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Metamorphosis of the Oconee River in the Georgian Coastal Plain, 1805~1973.**

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1. Introduction.

The various effects of human activities on the landscape have been given great attention during the last decade. Concern over the environment has led to a flood of publications in environmental geomorphology[1]. As the human population has grown and human activities have alterd the landscape for cultural purposes, man as a gemorphical agent has been of interest and concern to geographers. Young(1980) showed from a study of Loch Moy Inverness-shire that man-induced change in one country is equal to natural changes in the entire post-glacial period[2]. In this context, a new term 'cultural geomorphology' has been widely used in recent times.

The nature and magnitude of human influence upon the rate of erosion and drainage basin dynamics have attracted a considerable amount of attention. Many aspects of man-induced landform changes, however, have not received proper attention, because the extent of human impact is highly variable. River metamorphosis due to human impact is highly variable and it is

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** This paper was originally prepared for Seminar in Geomorphologhy in 1982, University of Georgia, U.S.A. The author wishes to thank Dr. Brook, author's major professor, for his useful comments and encouragement.
1) Park, C.C., 1977, "Man-induced changes in stream capacity" In Gregory, K.J. (ed), *River Channel Change*, John Wiley & Sons, New York, pp. 121~144.
2) Young, J.A.T., 1980, "Nineteenth century flood protection schemes around Loch Moy, Inverness-shire", *Scottish Geographical Magazine*, vol. 96, pp. 166~72.

controlled by many variables. Man-induced channel changes are of two basic types-direct and indirect: changes in rates of erosion due to landuse changes are direct changes, flow regulation by a dam is a cause of indirect changes[3].

The Oconee river has experienced significant channel change, during the last 200 years, that have been brought about by the cultural activities of man. During the cotton plantation era(1860~1920), the average depth of soil loss in Georgia has been estimated as 7.5 inches. A considerable amount of sediment accumulated on the channel bed and caused it to be elevated. Such evidences are well documented in Trimble(1974)[4]. After the cotton plantation era, the Oconee river basin has been managed in low erosive land use. In 1953 the Sinclair reservoir was constructed and in approximately 1980 the Oconee reservoir was built. Flow control by these dams has indirectly influenced the lower part of the Oconee river channel.

In this paper the metamorphosis of the Oconee river is examined by historical and descriptive methods. Sinuosity and channel width are measured and descriptive model of island development is built.

2. Literature review.

Gregory(1977) has classified the history of river channel study into four phases:(i) suspected changes before 1900, (ii) assumed changes during the Davisian era, (iii) measurement of channel changes after 1945, and(iv) predicted changes since 1970[5]. The study of assumed changes was based upon the Davisian cyclic progression of landscape evolution.

The measurement of channel change was motivated by the Hortonian channel ordering system. Since this phase of investigation river channel studies have been conducted alongside hydrological studies. During the last decade, "one of the most outstanding problems has been to distinguish between evolutionary seiquences of change and adjustment inspired by direct and indirect human activities".[6] The main activities of man that causes river channel changes are agricultural activities, dam construction, deforestation, afforestation, road construction, and urbaniztion. These phenomena can be categorized as(i) changes in sedimentation and(ii) changes in river regime.

Wolman(1967) showed from studies in the Maryland Piedmont that sediment yield is closely related with land use[7]. He found that the sediment yield from a forested area in the pre-farm era was less than 100 tons/sq. mi./year. The sediment yiel from agricultural land ranges from 300 to 800 tons/sq. mi./year, that from an area exposed during construction exceeds 100,000 tons/sq. mi./year. Trimble(1974) argued that a tremendous amount of sediment washed into the Oconee river during the cotton plantation era totally altered the

3) Park, op. cit., footnote 1, pp.121~144.
4) Trimble, S.W., 1974, *Man-induced Soil Erosion on the Southern Piedmont 1700~1970*, Dept, of Geogr. Univ. of Wisconsin, Milwaukee,
5) Gregory, K.J., 1977, "The context of river channel change." In Gregory, K.J. (ed), *River Channel Change*, John Wiley & Sons, New York, pp.1~12.
6) Gregory, op. cit., footnote 5, pp.1~12.
7) Wolman, M.G., 1967, "A cycle of sedimentation and erosion in urban river channels," *Geografiske Annaler*, 49(A), pp.385~395.

morphology of the river[8]. After cotton plantation era the turbidity of the Oconee river dropped markedly.

Naddler and Schumm(1980) have shown that straight, wide, braided, and intermittent channel pattern changed into narrower and sinuous channel due to climatic change, land use change, and flow regulation over a period of 150 years[9].

One of the most significant changes man can make to a river is the construction of a dam. The consequencies of dam construction for alluvial morphology has been the subject of increasing attention and the detailed effects continue to be elaborated. Mansue et al. (1974) have shown that reservoir construction reduced sediment discharge by 20% in the Stony Brook Basin, New Jersey[10]. The Glen Canyon Dam constructed in 1963 induced a four fold reduction in peak discharge. Approximately 25% of the alluvial fans along the Grand Canyon were noticeably enlarged between 1964 and 1973, because there were considerable differences in sediment transport capacity[11].

Channel processes are so complex that the significance of individual events is not easily isolated. Processes are usually investigated over long periods. Mosely(1980) concluded that 90% of variability in the determinate character of channel morphology can be explained by dominant discharge, bed sediment discharge, and bank sediment character, while only 30% of the variability in the braiding index and sinuosity could be accounted for by indices of hydrologic regime and sediment characteristics[12]. He also argued that the hydrologic geometry would be only semi-determinate, because of the influence of flood plain vegetation, its root, network characteristics, variation in bank materials, and boundary effects.

3. Study area, methods, and data sources.

The study area is located in the Lower Coastal Plain of Georgia. The investigated stream reaches(Region A and Region B) make boundaries among Laurence County, Wheeler County, Montgomery County, and Treutlen County(Fig. 1). Flood plains of 1~2 mile wide in Region A and 2~4 mile wide in Region B are well developed along the channel reaches. There are numerous evidences of former channels, including oxbow lake, over the flood plains. The Oconee river shows perennial richness in suspended load. The main reasons for choosing this area for study are: (i) relative absence of man-made structures except 57 Ga. Highway bridge, (ii) the longevity of hydrological data, and (iii) available data and maps from U. S. Army Corps of Engineers.

Channel processes are so complex that such studies are commonly applied to phe-

8) Trimble, op. cit., footnote 4.
9) Nadler, C. T. and Schumm, S. A., 1981, "Metamorphosis of South Platte and Arkansas Rivers, Eastern Colorado," *Physical Geography*, vol. 2, pp. 95~115.
10) Mansue, L. J. and Anderson, P. W., 1974, *Effects of Land Use and Retention Practices on Sediment Yields in the Stony Brook Basin, New Jersey*, Geol. Sur. Water-Supply Paper, 1798L.
11) Howard, H. D. and Dolan, R., 1980, "Geomorphology of the Colorado River in the Grand Canyon," *Journal of Geology*, vol. 89, pp. 269~98.
12) Mosley, M. P., 1981, "Semi-determinate hydraulic geometry of river channels, South Island, New Zealand," *Earth Surface Processes*, vol. 6, pp. 127~38.

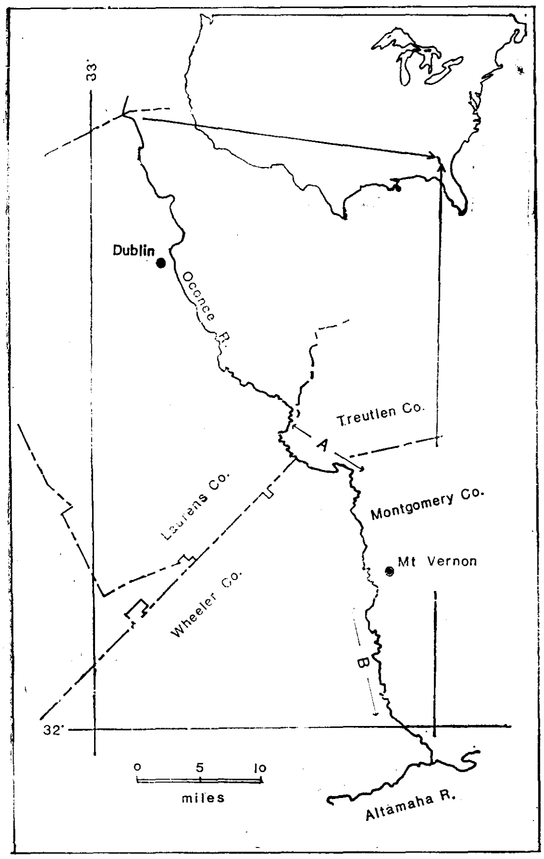

Fig. 1. The Study Area.

nomena of a long time period. The techniques applied in this paper are historical methods. Sinuosity and channel width are measured. Hydrological data are analyzed in terms of extreme value statistics.

Data sources are 1805 plats of the Georgia Land Lottery System, 1910 maps at a scale of 1 : 10, 000 produced by U. S. Army Corps of Engineers, and 1973 topographic maps of a scale of 1 : 24, 000 based on aerial photographs taken in 1973. The Georgia Land Lottery was carried out in the early 1800's by the State of Georgia[13]. It composed a series of six Land Lotteries. This survey produced several million large-scale land maps and plats. Many plats include the major natural or artificial features, such as large trees, major rock outcrops, swamps, and drainage features. The Oconee river was an important land lot boundary. In this work it has been assumed that the 1805 plats show the position of the Oconee river channel relatively accurately, although channel widths may not be accurate. The 1805 plats of the Land Lottery System have been used to locate the Oconee river channel in 1805 allowing measurements of channel sinuosity to be made.

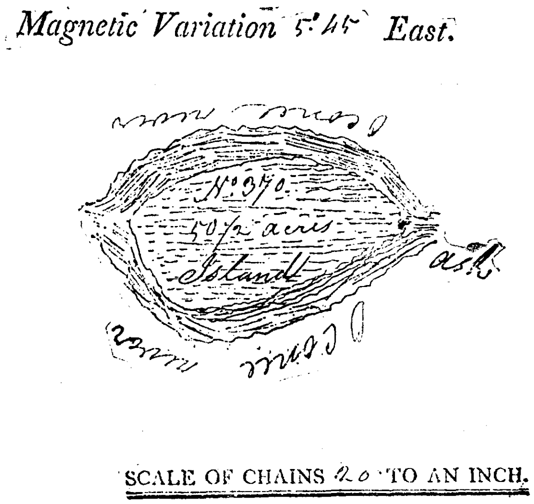

Fig. 2. Island depicted on plat Number 370, 1805.

The U. S. Army Corps of Engineers conducted a detailed river channel survey in 1910. The final maps were produced on 12 sheets at a scale of 1 : 10, 000. These maps are valuable for channel morphologic studies. They include channel depths(especially along tal weg), sand bars, and vegetation on the flood plains. Measurements of sinuosity and channel widths in 1910 were made from these maps.

1973 topographic maps were produced from

13) De Vorsey, L. Jr., "Early maps as a source in the reconstruction of southern Indian landscapes," in Hudson, C. M. (ed.), 1971, *Red, White, and Black: Symposium on Indians in the Old South,* South Anthropological Society Proceedings, no. 5, Univ. of Georgia Press, pp. 12'~30.

aerial photographs taken in 1973. Sinuosity and channel width were measured directly from these maps.

Hydrological data are available for the period 1903 to 1980 for Dublin and Mt. Vernon. The Dublin data were selected for statistical analysis, as this site is located just upstream of the study area.

4. River Metamorphosis

During the last 200 years there have been drastic channel changes in the Oconee river.

(1) Channel changes between 1805 and 1910

1805 plats show the channel morphology in the pre-cotton plantation era. Sinuosity is 1.15 in Region A. and 1.45 in Regoin B. According to Schumm's(1977) standard, these values are regarded as those of a bed load and mixed load type channel[14].

From the early 1800's to 1920 cotton cultivation caused a large volume of sediment to be transported to the streams. The river channel bed was raised and the channel developed in sediment layers. Sinuosity increased from 1.15 to 1.94 in Region A and from 1.45 to 2.11 in Region B.

The relationship between sinuosity and amount of sediment or characteristics of channel perimeter has been presented by Schumm (1963)[15]: the channel sinuosity(P) is a function of the percentage of silt and clay in the perimeter of the channel

$$P=0.94\ M^{0.25}$$

Sinuosity values of 1910 channels exhibit the channel type of mixed load suspended load. The percentage of silt and clay in the perimeter of the Oconee river channel can be estimated by Schumm's equation (Table 1). These values display that the percentage of silt and clay in the perimeter increased nine times in Region A and five times in Region B.

Table 1. Sinuosity of the Oconee River Channel 1805, 1910, and 1973.

Year	Sinuosity	
	Region A	Region B
1805	1.15	1.45
1910	1.94	2.11
1973	1.81	1.92

(2) Channel changes between 1910 and 1973

During this period, there were changes in sediment production and as well an in hydrologic regime. Erosive land use associated with cotton continued until 1920. After this there was a gradual decrease in sediment erosion, but there was still a high percentage of silt and clay materials in the channel perimeter(Table 2). As high sediment loads persisted the channel continued to be degraded[16]. Sinuosity decreased from 1.94 to 1.81 in Region A and from 2.11 to 1.92 in Region B. The decrease in sinuosity was mainly due to a decrease in sediment load and meander-cut. During this period 10 meander cuts occurred in both of Region A and Region B.

14) Schumm, S.A., 1977, *Fluvial System*, John Wiley & Sons, New York.
15) Schumm, S.A., 1963, "Sinuosity of Alluvial Rivers on the Great Plains", *Geologic Society of Amer. Bulletin*, vol.74, pp.1089~1100.
16) Mead, R.H. and Trimble, S.W., 1974, *Changes in Sediment Loads in Rivers of the Atlantic Drainage of the United States Since 1900*, Effects of Man on the Interface of the Hydrologic Cycle with the Physical Environment IAHS-AISH Publ. No.113, pp.99~104.

Table 2. The Estimated Percentage of Silt and Clay in the Perimeter of the Oconee River Channel 1805, 1910, and 1973.

Year	Region A	Region B
1805	2.24%	5.66%
1910	18.14%	25.39%
1973	13.75%	17.41%

The construction of the Sinclair reservoir in 1953 brought significant changes in the hydrologic regime of the Oconee river. The flood frequency curve before and after dam construction displays almost double reduction in 50% exceedance values. The extreme value, which is based on the probability of exceedance, is critical as determinate variable[17].

According to Schumm(1966)[18], the relationship between channel width, discharge, and the pecentage of silt and clay in the channel perimeter is defined as

$$\text{Channel width} = \frac{\text{Discharge}}{\text{\% of silt and clay.}}$$

The result of channel width measurements is consistant with Schumm's definition(Table 3). Maximum annual discharge, which is critical for channel geometry, decreased and

Table 3. Measurement of Channel Width(x) and its Standard Deviation(s).

Year	Region A	Region B
1910	n= 35 x=221.32 s= 50.29	n= 21 x=245.52 s= 44.62
1973	n= 21 x=213.75 s= 58.14	n= 21 x=221.32 s= 64.89
1910~1973	t=0.49< t54, .05=1.67	t=1.41< t40, .05=1.68

the percentage of silt and clay materials in the channel perimeter decreased by a relatively small amount. The channel width decreased from 221.32 ft to 213.75 ft in Region A and from 245.52 ft to 221.32 ft in Region B. However, the null hyphothesis can not be rejected at the 5% level of significance: the channel widths of 1910 and 1973 are not different statistically.

One of the most dominant changes in this period is sand bar development. Even on topographic maps of a scale 1 : 24,000, 13 newly developed large sand bars can be detected in Region A. It can be assumed that sediment transport capacity significantly decreased through dam construction.

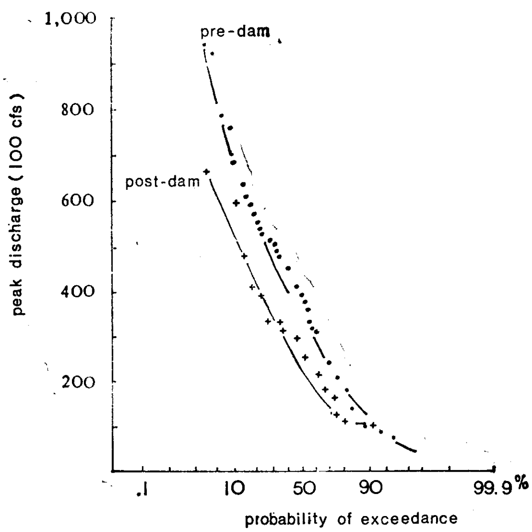

Fig. 3. Maximum annual discharge distribution of pre-and post-dam construction at Dublin.

Islands developed by meander-cut: 4 in Region A and 5 in Region B. Island is also effaced by channel filling. The sequence of island development and disappearance in this area is illustrated in Fig. 4.

17) Leopold, L.B., Wolman, M.G., and Miller, J.P., 1964, *Fluvial Processes in Geomorphology*, W. Freeman, San Fransisco.

18) Schumm, S.A., 1969, "River Metamorphosis," *Pro. Amer. Soc. Civ. Engrs. J. Hyd. Div.*, vol. 95, pp. 251~273.

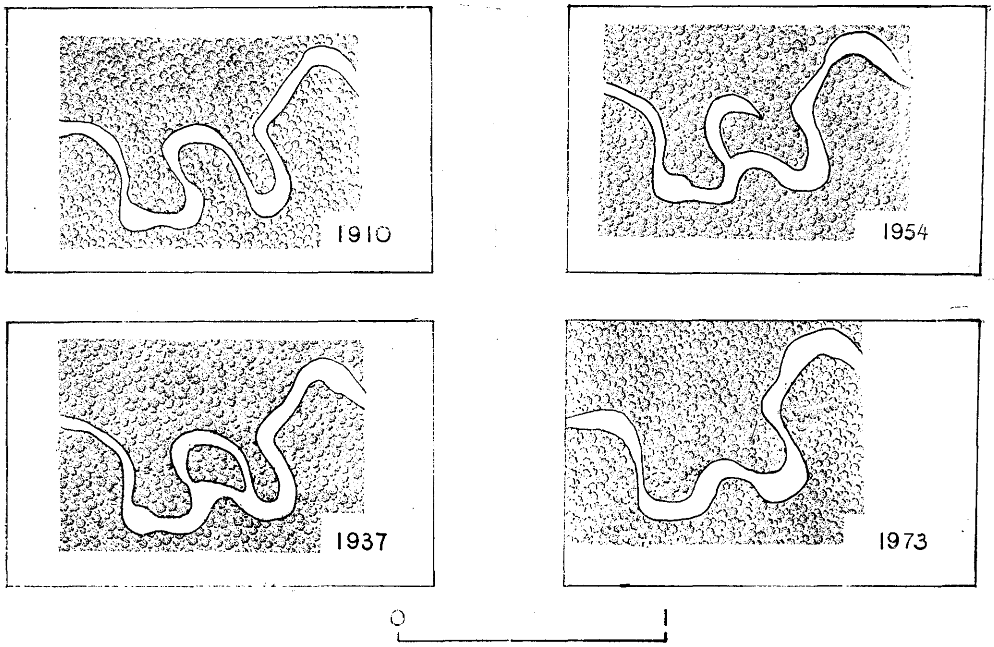

Fig. 4. Model of island development.

5. Conclusions.

During the last 200 years the Oconee river has experienced drastic channel changes due to the cultural activities of man. During the cotton plantation era(1960~1920), meanders developed and channel sinuosity increased from 1.15 and 1.45 to 1.94 and 2.11 respectively. The percentage of silt and clay materials in the channel perimeter can be estimated from the values of sinuosity; these values exhibit a five to nine times increase in silt and clay materials in the channel perimeter. The main reason for these changes is heavy sediment production owing to erosive land use.

After the cotton plantation era, erosive land use decreased, but heavy sediment transport has still continued even today. The gradual decrease in sediment load and reduction in sediment transport capacity have been brought about by construction of the sinclair reservoir and the Oconee river has continued to change: sinuosity has decreased from 1.94 and 2.11 to 1.81 and 1.92 respectively, islands have developed, and there has been substantial growth of sand bars.

오코니 江의 河道變化

국문요약 ;

柳　根　培*

지난 200年(1805~1973)동안, 美 Georgia의 오코니江은 人間의 多樣한 文化活動으로 顯著한 變化를 보여왔다. 本 硏究에서는 1805년에 Land lottery system의 기초자료로서 發刊된 Sketch map, 1910년에 發行된 美工兵團의 1 : 10,000 寫眞地圖, 1973년에 發行된 1 : 24,000 地形圖를 通하여 오코니 江의 河道變化를 分析하였다. Cotton Plantation 期間(1860~1920)동안, 土壤流失이 극심하고, 河川은 過重한 苛重을 부담하였다. 이 기간동안의 토양유실은 平均 7.5 인치에 이르렀다. 河川堆積物의 急增은 河道의 뚜렷한 變化를 招來하였던 바, channel sinuosity는 硏究地域 A에서는 1.15에서 1.45로, 硏究地域 B에서는 1.94에서 2.11로 各各 增加하였다. Schum (1963)의 公式에 따라 推定되는 channel perimeter의 silt와 clay의 함유율은 5倍에서 9倍의 增加를 보였다.

Cotton Plantation 期間이 지난후, 流失可能性이 높았던 土地利用은 줄어들었으나, 河道에 累積되었던 過重한 堆積物은 現在에도 계속 運搬되고 있다. 1953년 Sinclair Reservoir가 건설되어 洪水流量이 調節되면서 오코니江은 또다른 樣狀의 變化를 보여 왔다. 流量調節은 50% exceedance value를 半減시켰고, 河川의 運搬能力을 현저하게 저하시켰다. channel sinuosity는 硏究地域 A에서는 1.94에서 1.81로, 硏究地域 B에서는 2.11에서 1.92로 各各 減少되었고, meander-cut을 通하여 많은 island가 發達되어 왔다.

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