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Application of Thermal Infrared (FLIR) and Visible Videography to the Monitoring and Restoration of Salmonid Habitat in the Pacific Northwest

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ABSTRACT

The focus of this project is the application of thermal infrared and visible videography to the monitoring and restoration of riparian areas important for rare and endangered species of salmonids in the Pacific Northwest. Basin and reach-level patterns of water temperatures within ranges critical to salmonids can be described using imagery acquired with an airborne Forward-Looking Infrared (FLIR) thermal scanner. Thermal infrared and visible videography of over 1500 kilometers of rivers and streams in the Pacific Northwest was collected from a low-flying helicopter during late-summer in 1995. A longitudinal profile of average stream temperature is presented for a 60 km section of the Middle Fork of the John Day River, Oregon. Through the use of a global positioning system, data derived from both thermal infrared and visible videography can be linked to other spatially-explicit data layers in a geographic information system (GIS). Once in a GIS, these data become readily available to land managers and policy makers involved with monitoring and restoration efforts.

INTRODUCTION

Water temperature is of critical concern for the survival of spring-run chinook salmon (Oncorhynchus tshawytscha) in the Pacific Northwest. The water temperature optima for the migration, holding, and spawning life history phases of spring-run chinook salmon are estimated to be 7-16 °C, 8-13 °C, and 6-12 °C, respectively (McCullough 1993). The migration of adults is effectively blocked by water temperatures greater than 21 °C, and the upper limit of water temperature for suitable habitat is 24 °C (McCullough 1993). Summer water temperatures in eastern Oregon, Washington, and Idaho frequently exceed thermal tolerance zones for spring-run chinook and other salmonids.

Recent work using a forward-looking infrared (FLIR) scanner to assess water temperature patterns on tributaries of the John Day River in Oregon suggests that spring-run chinook respond to local differences in stream temperature (Torgersen 1996, Torgersen et al. 1995). This pattern of behavior was particularly pronounced in areas where summer water temperatures exceeded critical thresholds. Describing how water temperatures vary over multiple scales is, therefore, central to monitoring and restoring salmonid habitat in the Pacific Northwest.

Thermal infrared and visible videography of over 1500 kilometers of eight Pacific Northwest river systems important for salmonids was collected during late-summer in 1995 from a low-flying helicopter. Sections of the following river systems were sampled: Asotin Creek (WA), Grande Ronde River (OR), Imnaha River (OR), John Day River (OR), Lolo Creek (ID), Tucannon River (WA), Umpqua River (OR), and Yakima River (WA). Results from the upper 60 km of the Middle Fork of the John Day River (OR) are presented in this paper.

METHODS

Thermal infrared and visible videography were collected for the upper Middle Fork of the John Day River between approximately 13:40 and 14:20 on August 25, 1995. An Agema 1000 FLIR vertically mounted on the underside of a helicopter was used to acquire thermal infrared data within a 5-55°C temperature range as grayscale imagery. A color video camera (visible spectrum) bore-sighted with the FLIR was used to record simultaneous visible spectrum data. The videography was collected from an altitude of 425 meters above the ground which provided an image swath width of 150 m.

The thermal infrared and visible data were recorded in S-Video format on separate Hi-8 video tapes. Individual frames in the thermal infrared and visible video tapes were labeled in-flight with identical SMPTE time code stamps. Additionally, the longitude and latitude of the helicopter calculated by an on-board global positioning system (GPS) were recorded at one second intervals on the sound track of both the thermal and visible video tapes using a Horita GPS3 SMPTE time code generator/reader. These coordinates and the corresponding SMPTE time code were extracted post-flight and written to an ASCII file using the Horita system. This enabled digitally captured frames from both the thermal and visible video tapes to be integrated with spatially-explicit data layers in the Arc/Info and ArcView geographic information systems (GIS).

Digital images with ground resolutions (or pixel size) of 25-30 cm were captured post-flight from the analog video tapes using a TARGA+ digitizing board and a DiaQuest video animation controller. In the captured grayscale thermal images, 256 shades of gray (0-255) corresponded linearly to the temperature range of 5-55°C. These digital images were processed by using custom Arc/Info Arc Macro Language programs to 1) convert the thermal images to Arc/Info GRIDs containing the corresponding temperature values in degrees Celsius, and 2) color-code the thermal GRIDs to display and visually enhance temperature differences, enabling the user to extract stream temperature data. The primary uses of the visible videography in this study were to identify channel characteristics associated with cold-water areas and differentiate between land and water surfaces in the thermal imagery.

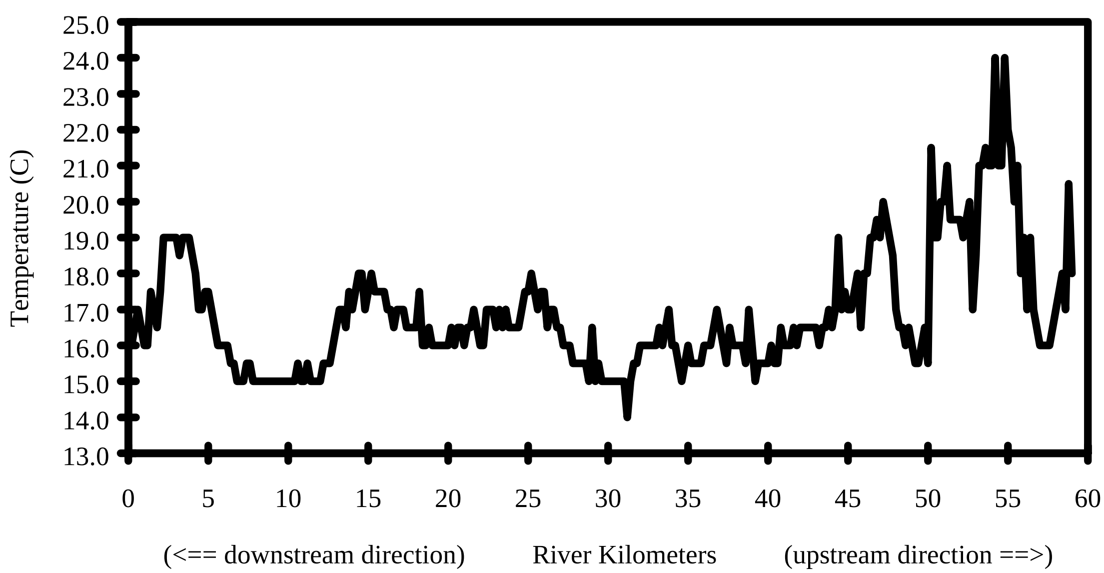
In order to describe the overall pattern of water temperature for the 60 km study section of the Middle Fork of the John Day River, a longitudinal profile of average stream temperature was generated by classifying and examining thermal image frames extracted at 200 m intervals.

RESULTS AND DISCUSSION

The average stream temperature profile for the Middle Fork of the John Day River indicates that the pattern of water temperature was highly variable (Figure 1). Interestingly, the highest average water temperatures were observed at the upstream end of the 60 km study section (right side of Figure 1). Certain downstream temperature decreases can be explained by cold-water inputs from cooler tributaries (e.g., the confluence of Clear Creek at river kilometer 50). The rapid increase in average stream temperature from river kilometer 50 to river kilometer 47 is, presumably, due to the rapid mixing of the cooler tributary water with the warmer water of the main stream channel.

Other downstream temperature decreases may be the result of relatively cool groundwater seeping into the main stream channel. For example, the gradual downstream decrease in stream temperature from river kilometer 45 to river kilometer 40 occurs in a relatively wide and unshaded valley. Although a downstream <u>increase</u> in stream temperature is normally associated with a lack of vegetative shading, we hypothesize that the observed downstream temperature <u>decrease</u> is due to progressively increasing amounts of relatively cooler groundwater flowing into the main stream channel.

Figure 1. Middle Fork John Day River Average Stream Temperature
(August 25, 1995)



CONCLUSION

Describing stream temperature patterns is of critical importance in the monitoring and restoration of salmonid habitat in the Pacific Northwest. Aerial thermal infrared videography is an effective way to describe the spatial variability of stream temperature patterns. By providing a continuous spatial record of stream temperature, thermal infrared videography can complement more traditional in-stream temperature data-loggers which provide a continuous temporal record of stream temperature. Through the use of a global positioning system, data derived from both thermal infrared and visible videography can be linked to other spatially-explicit data layers in a geographic information system. Once in a GIS, these data become readily available to land managers and policy makers involved with monitoring and restoration efforts.

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