CAPTURING THE GREEN RIVER -- MULTISPECTRAL AIRBORNE VIDEOGRAPHY TO EVALUATE THE ENVIRONMENTAL IMPACTS OF HYDROPOWER OPERATIONS

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The 500-mile long Green River is the largest tributary of the Colorado River. From its origin in the Wind River Range mountains of western Wyoming to its confluence with the Colorado River in southeastern Utah, the Green River is vital to the arid region through which it flows. The diverse geological and ecological setting that it traverses includes deep canyons and broad floodplains with extensive bottomlands. Large portions of the area remain near-wilderness with the river providing a source of recreation in the form of fishing and rafting, irrigation for farming and ranching, and hydroelectric power. In the late 1950's and early 1960's hydroelectric facilities were built on the river. One of these, Flaming Gorge Dam, is located just south of the Utah-Wyoming border near the town of Dutch John, Utah (Figure 1). Flaming Gorge Dam was completed in 1963 forming Flaming Gorge Reservoir which filled by 1974. The dam is used to provide water storage for irrigation, flood control, and for hydroelectric power generation.

Hydropower operations result in hourly and daily fluctuations (Figure 2) in the releases of water from the dam that alter the natural stream flow below the dam and affect natural resources in and along the river corridor. These fluctuations can be detected in the river downstream for well over 100 miles (Figure 3). Below the dam the river runs through wild country including Red Canyon and Browns Park, a well known hideout for outlaws in the "Old West". The river then enters Colorado for a short distance and flows through the Browns Park National Wildlife Refuge. It returns to Utah and enters Dinosaur National Monument where it runs through the Canyon of Ladore, Echo Park, Whirlpool Canyon, Island Park, and Split Mountain.

The environmental impacts of fluctuating flows on river and its resources are an important concern. The Green River supports a blue-ribbon trout nursery and serves as one of the last refugia for several endangered fish species native to the Colorado River Basin (Figure 4). Fluctuating flows may adversely affect native and endangered fishes by alternately draining and flooding their backwater nursery habitats. Trout populations may be adversely affected if nearshore substrates, such as gravel beds, that contain spawning areas are exposed during low water releases. Similarly, high releases may inundate shoreline vegetation and prevent or reduce seedling germination and the establishment of riparian vegetation which serves as habitat for terrestrial wildlife.

In the present study, we were interested in evaluating the potential impacts of hydropower operations at Flaming Gorge Dam on the downstream natural resources. Considering the size of the area affected by the daily pattern of water release at the dam as well as the difficult terrain and limited accessibility of many reaches of the river, evaluating these impacts using standard field study methods was virtually impossible. Instead an approach was developed that used multispectral aerial videography to determine changes in the affected parameters at different flows, hydrologic modelling to predict flow conditions for various hydropower operating scenarios, and ecological information on the biological resources of concern to assign impacts.

MULTISPECTRAL AERIAL VIDEOGRAPHY

Aerial videography is a method of collecting remotely sensed imagery using video technology. As in aerial photography, the imagery is collected by flying over the area of concern, but in this case video cameras are used to record the ground reflectance. For multispectral videography multiple video cameras with radiometers that are sensitive to different bands of the electromagnetic spectrum are used. The video images are electronically captured in a format usable by image processing GIS systems such as Erdas. The resolution of the images depends on the elevation of the aircraft, but is typically in the one to two meter range, a good resolution for determining changes in the extent of water and riparian areas. In contrast to aerial photography the video tapes are available for viewing and analysis immediately upon completion of the collection flight.

VIDEOGRAPHY DATA ACQUISITION

For this study three-band multispectral videography was collected using a video/radiometer remote sensing system developed by Utah State University (Neale, 1992). Three video recorders mounted on a fixed-wing aircraft recorded ground reflectance for the green (0.55 um), red (0.65 um) and near-infrared (0.85 um) portions of the electromagnetic spectrum. These bands were similar to Landsat Multispectral Scanner (MSS) red, green, and infrared bands that are extensively used for determining vegetation classes.

Multispectral videography was collected for several sample sites along about 100 miles of the Green River extending from the dam to beyond Split Mountain in Dinosaur National Monument (Figure 1). The river was videotaped in May and early June of 1992 under four different controlled release conditions at Flaming Gorge Dam thereby providing a record of the river under different flow conditions. Videotaped portions of the river included both canyon and bottomland areas. Releases from the dam during the data collection flights ranged from approximately 4000 cfs to 800 cfs.

IMAGE CAPTURE OF REMOTELY SENSED DATA

A video processing system was assembled to view the video tapes and capture imagery from the tapes. Components of the system included a Compaq Deskpro 386/25e with a VGA display and a Mitsubishi HC3925 Diamond Scan monitor, a non-interlaced, long persistence phosphor display for viewing video. A Targa+ frame grabbing board was installed to accept a composite signal from a Sony VC-9000 tape player. This tape player played 3/4" format video tapes and was connected via an RS-232C cable and interface to the computer. The Targa+ board was configured to grab a 32-bit, 512 x 486 pixel Targa format image. A FORA-300 Digital Time Base Corrector synchronized and corrected the signals from the monitor, frame grabbing board, and tape player. A Diaquest Series IIP frame sequencing unit with Action Animator software was used to capture series of images from the video tapes. About 30 images could be captured and stored on disk at one time.

The video tapes were previewed and specific river segments were identified for further analysis. A time code encoded on the audio channel #2 of each video tape was used to select and capture series of overlapping images that covered the river segments. Captured images from the red, green and near-infrared band videos were combined into composite three-band images and converted to an image format compatible with ERDAS image processing software.

DATA ANALYSIS

Following completion of image capture, there was a series of overlapping images for each river segment at four flows. The next step in the process involved preparing non-overlapping images from which the total surface water area, backwater size and abundance, and riparian zone could be determined (Figure 5). For this analysis, the riparian zone was defined as the area between the water's edge and the lower boundary of the upland zone where plants adapted to drier conditions predominated. The low (800 cfs) flow images were displayed with ERDAS software and the upper boundary of the riparian area was digitized. During this process the images were cropped at the upstream end to remove overlapping areas.

Supervised classification algorithms available in the Erdas software were then applied to the multispectral images to classify water and riparian areas. For the higher flows only the water areas were classified. The area of the riparian zone at the higher flows was estimated by subtracting the increase in water surface area from the riparian area at low flow. The images were scaled using panel markers that were placed at preselected locations along the river. Backwaters were identified on each image and digitized at all flows. Summaries of total surface water area, area of riparian vegetation, and backwater size and number were compiled for each river segment and used to formulate the relationship between these parameters and flow.

CONCLUSIONS

Multispectral aerial videography allowed us to rapidly collect detailed ground information over a large, remote area of river. This information was collected over a total of 4 days, with only 6 researchers in the field. The relationships developed between ecological parameters and flow proved to be extremely useful in assessing the environmental impacts of hydropower operations at Flaming Gorge Dam. Comparisons of similar river segments under different flow conditions provided a unique view of changes that occur in the river corridor for these flows (Figure 6).

Multispectral aerial videography offers a relatively inexpensive means of obtaining remotely sensed data at mid-range resolutions. The multispectral quality of the data lends itself to classification of vegetation parameters important in ecological analyses and is extremely useful in determining the extent of water area.

While much of the effort involved in capturing and compositing images from the separate video tapes for each spectral band has been automated, these tasks are still time consuming and computer intensive. New video recording system are currently being developed that capture digital image data directly, eliminating the need to capture images from videotape. There are also new cameras that record data for multiple spectral bands simultaneously, eliminating problems encountered in compositing the separate single band images. As these devices become more readily available, capturing the Green River and other natural environments for analysis will be an increasingly useful method of quantify natural resources and evaluating environmental impacts.

ACKNOWLEDGMENTS

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REFERENCES

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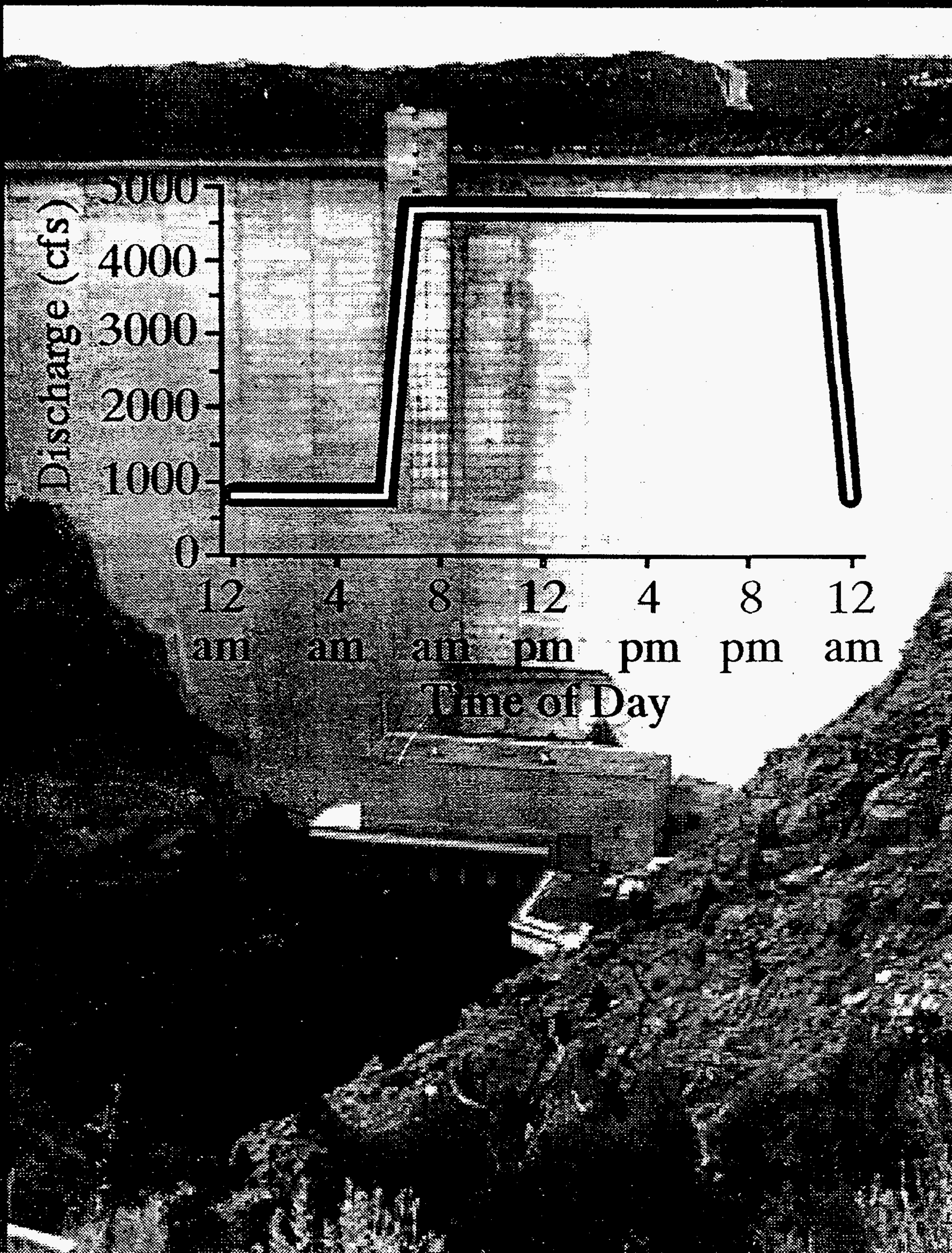
Daily Fluctuations in Discharge



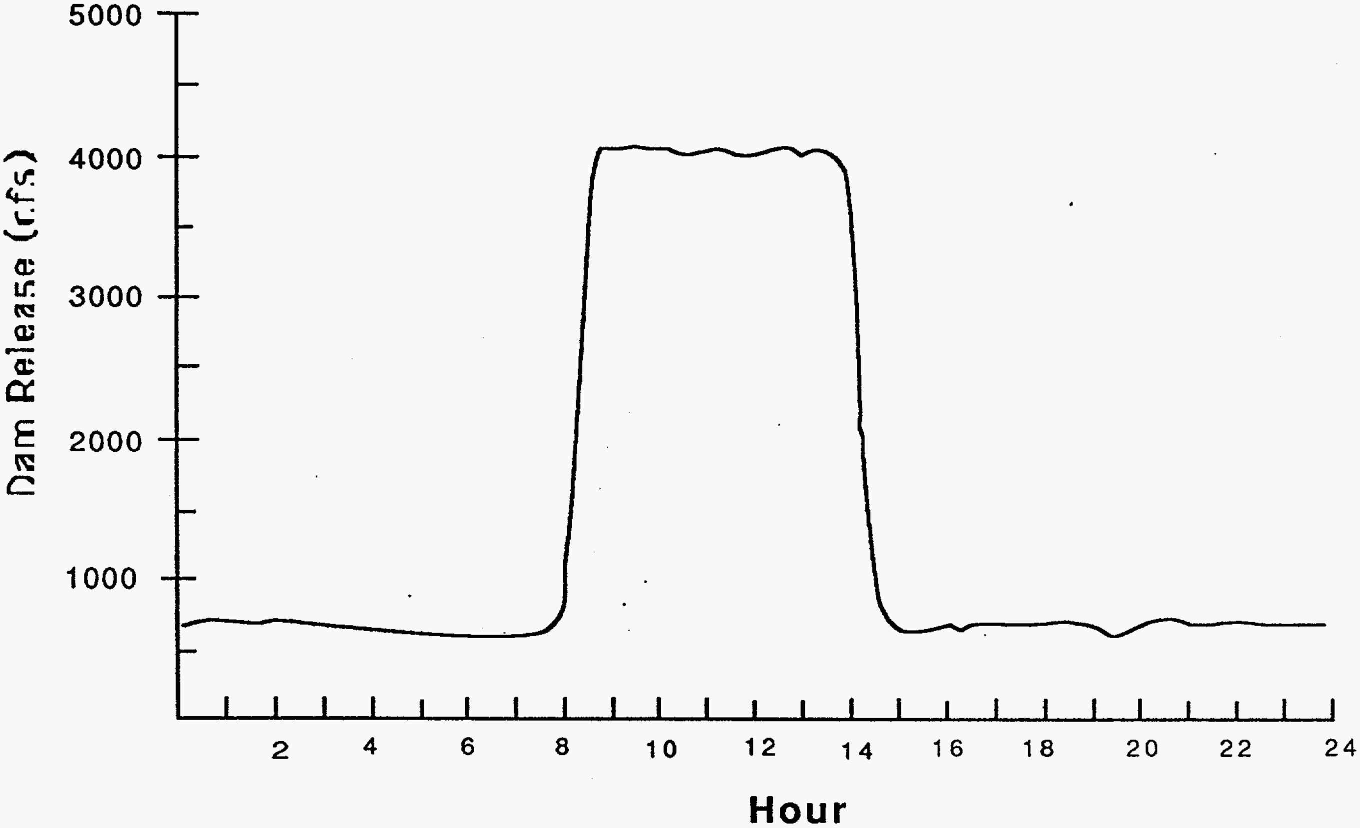
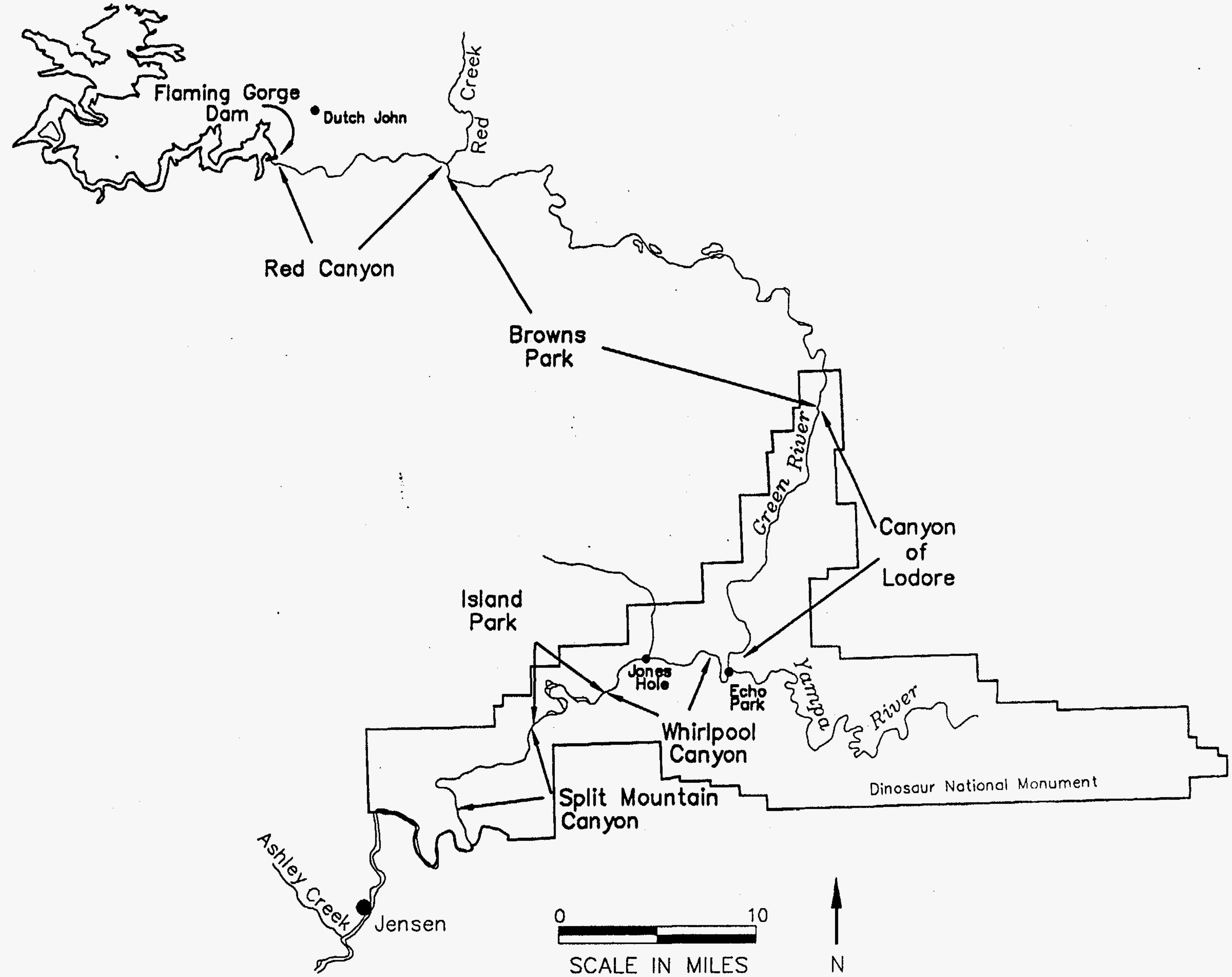


Figure 2. Typical daily water release pattern for hydropower generation.


Flaming Gorge Dam
Dutch John
Red Creek
Red Canyon
Browns Park
Green River
Canyon of Lodore
Island Park
Jones Hole
Echo Park
Yampa River
Whirlpool Canyon
Split Mountain Canyon
Dinosaur National Monument
Ashley Creek
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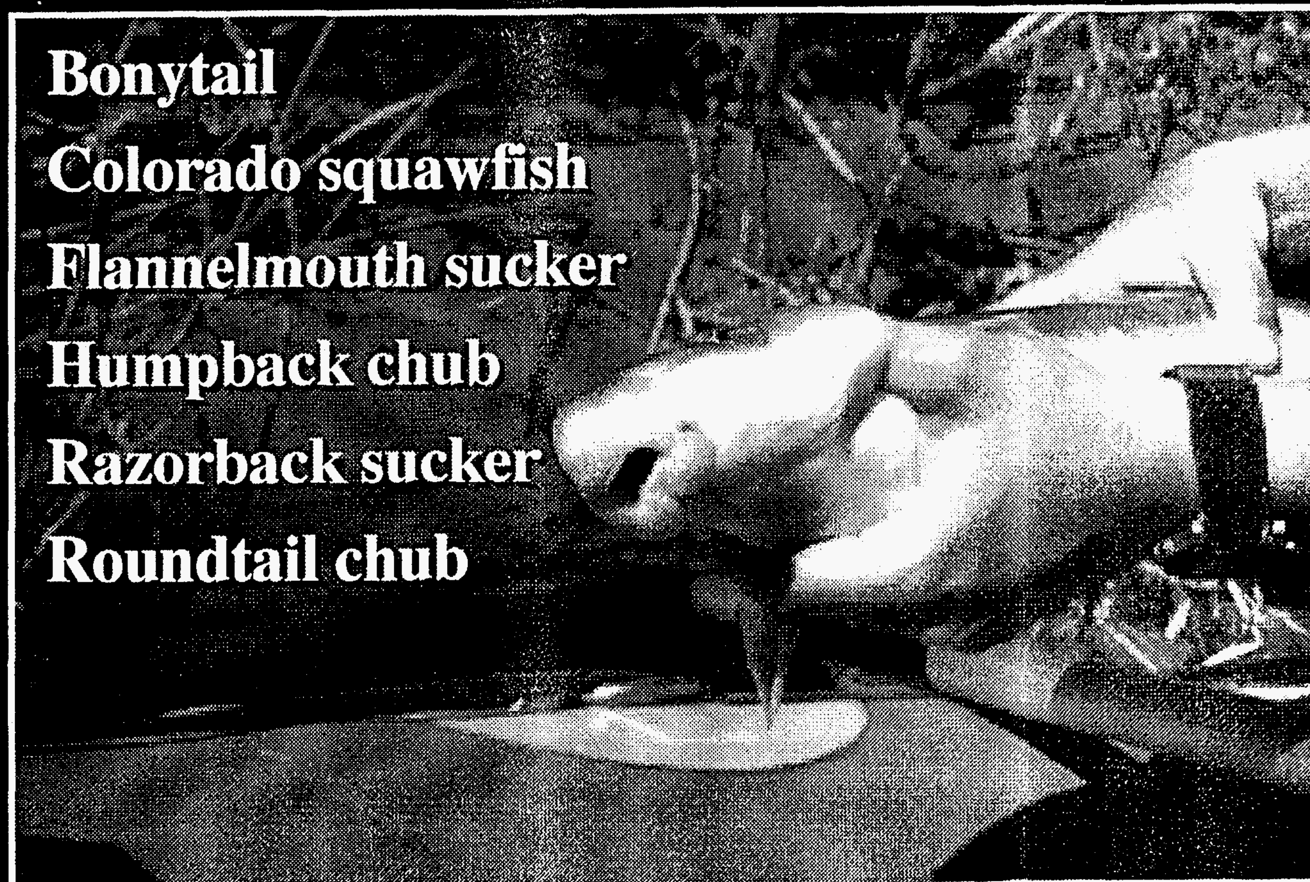

Water and Land Resources Are Quantified from the Video Images