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October 10, 1998

Hi Craig,

I am sending you my master's thesis on the fluvial geomorphology of the Rio Grande in White Rock Canyon. A soft copy of the GIS coverages based on aerial photos from 1935 to 1991 is also enclosed.

The objective of my study is to show the response of the Rio Grande upstream of Cochiti Dam (in White Rock Canyon) due to its closure in 1973. In order to assess the adjustment of the river's morphology and to differentiate between natural (due to water and sediment discharge) and human induced (the closure of Cochiti Dam) change, I surveyed the channel morphology between 1935 and 1991. The change of the fluvial morphology is documented using the longitudinal profile of the channel, its cross section and planform, and sediment data.

The theoretical basis of my approach is based on the assumption that the fluvial system is constantly attempting to establish an equilibrium. Rivers are three-dimensional, and the elements of the channel geometry, i.e. planform, profile, and cross section, are interdependent. The channel geometry is also dependent on water and sediment discharge, which are determined by the parameters in the drainage area (climate, topography, geology and sediment, vegetation and land use). Therefore, I analyzed the parameters and dynamics of the drainage area as well as of the study area in White Rock Canyon. Furthermore, I also analyzed the elements directly influencing the channel morphology in White Rock Canyon: sediment and water discharge, and the water level in Cochiti Lake.

The core of my study is the interpretation of aerial photos from 1935, 1951, 1963, 1975, 1982, 1986, and 1991, and the following transformation of the maps in a GIS (Geographical Information System). First, I manually mapped the planform of the Rio Grande on mylar using an APY (Analytical Photogrammeter by Yzerman). The orthophoto maps of the US Army Corps of Engineers, Albuquerque District 1981/1986 (scale 1:4800) were used as base maps (plates 6, 7, and 8) in order to establish a georeferencing system (New Mexico State Plane Coordinate System, Central Zone, Transverse Mercator Projection, 2,000 ft-grid) for my maps drawn from the aerial photographs and showing the planform of the Rio Grande.

Ecologist

The following classes were used to map the features in the floodplain:

ground cover classes	definition
dense upland vegetation	dense <i>Juniperus monosperma</i> , yet, no closed canopy cover; interspersed <i>Pinus ponderosa</i> on the alluvial fans of the tributaries
sparse upland vegetation	sparse cover with <i>Juniperus monosperma</i>
dense riparian vegetation	pre-dam situation: <i>Populus fremontii</i> var. <i>wizlizenii</i> and <i>Juniperus monosperma</i> post-dam situation: a dense growth of <i>Salix exigua</i>
sparse riparian vegetation	<i>Salix</i> and <i>Populus</i> sprouts, and weeds
submerged vegetation	due to rising water level
sandy area	established sandbars in the main channel or bare areas on the tributary fans
low sandbar	newly deposited sandbar
water	all water surfaces in the study area
landslide	landslide in the study area

To implement a GIS, ARC/INFO 6.1.1 (for workstations) was used to digitize the maps and to establish the topology. The geographical data were finally analyzed in Arc View 3.0, which was also used to generate the maps.

In order to interpret the change of the river channel as a three-dimensional entity, the mapped planform was compared to the long profile and the cross sections of the Rio Grande in the study area, and to the sediment data (all three parameters are based on data sampled by the US Army Corps of Engineers, Albuquerque District).

The results of the study contradict the Corps of Engineers hypothesis that most of the sediment will be deposited in the open main body of Cochiti Lake beyond the constriction of White Rock Canyon. The sediment, however, is deposited in the main channel of the Rio Grande at that point where the streaming water of the Rio Grande enters the standing water of the lake, i.e. in White Rock Canyon at the lower end of Bandelier National Monument. Due to the reduced velocity, the river loses its transport capacity resulting in the deposition of a sediment delta with bottomset, foreset, and topset beds. Unlike earlier predictions the delta front is not determined by the slope in White Rock Canyon but by the water level in the lake. Since the closure of Cochiti Dam the fluvial system has lost its stability and is no longer in equilibrium with mean discharge and sediment load. By aggrading the system is attempting to adjust itself to the altered base level and to reach its new equilibrium. Minor changes in the size and location of sandbars in the pre-dam system are merely various states (high water and low water configuration) of a stable channel. The post-dam system is dynamic and in the process of constant adjustment to the fluctuating water levels in Cochiti Lake. With the growing sediment delta the Rio Grande changes its planform in the study area. Between Arroyo Montoso and Capulin Canyon, on the deposited material, the river channel is straightening. Downstream between Capulin Canyon and Canyon 3 (see maps) the channel is braided between the many mud bars. The sediment analysis shows that most of the sand and gravel load of the Rio Grande must be deposited upstream of Frijoles Canyon because of the decreasing velocity of the Rio Grande. Based on the current sedimentation rate Cochiti Reservoir will have reached a new equilibrium between aggradation and sediment transport in 2073.

Not only does the altered base level of the Rio Grande due to the closure of Cochiti Dam influence the main channel but also its tributaries. They have a tendency to deposit their sediment load further upstream on their alluvial fans.

The changes in the channel's morphology have not remained without influence on the habitat in the canyon bottom. The riparian vegetation in the pre-dam period had an area of 27 ac (*Populus fremontii*/*Juniperus monosperma* community) in the study area whereas in 1991 it had reached an extent of 40.2 ac and *Salix exigua* had become the dominant species. The *Salix* community must be evaluated as a valuable habitat especially against the background that riparian habitats keep on vanishing in the Southwest due to river regulation. With the future growth of the sediment delta upstream in White Rock Canyon new damp mud areas will be established that seem to be an ideal growth medium for *Salix exigua*. Chances are that the new riparian habitat will extend upstream recolonizing part of the barren landscape in White Rock Canyon which resulted from the high water levels in the past.

I hope this brief summary will help you make use of the GIS coverages. It is very unfortunate that university policies made me write the thesis in German. But I hope that the maps and tables are somewhat self-explanatory.

If you have any problems with the coverages or if you need any more detailed translations of parts of the study, please, let me know. I have not found any time to give you a more detailed abstract at the moment because I am in the middle of my final exams.

Best wishes to you.

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Schriftliche Hausarbeit zur Zulassung zur
ersten Staatsprüfung für das Lehramt an Gymnasien
in Bayern nach der LPO I

Prüfungstermin: Herbst 1998
Prüfungsort: Universität Regensburg

**Eine qualitative Untersuchung der raum-zeitlichen Entwicklung der
Flußmorphologie des Rio Grande im White Rock Canyon,
New Mexico (USA) infolge der Errichtung der Stauanlage *Cochiti Dam***

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Fächerverbindung: Geographie/ Anglistik
10. Fachsemester

Vorgelegt im Januar 1998
bei
Prof. Dr. Toni Breuer