composite Landsat scene of the Sierritas (north to south is about 30 miles). The site is about 30 miles south of Tucson, Arizona. A striking feature of the site is the prominence of riparian vegetation along incised, linear streams. The dense vegetation begins at about 3700 feet elevation and extends to about 3250 feet elevation. Referring to figure 1, showing the topography of the area, an enclosing triangle is formed, with Sopori Wash as the base, Batamote Wash as the western side, and the east bounded by a line from the lower right corner of the map, passing northwest through the Sopori Wash gully at 3150 feet elevation. Such a triangle outlines the system watershed boundaries. The triangle has about 40 square miles area, wherein the area of the dense inner floodplain riparian tree vegetation amounts to about 5 to 6 square miles. Thus, within this system, there is an overall concentration ratio of 7 to 8 supplying runoff to the vegetated floodplains. Based on regression of rainfall with elevation for recorded stations in the Sierrita area (6), there is about 12.4 inches at 3000 feet to 17 inches at 3600 feet.

Of the prominent streams in the area, Batamote Wash and Proctor Wash are presently being studied in detail, and are the subject of this paper. Batamote Wash has a watershed area of nearly 16 square miles, extending from 5000 feet in elevation. Based on the annual rainfall and its altitudinal relationship, a volume of close to 13000 AF (acre-feet) represents the yearly volume of water input into the Batamote system. Of that amount, 10000 AF is generated within the 4000 to 3500 foot elevation interval. Proctor Wash extends from 5200 feet elevation, with a watershed area of around 5 square miles, generating a yearly Volume of around 4000 AF. Between 4000 to 3500 feet elevation 2000 AF is generated. Thus, the major portion of surface runoff and input into the incised stream systems occurs somewhat upslope of 3500 feet, and the dense canopy occupies lesser inclines below 3500 feet elevation.

The dominant perennial canopy is composed of bosque type mesquite (*Prosopis velutina*), and net-leaf hackberry (*Celtis* reticulata) trees. Dense stands of Celtis and Salix taxifolia are found in Batamote Wash along reaches where subsurface conditions perch the watertable. Interfluvial slopes presently are sparsely covered by unpalatable composites and some small, shrubby mesquite. Some patches of native grasses, such as Arizona cotton-top can be found.

Results and Discussion

Geology

The geology of the area has been compiled from field investigation, and various published sources (see references cited). Figure 2 shows the result of the geologic synthesis for this paper. The riparian habitats are incised into the Tuc unit, which is interpreted as a late Tertiary to early Quaternary conglomerate. It is seen to ring the upper riparian area, and overlies a middle Tertiary tuffaceous conglomerate, Tc. The Tc unit seems to have supplied detrital material to the formation of the overlying Tuc unit. On figure 2 is a line that shows the extent of the tan-brown silty floodplain soils in the riparian system (they do not occur on the interfluves). The relationship of the tan-brown silty soils to the geology illustrates their derivation from tuffaceous materials. Such soils have good infiltration and retention characteristics. The sandy and gravelly soils in downstream and recent channel deposits have poorer retention. The Q middle quaternary to recent deposits comprise red gravelly silts of outer floodplain deposits, tan-brown silts and gravelly silts of inner floodplain deposits, and red clay soils that cover the "whale-back" ridges (ballenos) of the interfluves.

Lineaments shown on figure 1 are seen on figure 2 to correspond to formation contact trends, which also correlate to surface features of the underlying units.

On figure 1 are shown lines of section for which figure 3 is drawn. Seismic stations are shown on figure 3; the depth to seismic horizons is from Sternberg, et. al. (1988). The seismic sensors were spaced to best delineate the deeper higher velocity layers. Nevertheless, when matched with field observations, the resolution of the 2400 and 3400 fps layers seems quite good. The interpretation is based on my field observations. In section XX' the active channel is incised into the Tuc unit, which crops out in a cliff on the west wall (shown in plate 2), and a series of shallow dipping layers on the east. At this site on Batamote Wash is found the Celtis and Salix stands. Interestingly, extrapolation of the outcropping layers at site X seems to correspond to depth of excavation in the Tuc unit in proctor wash, and the wash just east of the adjacent whale-back.

The section YY' shows the presence of an old shoulder at Y at the location of the seismic station. The tops of the ballenos eastward form a surface that includes the shoulder on the west side of Batamote Wash.

The Riparian Canopy and Alluvial Features

Figure 4 shows the relation of the perennial riparian canopy density to floodplain soils and interfluvial soils. This figure was compiled from density classified MSS 5/7 ratio, MSS 4/5 ratio, data from **figure 2**, and field observations. In Proctor Wash and Cowboy Wash, just east of Proctor Wash, dense floodplain vegetation occurs on the steeper gradient surfaces within the tan-brown silt line. Proctor and Cowboy Wash have extended the silt line somewhat onto lower slopes. In the streams to the east, dense canopy occurs on sandy and gravelly soils at lower gradients. The units in figure 4 marked as high iron oxide reflectance are the older reddish terrace deposits that have had the grass cover replaced by sparse shrubby composites. Runoff from these surfaces is now a source of renewed erosive input into the inner floodplain system of the streams.

Figure 5 shows the relation of active channels to old channels on terraces in Proctor Wash. This figure is compiled from remote sensing data and field observations. The stream sections AA' and BB' can be located on figure 1, and **figure 6**. **Figure** 5 shows the lateral inputs into the inner floodplain. These inputs are in the form of narrow incised gulleys channelling runoff from the sparsely vegetated outer red terrace surfaces. Increased erosion takes place along older established channels, or cuts older across older chlannels and obliterates the older terraces. The new channels are fairly straight where they are deepening and narrowing older straight reaches, but they show a tendency to increased sinuosity. This indicates that the greater energy of new flows is being dissipated through means of erosive meandering. The change in bed load observable from old channels to new is toward greater load size: mostly silts in the older brownish terrace streams, and cobbles and boulders in the new channels.

Figure 6 shows the relation of a new channel to an old channel where they coincide. The trees that grew on the banks of the old channel are still in place. The older channel is in silty deposits, with a broad, shallow morphology, and shallow banks. The new channel is narrower, with coarse bed load, and steeper erosive banks. **Plate** 3 shows a view of a new channel that cuts across an older straight channel; the location is about 1/8 mile above the section BB' on **figure** 5, looking upstream. In plate 3 the trees growing along the old banks clearly define the edges of the former channel. The older channel is broad and shallow, with stable shallow banks supporting the perennial canopy. The channel is in the tan-brown silts of the former floodplain. Plate 4, looking down-stream shows an old stable abandoned channel under a covered canopy, about six feet above the banks. The brighter center of the photo is the cross-cutting active channel.

Figure 7 shows the Batamote and Proctor Wash system in relation to the geologic sections, and channel sections in figures 7 and 8. **Figure** 7 shows active channels: they are confined by the walls of the older red gravelly silts that were entrenched and filled with the inner tan-brown floodplain alluvium. The stippled unit labelled "brown soils of lower alluvial fan" occur on the lower flat slopes of the whole balleno morphology system. The red gravelly silt of the older floodplain sediments, and the red soils that cover the balleno crests, grade into browner units towards Sopore Wash. **Figure** 8 shows the cross sections AA' and BB'. The sections show the depositional sequence in the sedimentation of the early Pleistocene channels excavated in the Tuc unit. The brown silts of the inner floodplain are shown in **figure** 8 with an uncertain interface at the base of the unit. This is in deference to the resolution at this depth of the seismic profiles, although the observations and interpretation in the geologic section in **figure** 3 strongly indicate that the upper Tertiary conglomerate forms the base of the inner floodplain 2400 fps sediment. The location of the riparian canopy is indicated by the trees drawn on the inner terraces. Arrows indicate active channels. Note that on the eastern side of the inner floodplain the older cemented red silts and gravel silts form active channel constraints. On **figure** 8 old stumps are drawn on the eastern red terrace above the inner floodplain. These locate a line of dead and weathered large trees that form a line about 50 feet from the inner red cliffs. Work is currently being done to map and identify these old weathered trunks and stumps. Section BB' shows living mesquite trees growing from the red cliffs: these trees were established before active channel erosion removed the former floodplain channel and banks from under the trees. The trees are about 3 feet above the active channel bed. Plate 5, looking downstream, shows the cliff walls with stunted mesquite, with their exposed roots. An eroded slope of the former terrace is at the right of the scene.

Synthesis and Conclusions

Figure 9 shows a composite summary of events in the southeastern **Sierritas** (note that the bedrock channel is drawn on a different scale than the topography of the inner floodplain). Within the channels excavated in the late Tertiary conglomerate, a progression of increasing lateral restriction and down-cutting erosion has taken place from early Quaternary to Recent times. This may partially reflect middle Pleistocene to recent structural evolution of the Tucson basin (cf. Davidson, 1973). The surfaces within the channels (specifically observed in Batamote and Proctor Wash) are numbered from 1 to 5, with 5 being the active channelling and erosion visible today. The perennial system was de-watered in the formation of the present active level, at which time the trees on the higher banks died as phreatic water was withdrawn from their roots. The mesquite bosques are probably times. Poplars may have present previous to mesquite bosque establishment, but the non-erosive characteristics of the channels seen on levels 4 and 3 may not have provided suitable conditions for their establishment. The present and recently deceased arboreal vegetation in this system, including the Sopori Wash, which was marshy bosque before recent erosion, seems to be an extension of Santa Cruz bosque environments. The demise of the southeast Sierrita riparian bosque system also seems to be linked to the fortunes of the lower Santa Cruz. From near the beginning of the present century, various factors have interacted to produce an erosional episode and de-watering of perennial bosques (Cooke and Reeves, 1976). This process has extended into perennial bosque areas in the southeast Sierritas through the Sopori Wash tributary. An interesting observation of an effect of the May third, 1887 Bavispe earthquake is made by Betancourt (1986): "From his ranch in the Sierrita Mountains, Hiram Stevens reported that the earthquake more than doubled the flow of nearby streams (Arizona Daily Star, June 2, 1988)." The rainfall in Tucson for May, 1887 was under 2 centimeters. This powerful earthquake (estimated magnitude of 7.2, felt in Santa Fe, New Mexico) affected stream and spring flow in southern Arizona (DuBois and Smith, 1980). The stored water in the Sierrita balleno sediments, perched as high as several hundred feet above the Santa Cruz, could have been released by the earthquake. Possibly, spring or seep flow into the ballenos was discontinued; (this possibility is being investigated). Thus, the de-watering and erosion of the southeast Sierrita system was occurring as the Santa Cruz flooding and erosion intensified (Betancourt, 1986). Figure 10 shows the relationship of major riparian areas in the Santa Cruz drainage system. Bosque communities below 3600 feet have diminished or disappeared. Arivaca cienega, at about 3600 feet, immediately connected to the Altar Wash, was saved from erosive drainage by the damming action of a concrete ford (Hendrickson and Minckley, 1985). The Sierrita perennial riparian site occurs on the other side of the drainage divide between Arivaca Creek and Sopori Wash, at about the same elevation. As with other perennial riparian habitats in the Santa Cruz drainage (Hendrickson and Minckley, 1985), the Sierrita site depended upon an impermeable substrate to perch water at the surface: in this case, the Pleistocene channels in the late Tertiary conglomerate. The erosive and hydrostatic changes within the Santa Cruz system have affected the river and its colateral perched perennial reservoirs. The profile of the southeast Sierrita riverine system indicates that the process of adjustment has been operative since the middle Pleistocene.

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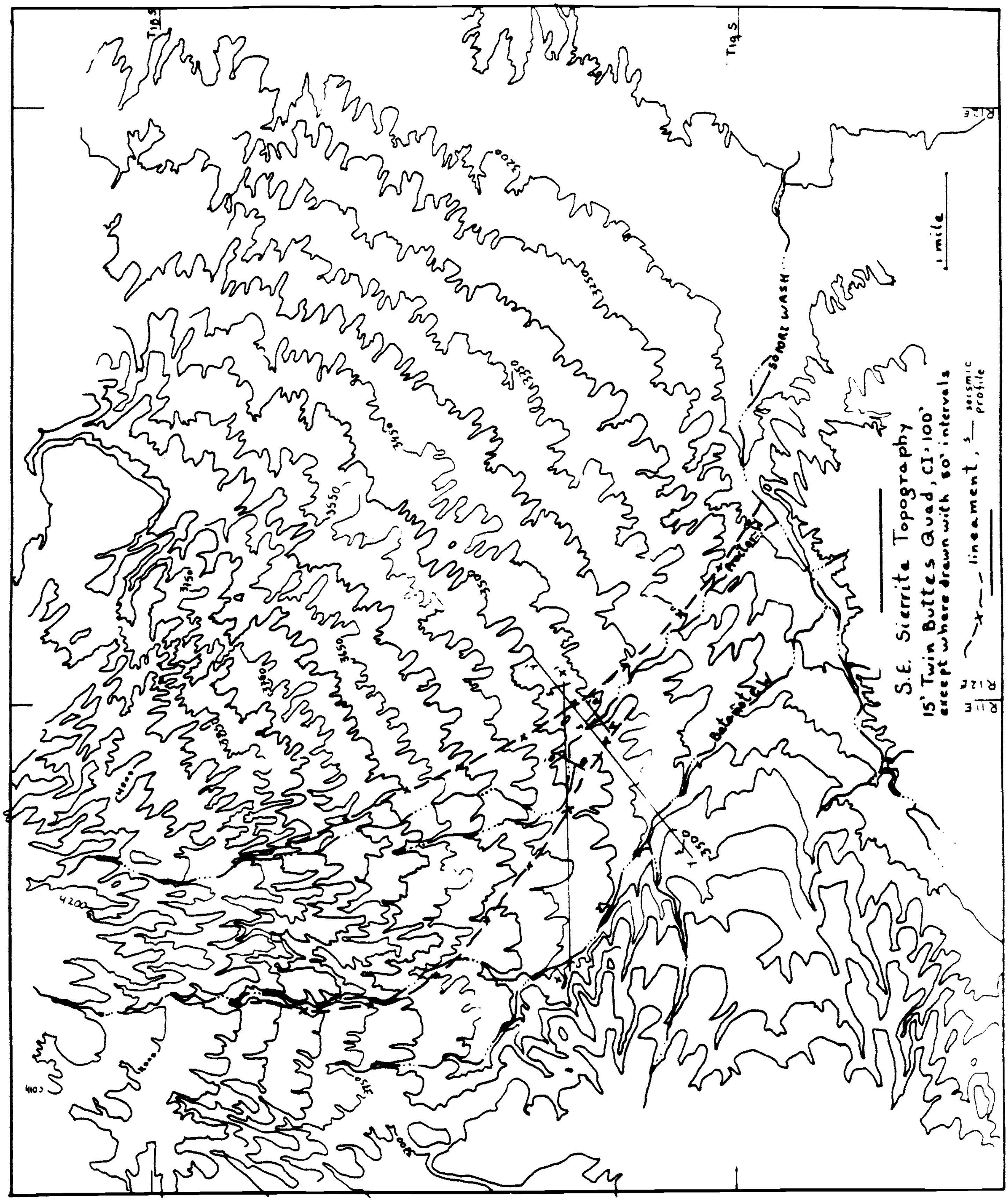
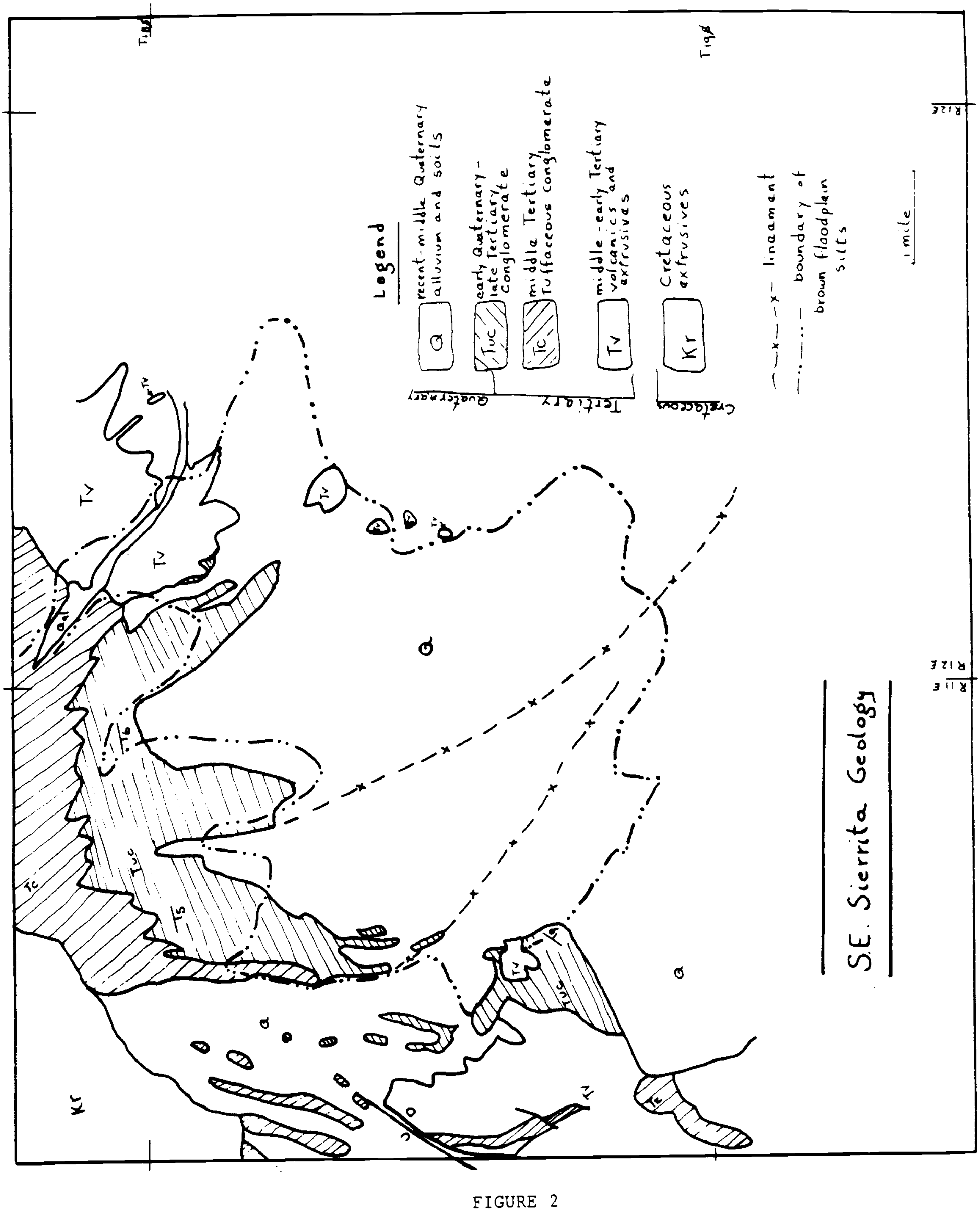
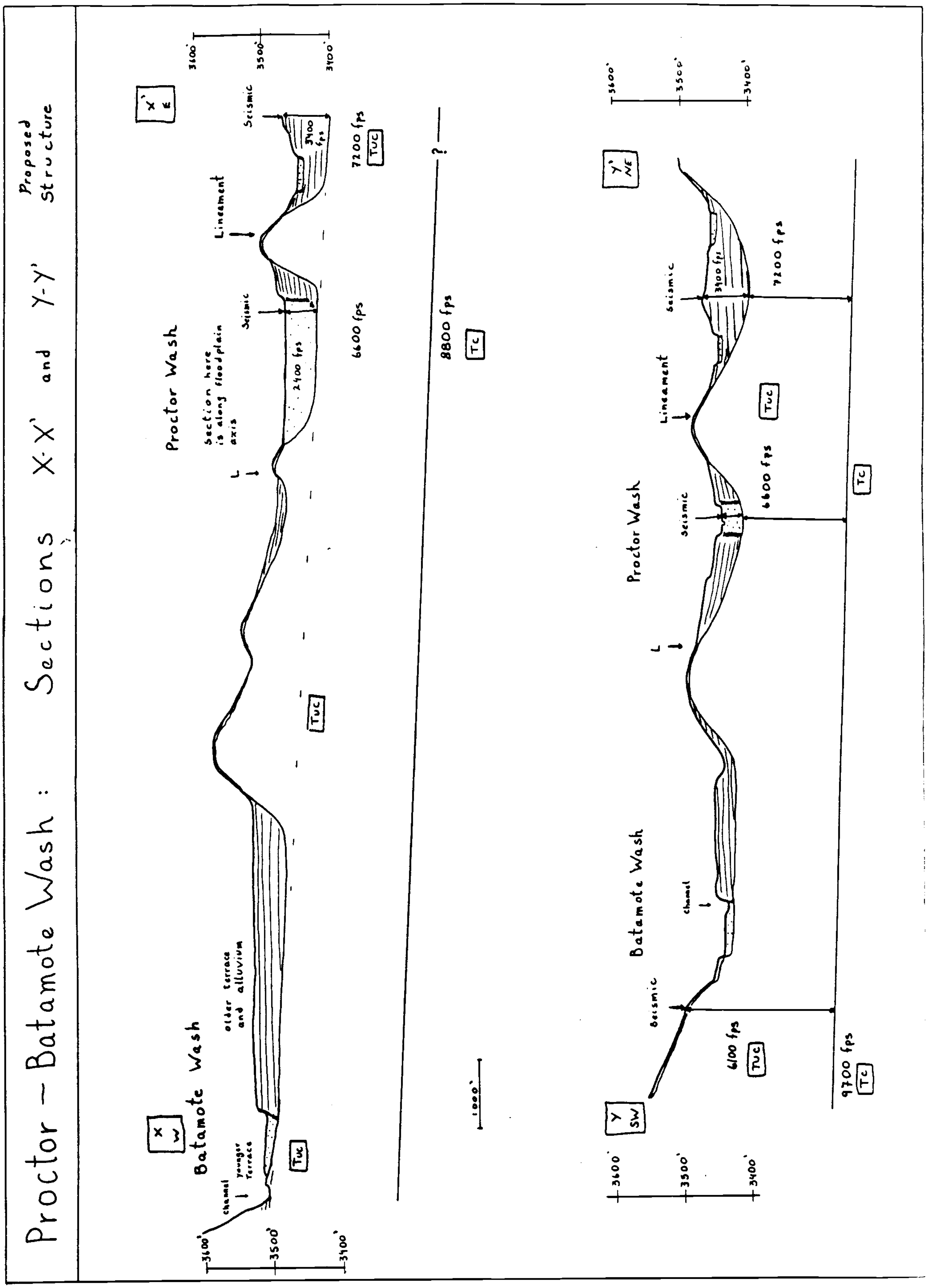

S.E. Sierrita Topography
15' Twin Buttes Quad, CI: 100'
except where drawn with 50' intervals
lineament
seismic profile
1 mile
SOPORI WASH
T19S
R12E
R11E

FIGURE 1



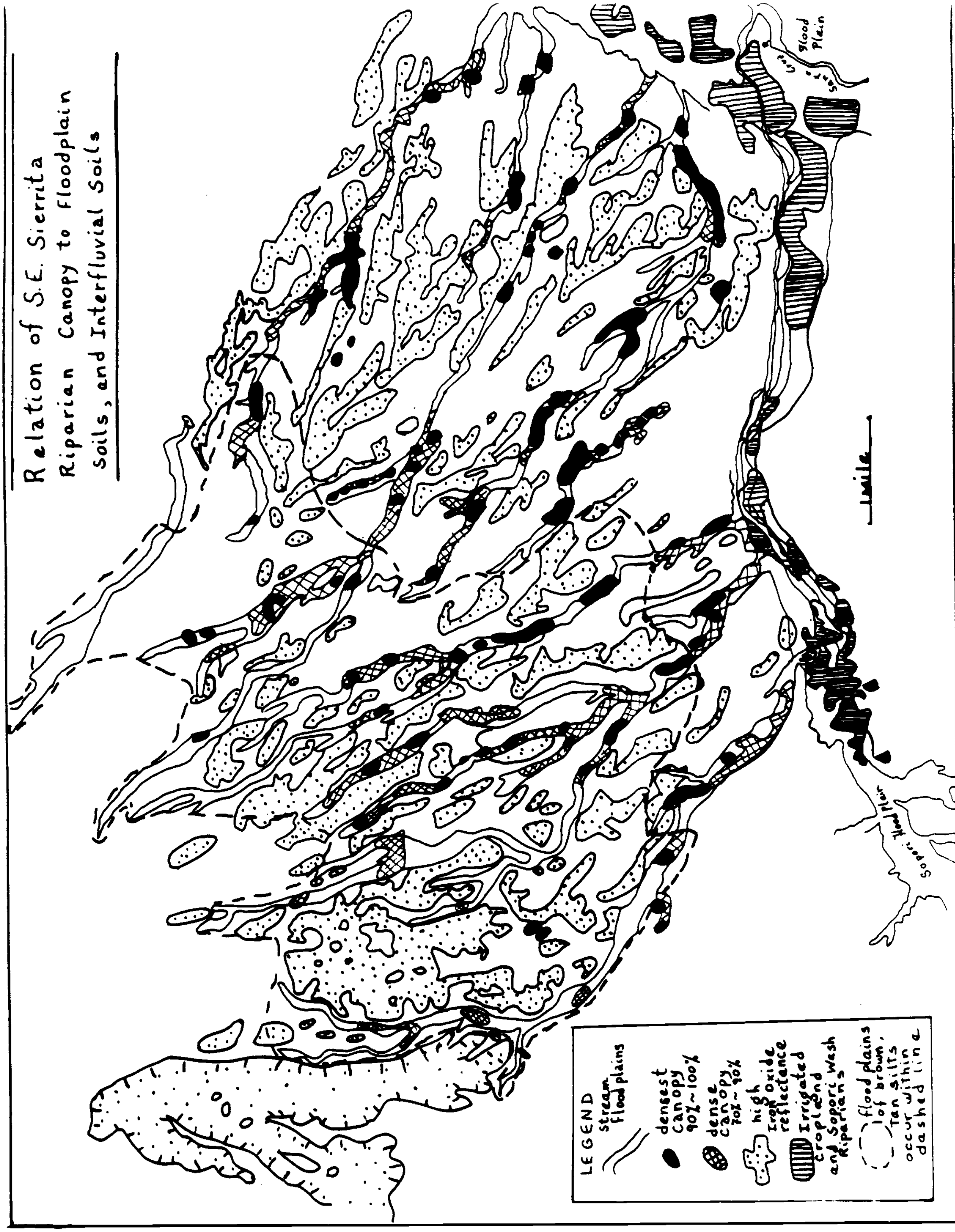
S.E. Sierrita Geology
Legend
Q recent-middle Quaternary alluvium and soils
Tuc early Quaternary - late Tertiary conglomerate
Tc middle Tertiary Tuffaceous conglomerate
Tv middle-early Tertiary volcanics and extrusives
Kr Cretaceous extrusives
Quaternary
Tertiary
Cretaceous
—x—x— lineament
—·—·— boundary of brown floodplain silts
1 mile
R12E
R11E

FIGURE 2



Proctor – Batamote Wash : Sections X-X' and Y-Y'
Proposed Structure
X W
X' E
Y SW
Y' NE
Batamote Wash
Proctor Wash
Section here is along floodplain axis
older terrace and alluvium
younger terrace
channel
Seismic
Lineament
L
Tuc
Tc
2400 fps
3400 fps
6100 fps
6600 fps
7200 fps
8800 fps
9700 fps
3600'
3500'
3400'
1000'

FIGURE 3



Relation of S.E. Sierrita
Riparian Canopy to Floodplain
Soils, and Interfluvial Soils
1 mile
LEGEND
stream floodplains
densest canopy 90%~100%
dense canopy 70%~90%
high Iron oxide reflectance
Irrigated cropland and Sopori Wash Riparians
flood plains of brown, Tan silts occur within dashed line
Sopori flood plain
Flood Plain

FIGURE 4

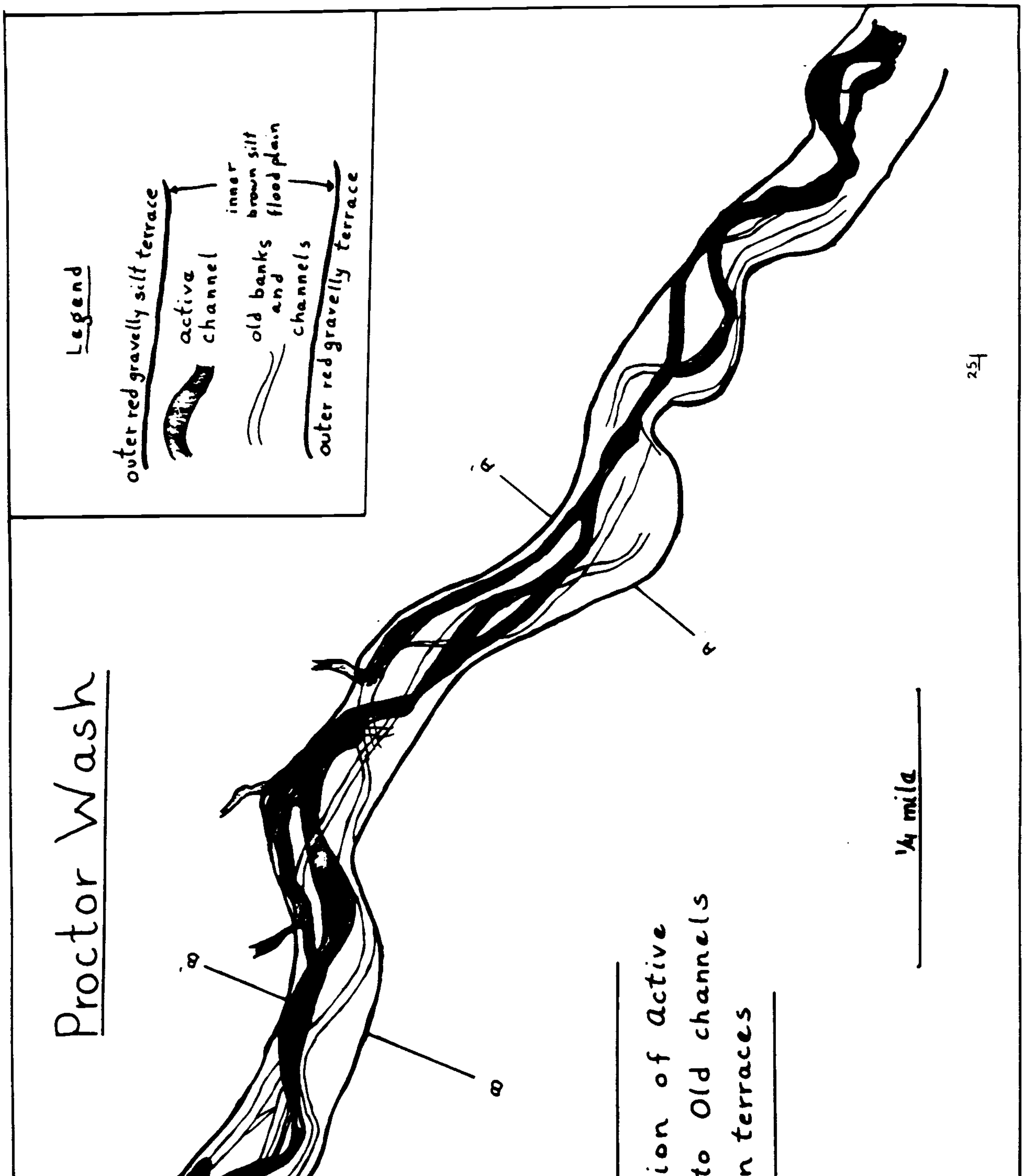

Proctor Wash
Legend
outer red gravelly silt terrace
active channel
old banks and channels
inner brown silt flood plain
outer red gravelly terrace
Relation of Active channels to Old channels on terraces
1/4 mile

FIGURE 5

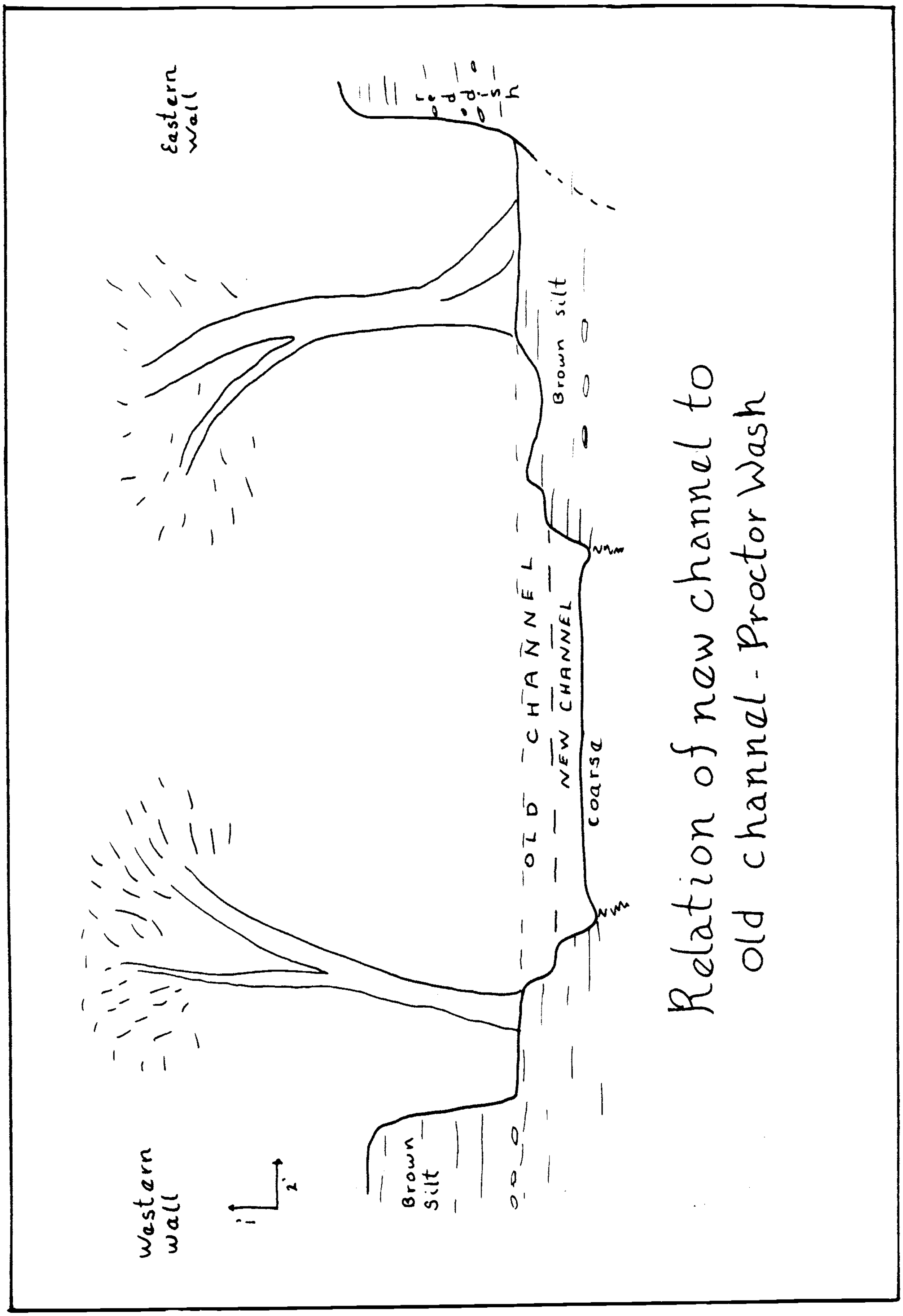

Relation of new channel to old channel - Proctor Wash
Eastern wall
Western wall
reddish
Brown silt
OLD CHANNEL
NEW CHANNEL
coarse
Brown Silt
2'

FIGURE 6

Channel and Alluvial Features of Batamote and Proctor Wash

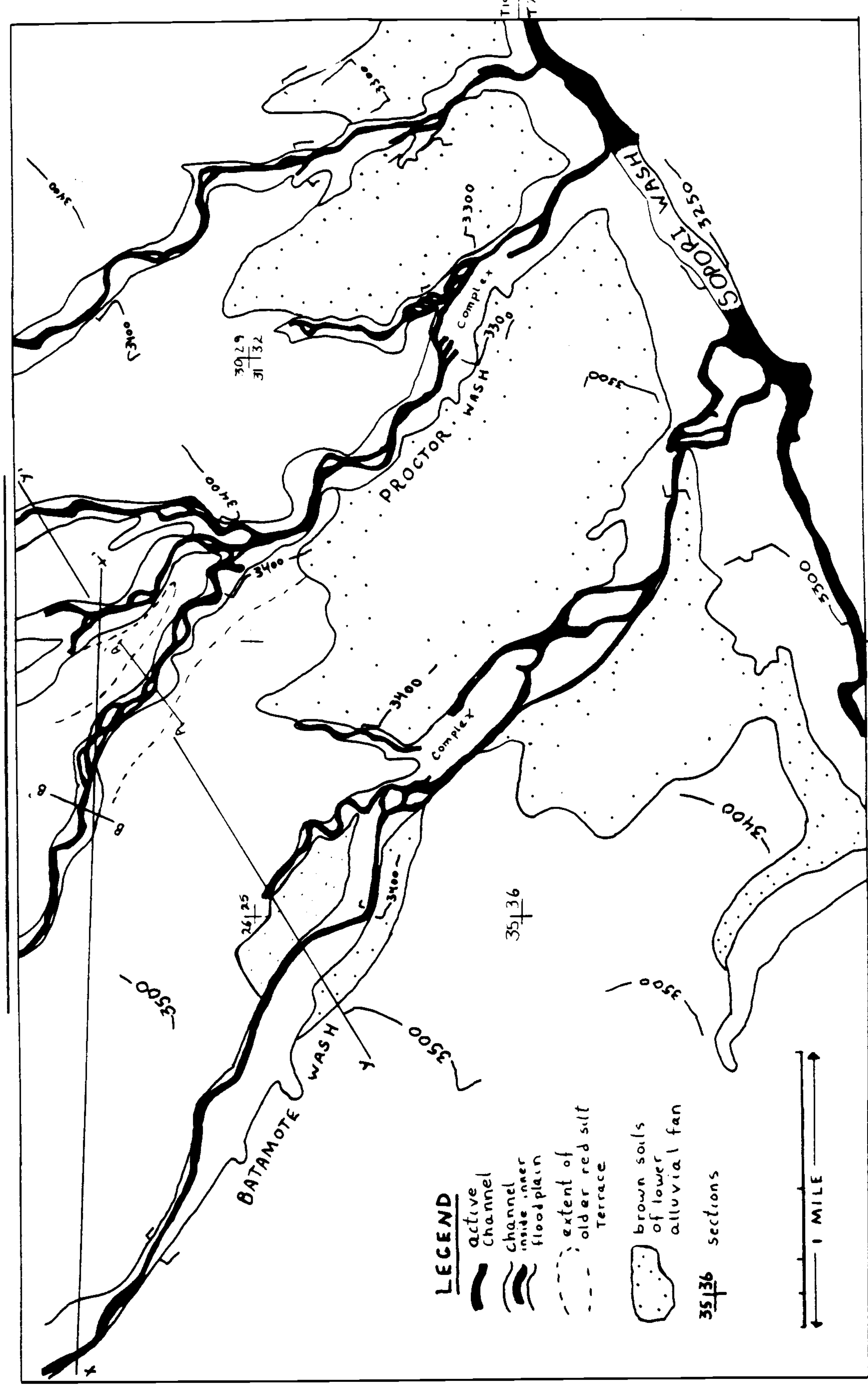
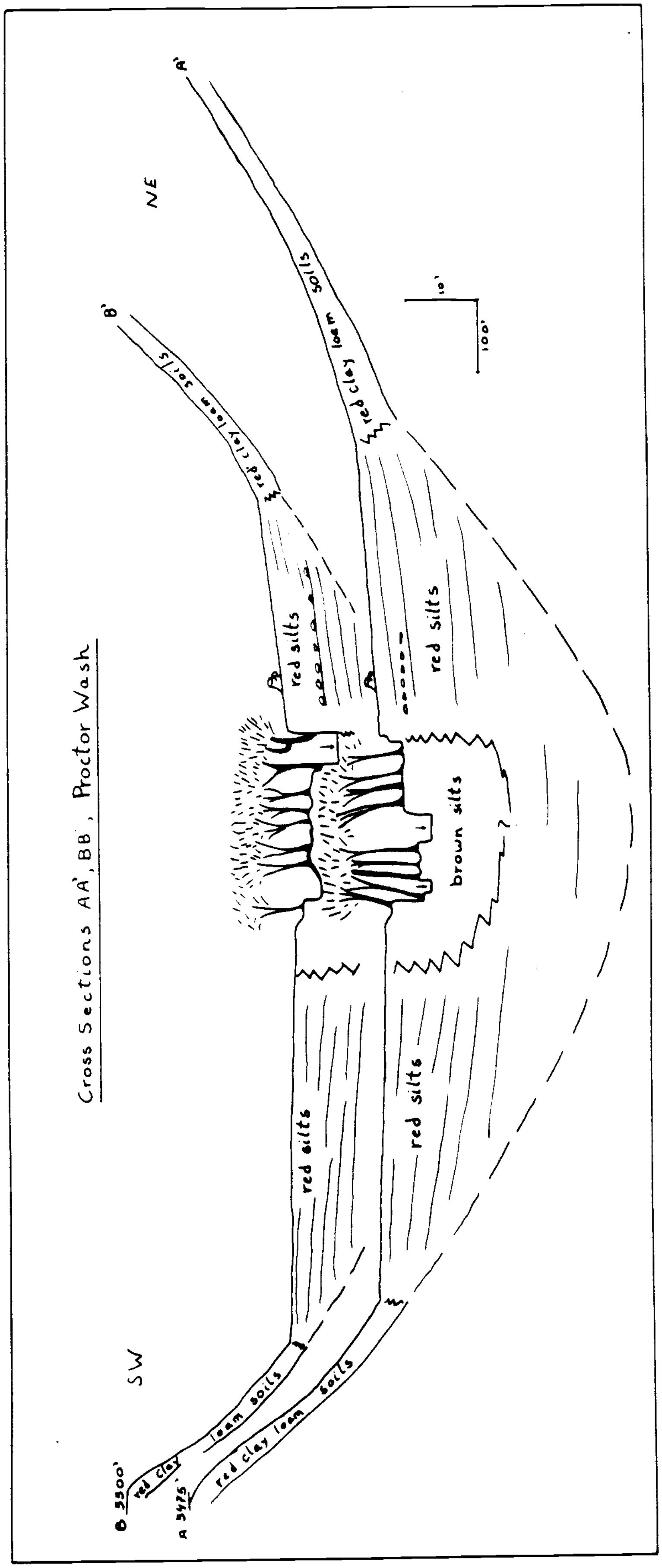


FIGURE 7



Cross Sections AA', BB', Proctor Wash
SW
NE
B 3500'
A 3475'
red clay
loam soils
red clay loam soils
red silts
brown silts
red clay loam soils
red clay loam soils
B'
A'
10'
100'

FIGURE 8

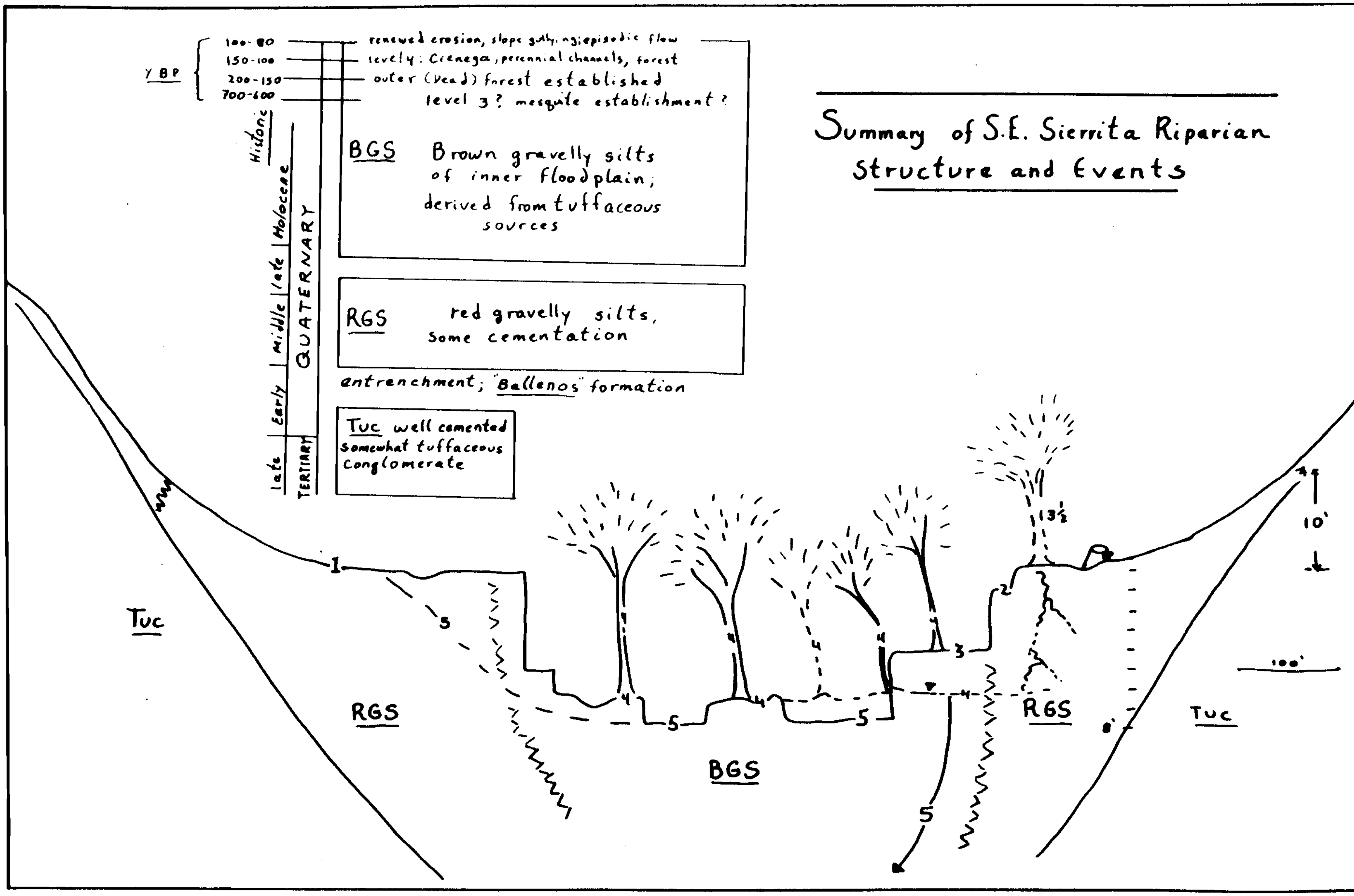
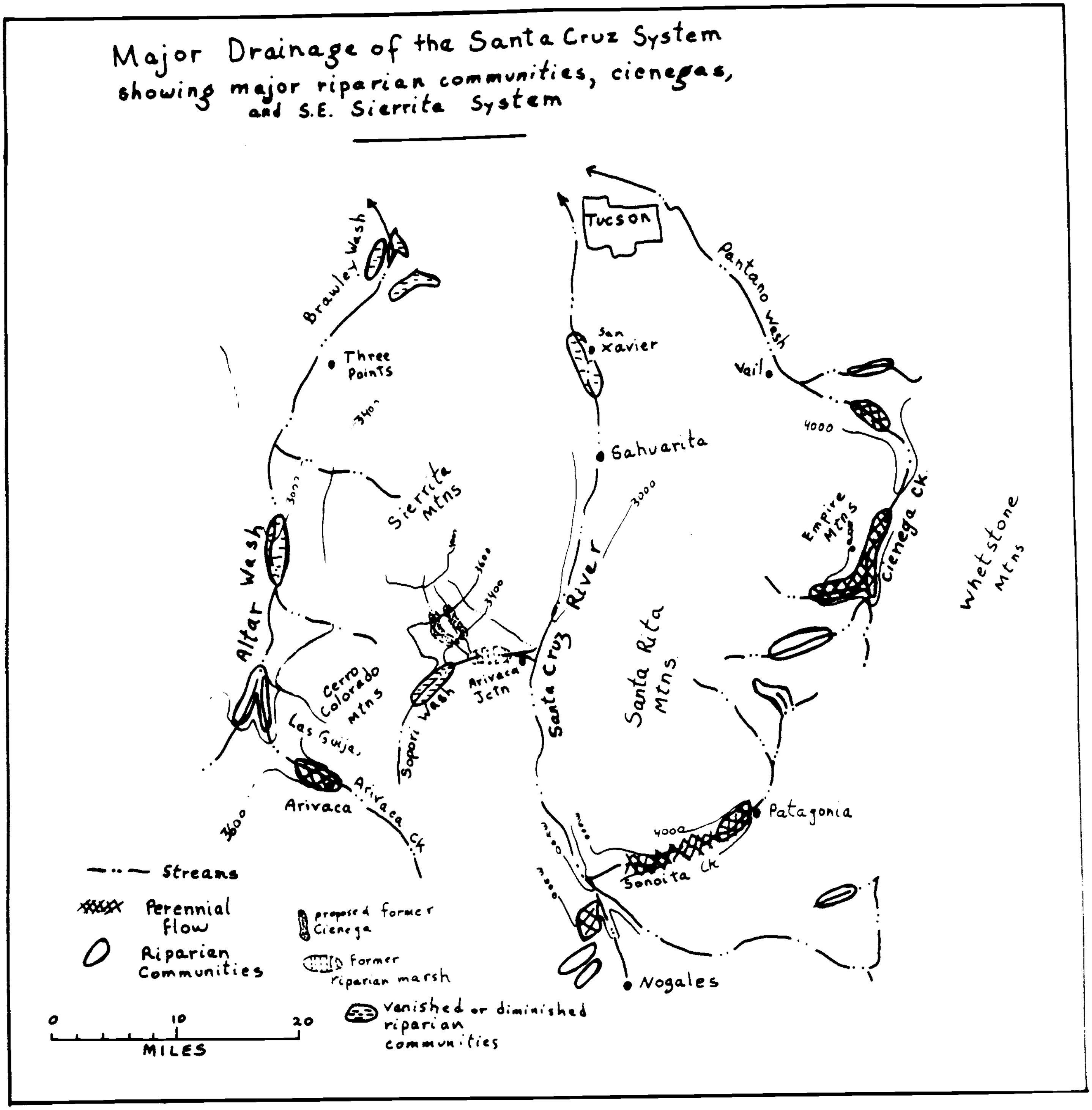

Summary of S.E. Sierrita Riparian Structure and Events
Y BP
100-80
150-100
200-150
700-600
renewed erosion, slope gullying; episodic flow
level 1: Cienega, perennial channels, forest
outer (Dead) forest established
level 3? mesquite establishment ?
Historic
Holocene
late
middle
Early
late
QUATERNARY
TERTIARY
BGS Brown gravelly silts of inner floodplain; derived from tuffaceous sources
RGS red gravelly silts, some cementation
antrenchment; "Ballenos" formation
Tuc well cemented somewhat tuffaceous conglomerate
Tuc
RGS
BGS
RGS
Tuc
10'
100'

FIGURE 9



Major Drainage of the Santa Cruz System
showing major riparian communities, cienegas, and S.E. Sierrita System
Tucson
Brawley Wash
Pantano Wash
San Xavier
Three Points
Vail
Sahuarita
4000
Sierrita Mtns
Altar Wash
Empire Mtns
Cienega Ck.
Whetstone Mtns
Santa Cruz River
Santa Rita Mtns
Cerro Colorado Mtns
Las Guijas
Sopori Wash
Arivaca Jctn
Arivaca
Arivaca Ck
Patagonia
Sonoita Ck
Nogales
Streams
Perennial flow
Riparian Communities
proposed former Cienega
former riparian marsh
vanished or diminished riparian communities
0
10
20
MILES

FIGURE 10

PLATE 1

BLACK AND WHITE COPY OF LANDSAT COLOR COMPOSITE SCENE OF SIERRITA MOUNTAINS. (ABOUT 30 MILES FROM NORTH TO SOUTH.)

PLATE 2. VIEW OF UPPER TERTIARY CONGLOMERATE FORMING WALL OF BATAMOTE WASH.

PLATE 3. VIEW UPSTREAM OF ABANDONED CHANNEL CROSS-CUT BY RECENT SINUOUS EROSIVE CHANNEL

PLATE 4. VIEW DOWNSTREAM OF ABANDONED CHANNEL UNDER CLOSED CANOPY.

PLATE 5. VIEW OF WALL OF ACTIVE CHANNEL, WITH STUNTED MESQUITE GROWING AT THE FORMER TERRACE LEVEL.