TRINITY RIVER RIPARIAN VEGETATION MAPPING - GIS

FINAL REPORT - PREPARED FOR:

Wildlife Task Group

Trinity River Restoration Project

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ABSTRACT

This project proposed to describe the impacts of reservoir filling and downriver flow release management on riparian vegetation along the Trinity River. A Geographical Information System (GIS) was used to map the riparian vegetation using pre- and post-dam aerial photos. Acreages of different riparian vegetation types were determined for comparison. Wildlife data collected during 1990's Trinity River Wildlife Survey were entered into the GIS and used to generate spatial attribute profiles, showing different species abundances and distributions along the river. The final product is a permanent record of vegetation along the Trinity River before the dam was completed (1962) and recently in 1989; as well as wildlife abundance and distribution from 1990.

INTRODUCTION

The construction of Trinity and Lewiston Dams on the Trinity River has resulted in major changes in the riparian zone below the dam sites. These changes are due to diversions of historic flow volumes and regulation of the existing releases to divert water to central and southern California. The riparian habitat has responded to these shifts in flow regime with changes in acreage, species composition and the average age of willow stands. Before the dam, annual spring floods scoured the river bottom and kept associated riparian vegetation at an early successional stage (i.e. small willow dominated). Post-dam conditions reveal a tremendous expansion and encroachment of riparian vegetation. Evans (1980) found an over 300 percent increase in riparian vegetation between 1962 and 1978.

The stated goal of the Trinity River Restoration Project is to improve the fisheries, while maintaining riparian dependant wildlife habitat. During spring and summer of 1990, the Redwood Sciences Lab (USFS - PSW) began a study of wildlife abundance and distribution along the Trinity River (Wilson et al. 1991). Specifically, we examined associations between wildlife taxa and successional stages of riparian vegetation. Evans (1980) showed that 1980 riverine habitat was characterized by predominantly old, mature riparian (alder/cottonwood) near the dam, with early successional willow vegetation becoming more abundant further downstream. This he felt was caused by an increase in scouring flows from feeder creeks and streams as one moved downriver from the dam.

Our preliminary results showed that indeed, the increase in riparian vegetation since the dam's inception has provided a home for many riparian dependent wildlife species. The yellow warbler and yellow-breasted chat (both California state "species of special concern"), are abundant and distributed throughout this section of the Trinity River, in both early and late successional riparian vegetation (Wilson et al. 1991). Habitat has been "improved" for many other species as well, including: beaver, river otter, mink, raccoon, common merganser, and adult western pond turtles. The above species appear to have benefited from the stable flows and increased abundance of mature riparian vegetation. Certain other wildlife species are known or suspected of being associated with early successional riparian vegetation (willow dominated and/or open gravel bars). Willow flycatchers (State-listed endangered) and foothill yellow-legged frogs (a Federal candidate and State-listed "species of special concern"), are two examples, and both were found in low numbers during our surveys. It is clear that managing for wildlife needs along the Trinity River will necessitate considerations for a wide variety of animal species, including rare and sensitive species with narrow habitat requirements.

The potential for conflict is apparent in regards to restoration projects for fisheries enhancement and wildlife needs. To enhance fish habitat, it has been proposed that feathering projects be undertaken to widen sections of the stream channel, providing more shallows for fish fry (C. Lane pers. comm., P.O.Box 1450, Weaverville, 96093). These feathering projects would also create conditions for early successional, willow-dominated riparian vegetation, which may benefit species like the willow flycatcher and foothill yellow-legged frog. However, mature riparian vegetation may be removed during these projects, potentially affecting wildlife species associated with it. Determining which sections of river could be feathered to benefit fisheries and early successional wildlife species, while minimizing habitat loss for other wildlife is one potentialuse of this GIS database.

OBJECTIVES

The overall goal for this GIS was to establish an efficient and effective spatial data management system to support monitoring and assessment of the Trinity River's ecological resources. To achieve this goal, this study addressed two primary objective:

OBJECTIVE I. To create a database using GIS for analysis and management of riparian vegetation and associated wildlife species along the Trinity River.

Task A. Map into GIS and quantifgy the historical distribution and composition of riparian vegetation prior to building of the dams in the early 1960's.

Task B. Map into GIS and quantify the present distribution and composition of riparian vegetation along the Trinity River.

Task C. Compare pre- and post-dam riparian maps to quantify changes in riparian vegetation composition and acreage.

OBJECTIVE II. Produce maps of wildlife species abundances along a section of the Trinity River from the Lewiston Dam to the North Fork (the study section).

Task A. Using GIS, create a data layer of wildlife survey stations used during the 1990 wildlife studies.

Task B. Input wildlife abundance and distribution data from the 1990 wildlife survey into an attribute table.

Task C. Produce example maps of wildlife species abundances along the study section.

STUDY AREA

Our study area encompassed a 39 mile (63 km) stretch of the mainstem Trinity River from below Lewiston Dam downriver to the confluence with the North Fork of the Trinity River (hereafter called North Fork), in Trinity County, California (Fig. 1). Sixty percent of the land adjacent to the river along this stretch is managed by the Bureau of Land Management. The majority of the remainder is privately owned, with a small portion belonging to the U.S. Forest Service. The elevation of the river ranges between 420 and 550 meters. We divided the river into 16 unequal length segments, hereafter called Reaches, averaging 1.95 miles (3.14 km) in length, which were determined by boat launch access (Fig. 1). Actual length varied between 1.5 and 2.5 miles (2.41 and 4.02 km).

The dominant canopy tree species include Alnus rhombifolia (white alder), Salix lasiandra (yellow willow), and rarely Populus Fremontii (Fremont cottonwood) or P. trichocarna (black cottonwood). Sub-canopy tree and shrub species include Salix hindsiana (sand-bar willow) and Salix melanopsi. Understory species include Rubus snectabilis '(salmonberry), sedges (Carex spp.), rushes (Juncus spp.), horsetail (Eauisetum arvense), and various annuals. Evans (1980) defined four broad habitat types within the riparian zone: (1) bare rock or gravel bar, (2) willow dominant, (3) willow-alder mix and, (4) mature alder-cottonwood. The width of the riparian zone varies from 5 m to 50 m wide. The oldest and most mature riparian areas are closest to the dam because of the controlled flows and lack of flooding. Further

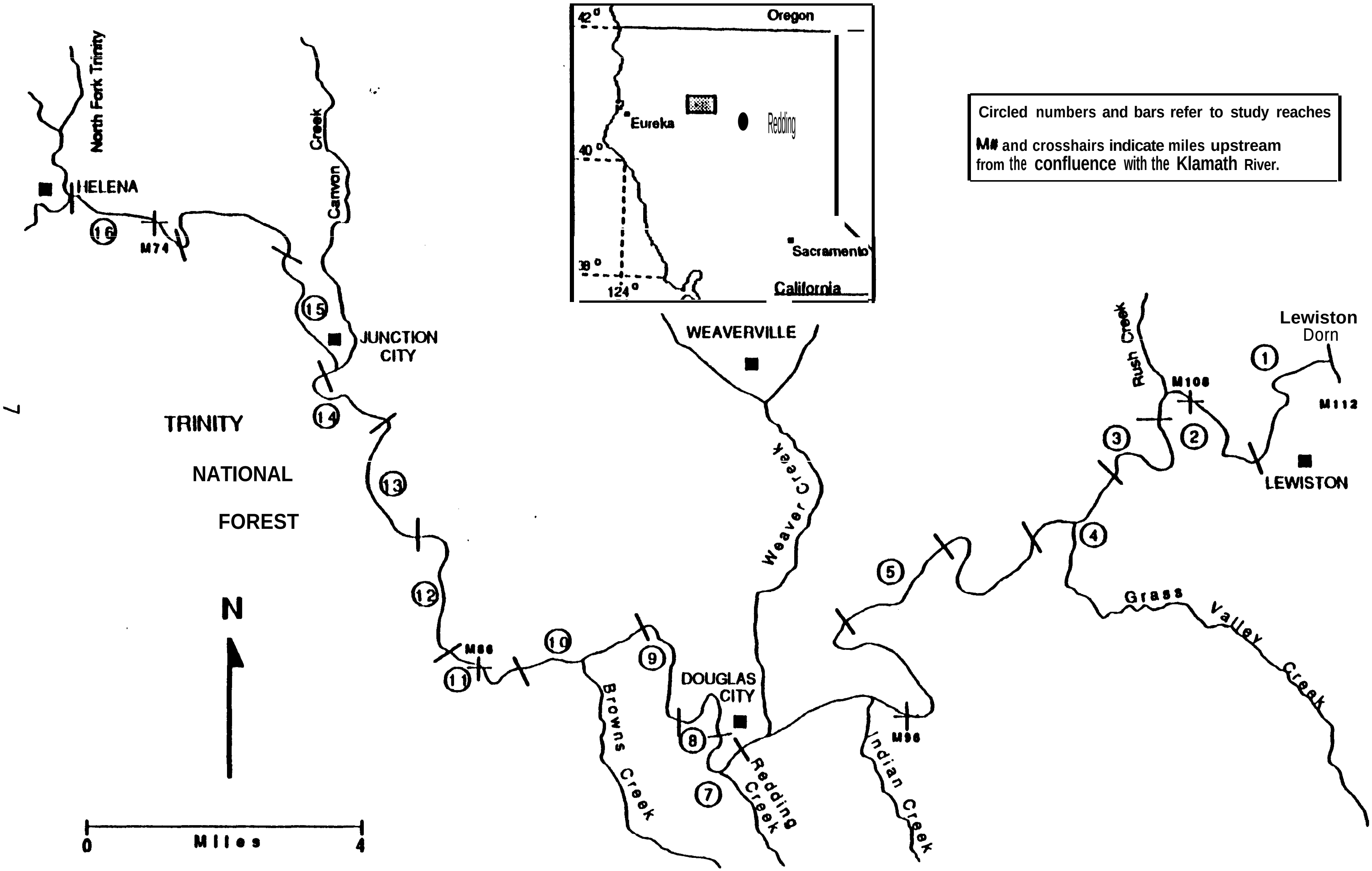

Figure 1. Location of study reaches along the maln fork of the Trinity River, Trinity county, California.

downstream, feeder streams contribute variable flows and create periodic flooding, resulting in some younger riparian vegetation. Mining tailings are extensive along the bottom third of the study area; some with scattered willows, and others barren of vegetation. Humans inhabit many areas along the floodplain, affecting wildlife community composition, distributions, and movements. The associated upland habitat may be categorized as montane hardwood-conifer on north facing slopes and montane hardwood on south facing slopes (Mayer and Laudenslayer 1988).

METHODS

There are three basic parts to this study and the methods for each will be discussed separately. The first two sections deal with mapping the riparian habitat from pre- and post-dam aerial photos, and creating vegetation polygon layers in a GIS. The third part of this project involves creating point coverages of survey stations with wildlife abundances attached as attributes.

Post-Dam Vegetation Layer

The general approach was to trace the riparian vegetation polygons from aerial photos onto mylar. These were then digitized into a GIS using Arc/Info software and became a vegetation data layer. Aerial photos taken during a flight in May, 1989 by the Bureau of Reclamation were used. These were flown at a scale of 1:6000 and provided very good resolution for identifying the difference between willow and alder vegetation. This flight was flown specifically for the Bureau to document what habitat adjacent to the main river course would be flooded during an artificially high water release of 2000 cfs. The aerial photos were xeroxed so that I could draw lines around identified polygons which represented different vegetation types. For continuity 'with Evans (1980) study, I used the same habitat characterizations: (1) willow dominated vegetation, (2) alder/willow mix, (3) mature riparian (alder/cottonwood), and (4) gravel bar, bare rock. Willow or alder dominant vegetation meant that greater than 2/3 of the canopy cover was comprised of willow or alder species. Prior to drawing polygons onto the zeroxed aerial photos, I field-proofed a sub-set of sites to make sure I could distinguish between willow dominant and alder dominant vegetation.

I used a stereoscope to effectively differentiate between willow and alder vegetation. Overlapping aerial photos were viewed in three dimension to differentiate the vegetation using plant height as well as color. I used different color pens to represent the different vegetation types, and traced the polygon boundaries onto the xeroxed aerial photos. Identifying willow dominant or ader dominant vegetation was fairly easy and I am confident about the accuracy of these designations. Willow/alder mix was a bit more difficult to discern. From the photo interpretation work, each polygon traced was given a riparian type designation. However, any that were uncertain were labeled as such to be field checked at a later date. After finishing the first pass of polygon tracing, I returned to the field to check questionable polygons and spot check the rest. Approximately 90 percent of the those that I was uncertain of were correctly classified. This field verification indicated that my interpretations from the air photos were correct.

The next step was to trace these identified polygons onto mylar for later digitizing. Because of differences in topography, aerial photos are not spatially correct and I was not able to trace directly from the xeroxed photos. "Spatially corrected" ortho-photos, taken in August,* 1989, were obtained from the U.S. Forest Service Regional Office in San Francisco, California. These ortho-photos were sent as 4 ft. by 6 ft. sheets that were enlarged to 1:6000 from the much smaller scale flight (1:24000); UTM coordinates were provided on two sides. The tracing of the vegetation polygons was done onto mylar layed over these ortho-photos. I used the xeroxed aerial photo polygon designations as a guide to accurate tracing. Between 4 and 10 registration tic marks (depending on the length of river traced) were uniformally spaced onto the mylar. Eight separate non-overlapping maps were developed to be digitized and later joined into one map covering the entire 39 mile section of river. For a thorough discussion of the GIS methods used in digitizing and editing the coverages see Appendix C.

Pre-dam Vegetation Layer

The following is a discussion of the techniques used to create the Arc/Info GIS polygon coverage of vegetation taken from aerial photos along the Trinity River during the year 1960, the year the Trinity and Lewiston dams were under construction. The 1960 coverage is not as accurate as the 1989 coverage. The primary reason is that it was not possible to ground truth my interpretation vegetation types from the aerial photos. In addition, the aerial photos in 1960 were flown at a scale of 1:15,480 compared to 1:6000 for the 1989 photos. As a result, though I am confident that I accurately identified the presence or absence of riparian vegetation along the river, I have less confidence in my ability to accurately discern whether the vegetation was willow, alder, or willow/alder mix.

Aerial photos taken during 1960 were obtained from both Weaverville and Big Bar Ranger Districts of the U.S. Forest Service which covered the same 39 mile section of the Trinity River as the 1989 photos. These aerial photos ("Ell" series) were flown in July of 1960. Since no spatially corrected ortho-photos were produced from these early aerial photos, it was necessary to determine how much variance in spatial scale there might be on any given photo. By comparing identical distances between two objects from the 1989 ortho-photos and the 1960 aerial photos, I discovered a scale range on the 1960 photos of between 1:12,000 to 1:18,500. This would obviously cause problems with regards to distortion in the final map and make comparisons with the 1989 coverage inaccurate. However, one way to deal with this problem was found by using Arc/Info's 'rubber sheeting" process and summarized as follows (see Appendix C for a thorough discussion). A spatially incorrect coverage (in this case the 1960 one) is "stretched" to fit a spatially correct coverage (our 1989 one) using 'links'. "Links" are points that represent an object that is in the identical location between 1960 and 1989. So, basically the idea is to find trees or shrubs that are identical in both sets of photos and then digitize these 'points into each coverage. In my situation, the 1989 photos were spatially correct, and 1960 photos were "stretched" to fit them using these links.

The basic process for creating the 1960vegetation layer was as follows. The first task was to trace the polygons, links and tics onto mylar for later digitizing. Due to the small scale of the photos, I used Humboldt State University's Map-O-Graph, a device which enables one to enlarge an aerial photo and project it directly onto mylar for tracing. In order to accurately trace the boundaries of the different 'vegetation' types, the photos were enlarged to approximately the same scale as the 1989 photos. As with the 1989 coverage, this coverage (TRINVEG_60) has 4 attributes. Two were automatically added after building the coverage and include each polygon's area and perimeter. As before, I added polygon labels (numbers) and riparian vegetation types (RIPTYPE). The categories identified in RIPTYPE are identical to the 1989 coverage, with three additional ones: (1) bare ground, gravel bar; (2) willow dominant; (3) willow/alder mix; (4) alder dominant; (5) water, pond, side-channel; (6) gravel bar above annual floodplain (this was added because there was a clear difference from the annually, scoured gravel bars described above); (7) mining tailings; (8) bedrock (see Appendix C., habitat category differences between 1960 and 1989 coverages, for an explanation regarding the three extra habitat categories mapped in the 1960 coverage and not the 1989). The digitizing and editing proceeded similar to the 1989 coverage and is described in Appendix C.

Wildlife Attributes

The second step involved creating a data layer in the GIS of wildlife abundances and distribution along the Trinity River. Two steps were necessary to accomplish this; (1) creating a data layer of survey stations and (2) adding attributes to the station layer of wildlife abundances taken during 1990-1992 survey's (Wilson et al. 1991, Lind et al. 1992). We used several survey techniques to sample the wildlife along the Trinity River: (1) systematic point counts for birds, (2) time-constraint searches and pitfall trapping for small mammals, reptiles, and amphibians, and (3) float surveys for riverine species not encountered in the previous techniques. Appendix A gives a description of the methods for these techniques.

The station coverage was created as follows. 292 Stations were located systematically along the 39-mile section of river (Fig. 1). These stations were accurately located first on aerial photos and then on the same ortho-photos used to map the vegetation layers. The stations (points) were then transferred to mylar to be digitized into a point coverage called TRINSTAT_1. These stations were traced onto the same mylars from the same ortho-photos used for the vegetation layer described above (TRINRIV_89). The important point is that the scale is exactly the same so that the station coverages can be overlayed directly onto the vegetation layer.

From this original point coverage, other station coverages (beginning with TRINSTAT) were made and include attributes of abundances of different wildlife species and vegetation surveyed by different 'techniques described in Appendix A. Seven station coverages were created: (1) **TRINSTAT_FLT** - riverine wildlife species, (2) TRINSTAT TCS - time-constrained survey wildlife species, (3) TRINBIRD RI AND TRINBIRD RO - two coverages for birds, (4) TRINSTAT PF - pitfall survey of wildlife species, (5) TRINSTAT VEG - vegetation variables, and (6) **TRINSTAT_TURT** - turtle surveys during 1990 and 1991.

RESULTS

Pre- and Post-Dam Acreage Comparisons

Comparisons of riparian habitat between 1960 (pre-dam) and 1989 (post-dam) are presented below (Table 1.) and substantiate and quantify Evans (1980) results. There has been a tremendous expansion of riparian vegetation along the Trinity River since the dam was completed in 1962. 350 hectares (864.5 acres) were present in 1989 compared to only 120 hectares (296.4 acres) in 1960. The composition of riparian vegetation has also changed. In 1960 the majority of vegetation was early-successional willow vegetation. In 1989, a much greater percent was comprised of later successional alder and willow/alder mix. Another very striking difference between the 1960 and 1989 habitat conditions is how much gravel bar has been lost. There were approximately 300 hectares (741 acres) of gravel bar in 1960; there are currently less than 20 hectares (49.4 acres). Channelization has occurred as a result of stable flows and lack of annual scouring spring floods. This has resulted in a decrease in the surface area that the river covers. Approximately 100 hectares (247 acres) more open water habitat was present in 1960 than in 1989 (Table 1.).

Table 1. Comparison of riparian habitat between pre- (1960) and post-dam (1989) years along a 39-mile stretch of the Trinity River, California. Numbers reflect hectares mapped by riparian type.

RIPARIAN TYPE[a]	1960	1989
Willow	96.9 (239/22%)[b]	131.9 (326/36%)
Willow/alder	27.3 (67/06%)	154.7(382/41%)
Alder	2.5 (601%)	70.2 (173/19%)
Total vegetation	126.7 (313/29%)	356.8 (881/96%)
Gravel bar	304.5 (752/71%)	16.4 (41/04%)
Water	243.5 (601)	159.1 (393)

[a]The three riparian types represent seral stages; progressing from willow dominant, willow/alder mix, to alder dominant. Gravel bar is open, unvegetated, rocky areas adjacent to the river, and water is primarily the river itself with a few side-channels and ponds.

[b](acres/%) - number of acres followed by percent of total riparian habitat (including gravel bar) and excluding water.

Riparian Vegetation Coverages

1960 and 1989 Riparian Habitat Coverages

TRINRIV_60 - This is the polygon coverage of the Trinity River taken from 1960 aerial photos. As described above in the methods, the only attribute which I added to this coverage was RIPTYPE (riparian type). The values were described previously and are repeated below for quick reference.

1= gravel bar, bare rock
2= willow dominant (>2/3 willow vegetation)
3= willow/alder mix
4= alder dominant
5= water (river, side-channels, and ponds)
6= bare or rocky ground above annual floodplain
7= mining tailings
8= bedrock

TRINRIV_89 - polygon coverage of the Trinity River taken from 1989 aerial photos. As with the above 1960 coverage, this one has just one added attribute, RIPTYPE (riparian type). All polygon coverages have Area and Perimeter attributes associated with each polygon.' There are five values for the riparian type attribute:

1= gravel bar
2= willow dominant vegetation
3= willow/alder mixed vegetation
4= alder dominant vegetation
5= water

Station Vegetation Coverage

TRINSTAT_VEG

This is a point coverage that contains 186 of the 292 survey stations. See the methods section in Appendix A for a thorough discussion of how and which stations vegetation sampling took place. Though vegetation data was collected at each station in 4 broad categories, only 3 are represented in this coverage. These include: (1) ground cover variables recorded at only the 47 pitfall and time-constrained search stations, (2) under- and over-story vegetation cover, and (3) tree counts. Appendix B has a list of all variables measured (with descriptions) and mnemonics of only those used in this coverage. The attributes in the **TRINSTAT_VEG** coverage will be listed below by category.

Ground Cover - these variables are presented as percents of the total measured in each macrohabitat type (e.g., 10 meters of talus along 30 'meters of riparian gives a value of 33%).

CNPYHRP	Canopy height
TALSRP	Talus
LTTRRP	Litter
BARERP	Bare soil
GRASRP	Grass and grass-like vegetation
HERBRP	Herb
LOGRP	Logs
BDRKRP	Bedrock
SANDRP	Sand
VEG	Total vegetation
TOTROCK	Total rock

Canopy Cover - all vegetation between 0.5 m and 2.0 m and taller than 2.0 m that intersects a 50 m tape measure is listed as percent of the total for each macrohabitat type. Each mnemonic in the "INFO" file is followed by a "_1" for understory measurements; and "-2" for overstory measurements.

FHRIP1	FHRIP2	Ferns and horsetails
SHRIP1	SHRIP2	Shrubs
WLRIP1	WLRIP2	Willows
ALDRIP1	ALDRIP2	Alders
COTRIP1	COTRIP2	Cottonwood
OHWRIP1	OHWRIP2	Other riparian hardwoods
UHWRIP1	UHWRIP2	Upland hardwoods
CONRIP1	CONRIP2	Conifers
OPNRIP1	OPNRIP2	Open
GHRIP1	GHRIP2	Grass/herb
CCRIP1	CCRIP2	Canopy cover

Tree Counts - mnemonics are listed for counts of both medium and smaller sized trees, and large trees. The mnemonics ending in"'_l" are for trees less than or equal to 40 cm dbh; those ending in "_2" are trees greater than 40 cm dbh. The small to medium sized trees were counted within a 5 m band on either side of the 50 m transect line while the large trees were counted in a 10 m band. They are listed below:

WLRIP1	WLRIP2	Willows
ALRIP1	ALRIP2	Alders
CTRIP1	CTRIP2	Cottonwoods
OHWRP1	OHWRP2	Other riparian hardwoods
UHWRP1	UHWRP2	Upland hardwoods
PPRIP1	PPRIP2	Ponderosa pines
DFRIP1	DFRIP2	Douglas-fir
DPRIP1	DPRIP2	Digger pine
TTRRIP1	TTRRIP2	Total trees
RIPTR1	RIPTR2	Riparian trees
	SNAGRP	Snags
	DBRRP	Debris piles
	LOGRIP	Logs

TRINBIRD_RI

This is a point coverage of the wildlife survey stations with selected bird species abundances as attributes. See methods (and Appendix A) for a description of how this data was collected. Attributes that represent 19 species of birds censused were added to this point coverage (see below and highlighted in Appendix D). The attributes are listed by the bird species' mnemonics, followed by a "_1" or a "_2", which represents the first and second survey, respectively. The values represent the total number of birds of that species detected within a 25-m-circle of each survey station (RI means "within riparian"). Though many more species were detected during the surveys (Appendix C.), we selected these 19 because they represented greater than 80% of the total bird numbers detected or were species of special concern (willow flycatcher). This coverage contains data for the 292 stations (points) that were surveyed.

Two maps are provided that show yellow-breasted chat abundance along the river during our surveys of 1990 (Figs. 2 and 3, Wilson et al. 1991). This is a State "species of special concern" and true riparian obligate neotropical migrant bird. The two figures represent different surveys and reflect numbers seen within a 25-m circle of each station. These maps clearly show sections of river with the greatest abundance of this species. In this case, the section of river from Douglas City to Evans Bar appears to have a uniform distribution of chats.

Yellow-breasted Chat Abundance Along the Trinity River - Survey 1

Figure 2. Yellow-breasted chat abundance along the Trinity River during the summer of 1990 (Wilson et al. 1991). Symbols reflect total number observed during census #1 within a 25-m radius of each station. See Appendix A *for* a discussion of the methods used in collecting this data.

Yellow-breasted Chat Abundance Along the Trinity River - Survey 2

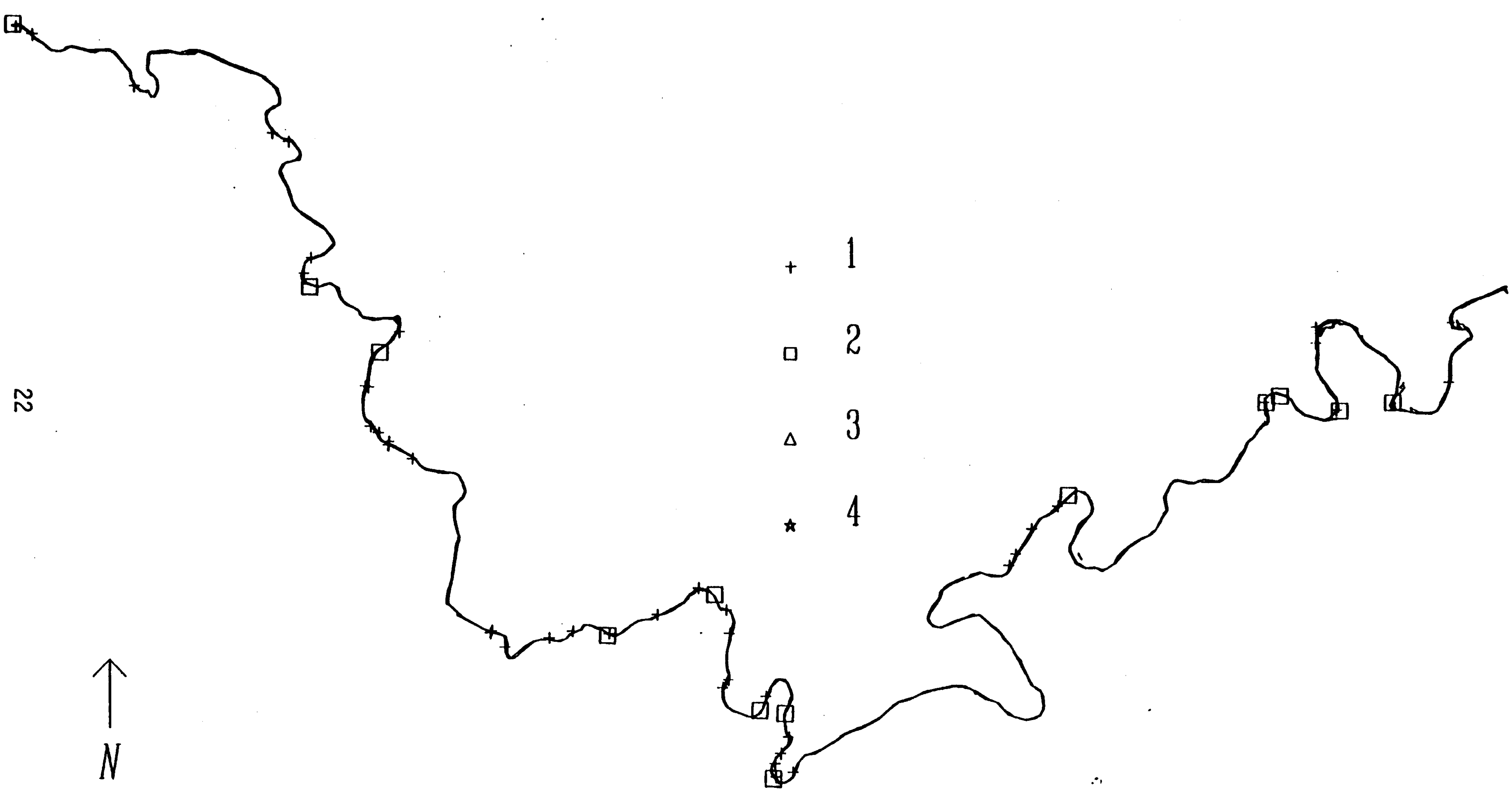

Figure 3. Yellow-breasted chat abundance along the Trinity River during the summer of 1990 (Wilson et al. 1991). Symbols reflect total number observed during census #2 within a 25-m radius of each station. See Appendix A for a discussion of the methods used in collecting this data.

This gives an example of the value of GIS in land use planning. In managing for this species, knowing where they are abundant could help in deciding areas of the river that restoration projects could proceed (eg feathering projects) with minimal impact.

Attributes for coverages TRINBIRD RI AND TRINBIRD RO

AMRO_1 AMRO_2 = American robin
BHGR_1 BHGR_2 = Black-headed grosbeak
BUSH-1 BUSH-2 = Bushtit
LEGO_1 LEGO_2 = Lesser goldfinch
MAWA_1 MAWA 2 = Macgillivary's warbler
NAWA_1 NAWA-2 = Nashville warbler
NOOR_1 NOOR 2 = Northrn oriole
OCWA_1 OCWA-2 = Orange-crowned warbler
RSTO_1 RSTO-2 = Rufous-sided towhee
SCJA_1 SCJA-2 = Scrub Jay
SOSP_1 SOSP 2 = Song sparrow
TRSW_1 TRSW-2 = Tree swallow
WAVI_1 WAVI-2 = Warbling vireo
WETA_1 WETA_2 = Western tanager
WIFL 1 WIFL_2 = Willow flycatcher
WIWA-1 WIWA_2 = Wilson's warbler
WWPE-1 WWPE 2 = Western wood-peewee
YBCH-1 YBCH-2 = Yellow-breasted chat
YEWA_1 YEWA_2 = Yellow warbler

TRINBIRD_RO - This coverage is similar to the above TRINBIRD_RI except that the survey counts were for all birds detected in riparian vegetation, but outside the 25-m-circle surrounding each station (see methods and Appendix A.). The attributes are identical to the above list and are associated with each of 292 survey stations.

Riverine Wildlife Species Coverage

TRINSTAT_FLT

This coverage includes all 292 stations surveyed and represents abundances of riverine species detected relative to the nearest station (Appendix E). I included Appendix E from our 1991 report (Wilson et al. 1991) for reference to the species' scientific names and to show their distribution by Reach (see Fig. 1 for a map of the Reaches). As the methods describe (Appendix A.), there were 5 float surveys during the spring/summer of 1990. The attributes that follow are repeated and represent each of the 5 surveys. Each mnemonic is followed by numbers 1 through 5.

ACSP1 - ACSP5 = Accipiter species (includes Cooper's and sharp-shinned hawks)
AMDI1 - AMDI5 = American dipper
BAEA1 - BAEA5 - Bald eagle
BEAV1 - BEAV5 - Beaver
BEKI1 - BEKI5 - Belted kingfisher
COME1 - COMES - Common merganser
DEER1 - DEER5 = Deer
GOEA1 - GOEA5 = Golden eagle
GBHE1 - GBHE5 - Great-blue heron
GRHE1 - GRHE5 = Green-backed heron
MALL1 - MALL5 = Mallard
MINK1 - MINK5 = Mink
RIOT1 - RIOT5 = River otter
SPSA1 - SPSA5 = Spotted sandpiper
POTU1 - POTU5 = Western pond turtle
WODU1 - WODU5 = Wood duck
KILL1 - KILL5 = Killdeer
OSPR1 - OSPR5 = Osprey
RTHA1 - RTHA5 = Red-tailed hawk

Small Mammal and Amphibian Coverages

TRINSTAT-PF

This coverage contains species attributes from our pitfall trapping surveys and are associated with only 45 of the 292 survey stations along the Trinity River (see methods and Appendix A). The pitfall traps caught many small mammals, a few reptile species, and several amphibians. The numbers associated with each attribute represent total captures of each species by pitfall survey station (Table 2).

Shrew (primarily Sorex trowbridei), abundance along the river by this sampling method is shown in Figure 4. This was provided as an example of what can be done with these coverages. As one can see, though shrews are fairly well distributed along the river, there is one section of river where they are clearly more abundant. This section of river is between Douglas City and Steiner Flat. An interesting excercise would be to overlay this coverage onto the vegetation map and look for patterns. I do know that this section of river has quite a lot of alder dominant vegetation, which may be preferred to earlier successional riparian willows by this species.

TRINSTAT-TCS

This is a point coverage representing time-constrained survey stations (the same ones used for the pitfall surveys above). This technique (see Appendix A) involved active searching for amphibians and reptiles. Though many species encountered were similar to the pitfall technique, there was a noticeable increase in reptiles caught, particularly snakes (Table 2). The attributes associated with this coverage represent total captures at each station and are listed in Table 2.

Table 2. Common and scientific names, and total captures of mammals, amphibians, and reptiles. GIS attributes are listed as Mnemonics (MNE). Timed searches (TCS) were done in April and May and pitfall trapping (PF) was done in July and August of 1990, along a 39 mile portion of the Trinity River in Trinity County, California.

Common Name	Scientific Name	MNE	Total Captures TCS	Total Captures PF
MAMMALS				
Trowbridge's shrew	Sorex trowbridgii	SOTR/1		44
Unidentified shrew	Sorex sp.	SOSP		412
Shrew-mole	Neurtrichus nibbsii	NEGI		17
Botta's pocket gopher	Thomomys bottae	THBO		4
Heermann kangaroo rat	Dipodomys hermanni	DIHE		1
Western harvest mouse	Reithrodontomvs megalotis	REME		3
Deer mouse	Peromyscus maniculatus	PEMA		28
Pinyon mouse	Peromyscus truei	PETR		3
California vole	Microtus califomicus	MICA		9
Long-tailed vole	Microtus lonnicaudus	MILO		2
Unidentified vole	Microtus sp.	MISP		4
AMPHIBIANS				
Pacific giant salamander	Dicamntodon tenebrosus	DITE	1	
Rough-skinned newt	Taricha eranulosa	TAGR	10	34
Ensatina	Ensatina eschscholtzi	ENES	4	5
Black salamander	Aneides flavipunctatus	ANFL		2
Western toad	Bufo boreas	BUBO	1	29
Pacific treefrog	Hyla regilla	HYRE	4	14
Foothill yel-leg. frog	Rana bovlii	RABO	8	9
Bullfrog	Rana catesbeiana	RACA	20	
REPTILES				
Western pond turtle	Clemmvs marmarota	CLMA	3	
Western fence lizard	Scelonorus occidentalis	SCOC	74	625
Sagebrush lizard	Scelonorus gracious	SCGR	9	77
Unidentified lizard	SceloDonls sp.	SCSP		4
Western skink	Eumeces skiltonianus	EUSK	6	42
Western whiptail	Cnemidonhorus tigris	CNTI		1
N. alligator lizard	Elearia coerulea	ELCO	9	4
S. alligator lizard	Elgaria multicarinata	ELMU	11	11
Ringneck snake	Diadonhis punctatus	DIPU	2	
Sharptail snake	Contia tenuis	COTE	1	
Western racer	Coluber constrictor	COCO	18	
Striped racer	Masticoohis lateralis	MALA	1	
Gopher snake	Pituonhis melanoleucus	PIME	1	
Common garter snake	Thamnophis sirtalis	THSI		1
W. terrest. garter snake	Thamnophis elegans	THEL	1	
Unident. garter snake	Thamnophis sp.	THSP	1	
Western rattlesnake	Crotalus viridis	CRVI	2	

[1]Not used in GIS database.

Shrew Abundance Along the Trinity River

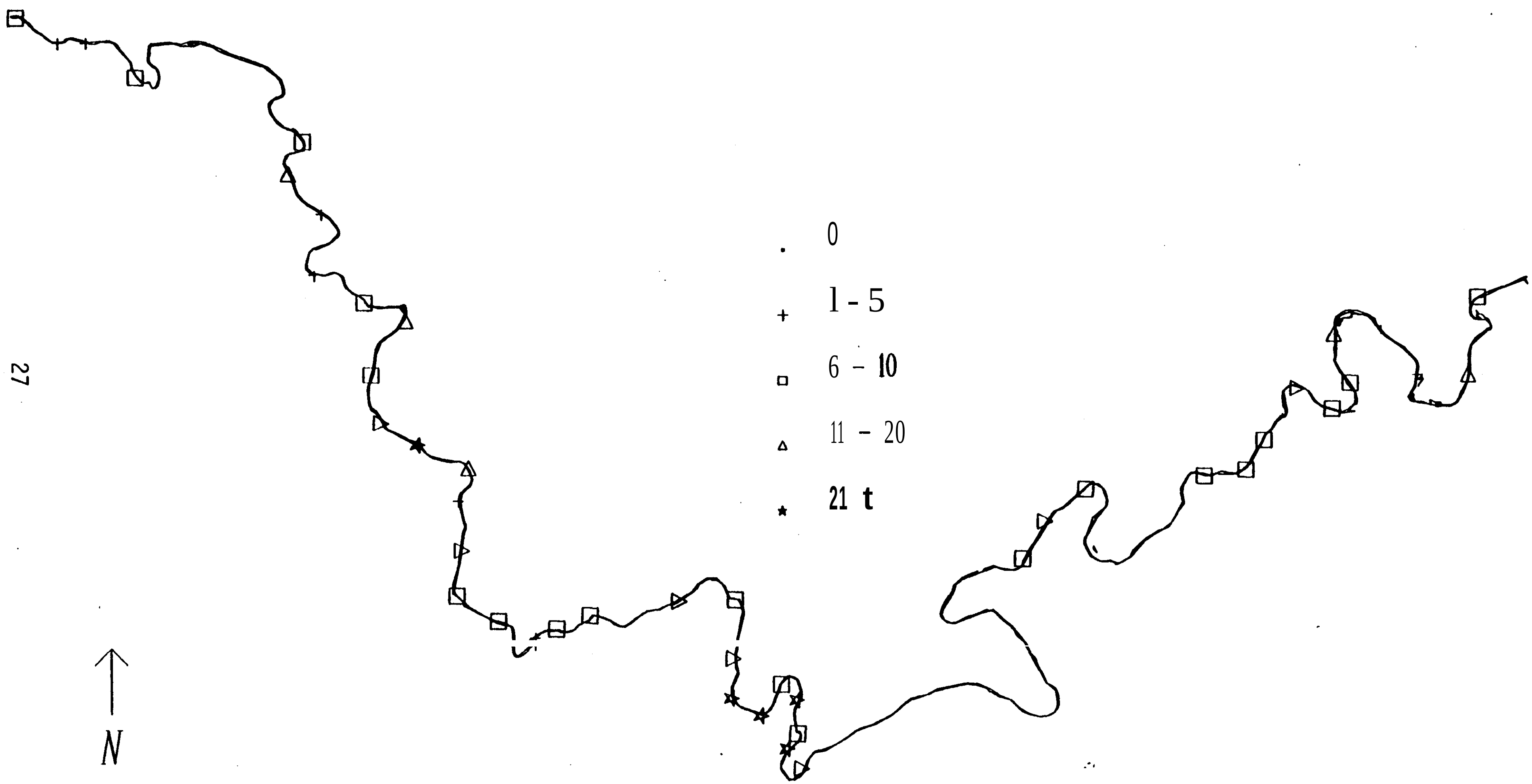

Figure 4. Shrew (primarily **Sorex** trowbridgii) abundance along the Trinity River during the summer of **1990** (Wilson et al. 1991). Symbols reflect total numbers captured at 45 pitfal stations (methods described **in** Appendix A).

Turtle Coverage

TRINSTAT_TURT

This is a point coverage of 292 stations representing turtle surveys done during the summer of 1991 (see methods in Appendix A.). There are two sets of turtle attribute data in this file which reflect different survey efforts. The first two are labeled as CLMA_1 and CLMA_2 2 and represent total abundance of turtles seen per station during two float surveys of the entire 39 mile stretch of river. These surveys took place in June and August, respectively. The second set of attributes represents numbers of turtles seen by station during float surveys of Reaches 10 and 11 only. The methods section describes how this was done; the purpose being to get a more accurate estimate of the true turtle population along the river. Five surveys of Reach 10 and 11 were conducted throughout the summer and are named CLMA A, CLMA B, CLMA C, CLMA_D, AND CLMA_E.

Western pond turtle abundance is shown in Figures 5 and 6 for the two total river surveys described above. This is good visual proof of the clumped distribution of this species along the Trinity River. Management decisions can be aided by this knowledge.

Western Pond Turtle Abundance Along the Trinity River - Survey 1

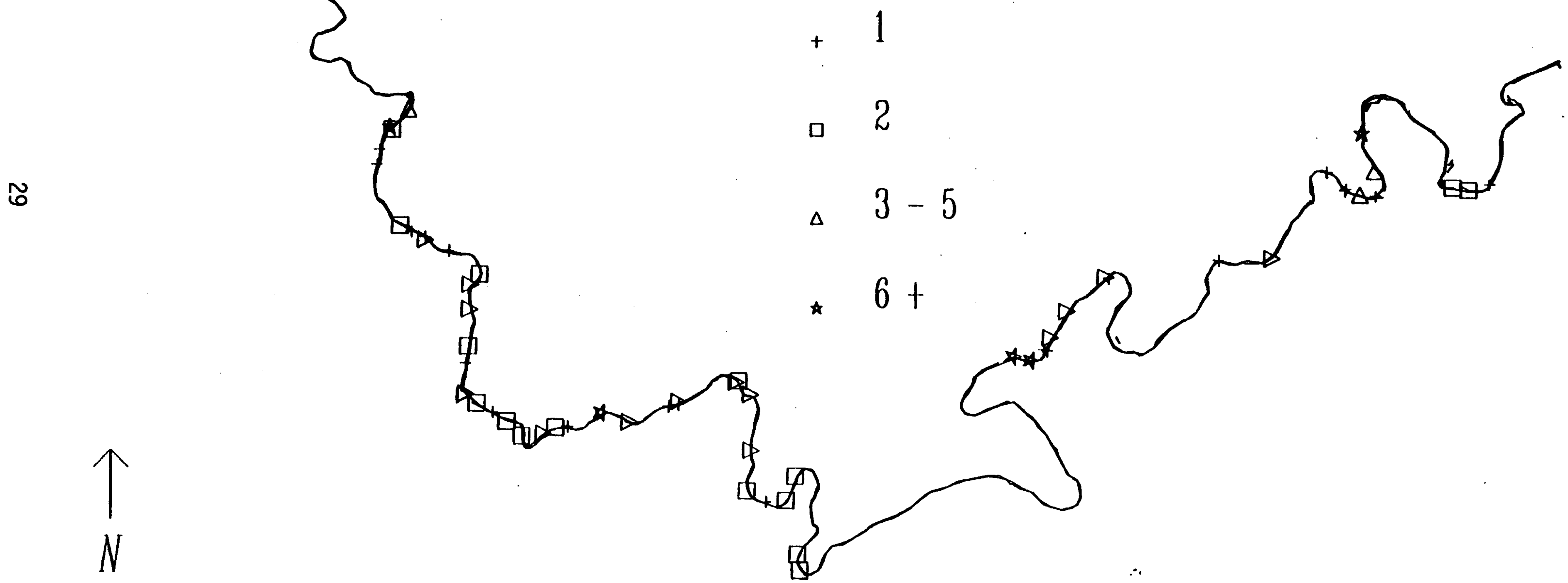

Figure 5. Western pond turtle abundance along the Trinity River during survey #1, June, 1991 (Lind et al. 1992). Symbols reflect total numbers seen to the nearest station along the 39-mile stretch of river between Lewiston Dam and the North Fork (methods described in Appendix A).

Western Pond Turtle Abundance Along t'he Trinity River - Survey 2

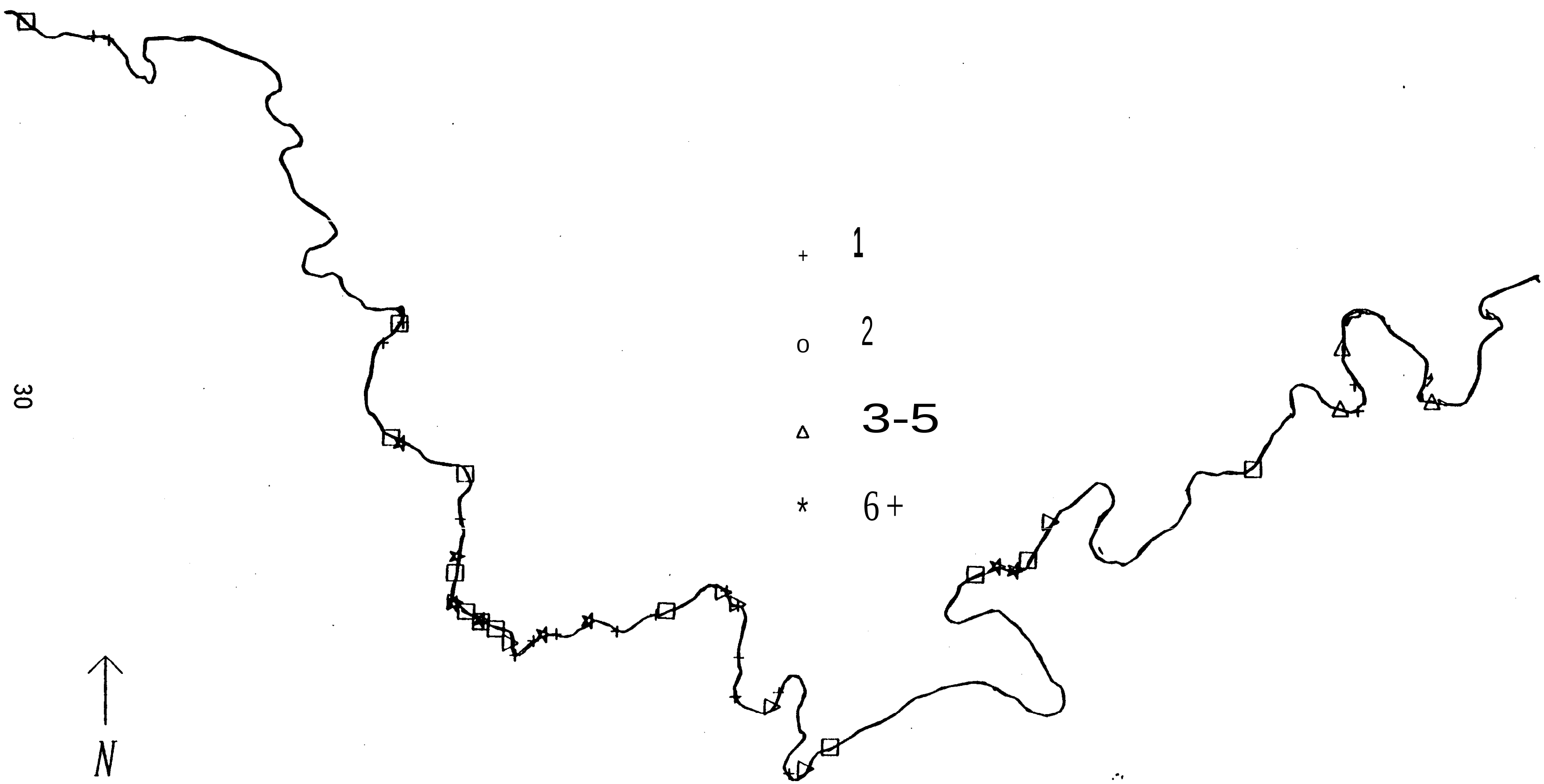

Figure **6.** Western pond turtle abundance along the Trinity River during survey #2, August, 1991 (Lind et al. **1992).** Symbols reflect total numbers seen to the nearest station along the 39-mile stretch of river between Lewiston Dam and the North Fork (methods described in Appendix A).

APPLICATIONS AND RECOMMENDATIONS

The potential uses for this GIS are many and will depend on the quality and quantity of data layers in the system. The Bureau of Land Management (BLM) in Redding has a Geographical Information System (MOSS) and currently is responsible for managing approximately 60% of the Trinity River between Lewiston dam and the North Fork. Their system already contains spatial data layers including: Trinity River, section lines, ownership (public, private), transportation (roads, bridges, etc.), archeological sites, upland timber types, recreation, soils. We have added two very important layers to this data base - riparian vegetation and wildlife abundance.

Many questions can be addressed by having ready access to maps of the riparian vegetation and wildlife abundance along the river. A Geographical Information System (GIS) is a tool for just such a purpose. The relationships among the data can be displayed using GIS analytical processes. The variety of processing and display techniques range from simple area calculations and overlays of multiple data layers, to investigations of proximal relationships and complex Boolean logic operations based upon numerous attributes or parameters. The following examples will show the types of analyses that can be done using GIS:

1. Wildlife distributions in different riparian types along the river - the wildlife layer (any species of interest) can be overlayed onto the vegetation layer. The resulting maps can be analyzed to see which riparian types and locations appear to be preferred by certain wildlife species.

2. Wildlife abundance in relation to private ownership or human disturbance - one can overlay the wildlife layer onto roads, parcels and ownership layers.

3. Boolean queries (AND, IF, NOT) can be used to make maps with specific criterion of interest (e.g. to locate willow patches larger than 2 hectares in size).

4. Proximity searches to examine habitat characteristics adjacent to rare wildlife sightings or nests - one can draw a circle around such locations and overlay it with the vegetation polygon layer, resulting in acreages of vegetation types surrounding each location.

5. Measurements can be done to compare pre- and post-dam changes in riparian vegetation acreage.

6. Choosing areas for fish habitat restoration projects (e.g. feathering projects), GIS can help delineate sections of river that meet designated criteria - such as riparian type, river morphology, river depth, floodplain width, distance (and visibility) from roads, etc.

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Appendix A. Methods used during the 1990 and 1991 Trinity River Wildlife Surveys (Wilson et al. 1991, Lind et al. 1992).

To adequately survey the 39 mile stretch of the Trinity River from Lewiston Dam to the North Fork, we traveled in inflatable kayaks. This stretch of the river was primarily Class I-II water (rapids with little maneuvering necessary to avoid hazards).

Survey and Analysis Levels

Sampling and analyses were conducted at four levels: reach, station, and riparian type.

Reach and Station

The river was divided into 16 unequal length segments, henceforth called Reaches, averaging 1.95 miles (3.14 km) in length, and were determined by boat launch access (Fig. 1). Actual length varied between 1.5 and 2.5 miles (2.41 and 4.02 km). Within each Reach, survey stations were systematically placed every 250-300 m, with one station on each side of the river at each location. Bird census stations were centered in the riparian habitat; the distance from shore was determined by the width of the vegetation but no greater than 25 m from the river. Census points were marked with flagging and a spray painted spot on the nearest tree. A few census points were located at the riparian/upland edge in areas where riparian vegetation was less than 10 m wide. Eleven Reaches contained 20 census points (10 stations on each side of the river), and four Reaches contained 18 census points (nine per side), totaling 292 points. Reach number 6 was not censused because stations could only be located on the right side of the river due to private property.

Riparian Vegetation

Survey stations were categorized as being in one of four riparian vegetation types (Evans 1980). We considered only the vegetation within a 25 m radius of the bird census station and defined the types as follows: (1) gravel/cobble bar - more than 2/3 of the area was gravel/cobble bar or sandy areas; (2) Willow (Salix sp.) dominant - greater than 2/3 of the vegetation cover was willow; (3) willow/alder mix (Salix sp. and Alnus sp.) - at least l/3 of vegetation cover was willow and l/3 is alder; (4) mature/alder dominant - greater than 2/3 of vegetation cover was alder or cottonwood (Populus sp.)

Vegetation Estimation

Measurine vegetation

To accurately describe the floristics and structure of the riparian vegetation along the Trinity River, we sampled 186 of the 292 survey stations spaced systematically along the river. All 47 time-constrained search stations and 45 pitfall stations (see below) were sampled. The remaining stations were sampled alternating sides at each successive station (e.g. l-right, 2-left, 3-right, etc.), for a mininum of 10 stations per Reach with 5 on either side.

Data was collected at each station in 4 broad categories: general site characteristics, ground cover variables, under- and over-story cover, and tree counts (see Appendix B for a more detailed account). Ground cover variables were recorded only at the 47 pitfall and time constraint stations; all other variables were recorded at 186 stations.

Vegetation variables were summarized and presented to characterize both the different riparian types and geomorphological types. Variables are presented **as** means, standard errors, and ranges for each riparian type or geomorphological type as follows: (1) ground variables (time-constrained and pitfall sites only) are expressed as percents of the total transect measured in the macrohabitat riparian vegetation type; (2) under- and over-story variables are expressed as percents of the total transect in the riparian vegetation; (3) tree count variables are presented as numbers per hectare.

Bird Censuses

Census Method

To investigate bird habitat use along the Trinity River, we used the fixed point-count method described by Hutto, et. al. (1986). The protocol was as follows: a Reach (Fig. 1) was randomly selected (without replacement) to census each day. A crew of two people started at the upper end of the Reach within 15 minutes of sunrise, floated to the first station, and hauled-out on either side of the river.

At each census point the observers recorded three kinds of data within a 10 minute period: (1) the number of individuals of each species detected within a 25 m radius surrounding the observer (at the census point), (2) the number of birds detected of each species beyond the 25 m radius but still within riparian vegetation (any questionable calls were put into 'other' category), and (3) the number of birds of each species detected in upland habitats. The level of detectibility varied between census stations due to factors such as river noise, road noise, gravel operation noise, and density of vegetation, type of vegetation species, type of terrain (open area versus steep canyon wall), etc. Recording birds within 25 m ensured a comparable probability of detection within this unit area among all stations. Bird detections were recorded immediately upon arrival at the station's center and continued for 10 minutes. As suggested by Hutto et al. (1986), birds that flushed from within the 25-m-radius circle upon the observer's arrival were recorded as "inside" detections. This was done because some birds are very shy and will temporarily leave an area occupied by human observers. Birds that were detected but unidentified before the end of the 10 minute count period were pursued after the end of the count for identification. Detections were recorded as singing (S), calling (C), or visual (V).

One Reach was censused per day. All stations were censused twice during the spring. Censusing began the last week of April and was completed by mid-June.

Data Analvsis

Our objective was to quantify the relative 'abundances and habitat association patterns of bird species closely associated with riparian vegetation. Bird abundances were analyzed for comparison by riparian vegetation type. All analyses were calculated using the census that yielded the largest numerical abundance per species (Blonde1 1981).

Riparian type. Census stations were categorized as occurring in one of four riparian vegetation types. Only 2 stations were categorized as gravel/cobble bar so we eliminated them from analysis. Species abundances were recorded as mean numbers detected per station within a 25-m-radius circle of each station for each riparian type. Only data taken within the 25-m-radius circle were included in this analysis because of unequal probabilities of detection at larger distances. To test the hypothesis of no difference in abundance between riparian types, a Proportion test (Zar 1984:p.395) was run comparing the proportion of stations in each riparian type at which each species was detected.

Float Surveys for Riverine Wildlife

Survey Method

River surveys were conducted to survey wildlife species that were closely associated with the water itself. The entire 39 mile stretch of river was surveyed 5 times between May 15, 1990 and August 2, 1990. Two surveys were conducted between 6 and 11 a.m. (5/15 to 5/21, and 7/23 to 8/2); two between 3 and 8 p.m. (5/29 to 6/7, and 7/5 to 7/9), and one between 10 a.m. and 3 p.m. (6/19 to 6/21).

Three days were needed (5 Reaches each) to complete the entire 39 miles of river. A survey involved two people floating the river in a kayak, one person navigating while the other recorded data. Since different species were active at different times of the day, 2 float surveys took place in the morning, 2 in the evening, and one at mid-day. A concerted effort was made to avoid double counting, as certain species were commonly flushed downriver by observers (common mergansers, wood ducks, and foraging green herons). This was done by keeping track of birds (flocks) advancing downriver and not counting new birds seen until the ones already recorded flew upriver overhead. Since we have no way of determining the bias (error), statistical significance is not presented with the analyses (see below).

<u>Data Analysis</u>

The primary goal of the float surveys was to characterize the distribution and relative abundance of riverine wildlife species. Species abundances are presented as mean numbers detected per survey for each Reach (1-16). To compare species abundances between surveys, total numbers detected by Reach for each survey are also presented. Twelve species with greater than 10 total detections were used for this analysis.

Common mergansers were of special interest in that they are a fish predator and very common along this section of river. This species gathers in large flocks of adults and large families. Besides characterizing their abundance by Reach, we also compared the number of flocks and family units by survey. Number of males detected are also presented for each survey.

Wood ducks are a species of concern because of their specialized nesting requirements (large cavities in trees), and their intolerance of disturbance (Bent 1923). We paid particular attention to their family size and abundance along the river. Flocks and families were recorded and presented as numbers detected per survey.

Time-constrained Searches

Methods

Time-constrained searches (timed-search) were used to gather data on the distribution and relative abundance of herpetofauna. This method consisted of two people moving systematically through a designated area searching under cover items, raking leaf litter, and examining vegetation for herpetofauna (see Welsh 1987 for details). Three to four of the 18-20 survey stations were sampled in each'of 15 Reaches for a total of 47 stations; Reach 6 was omitted due to its location adjacent to highway 299 and private land. This sub-sample of stations was systematic. One station (one side of the river or the other) was surveyed at every third survey location, starting at the dam and working downriver. Periodically sites other than the third station were chosen, to avoid private land in-holdings and areas of high human use (e.g. fishing access points). Timed-searches were conducted once at each station, in early April through early May 1990. A one person-hour timed search (two people searching for 1/2 hour) was conducted at each station. Searchers worked within a 30 m radius around the bird census point and covered all habitats. Timers were only stopped when an animal was positively identified (and escaped) or was captured and data recorded.

Data were taken at four spatial scales: the general site (station), the macrohabitat around each animal observation, the mesohabitat around each observation, and the microhabitat for each observation. Data were also taken on sex, age, size and weight of each animal observed (see Wilson et al. 1991, Appendix B for a detailed description of variables recorded at each level).

Data Analvsis

Time-constrained search data were analyzed to provide information on species composition, relative abundance, and habitat associations. Mean relative abundance of all species and species groups (e.g. frogs, lizards, etc.) are described.

Pitfall Trapping

Methods

We used pitfall traps (pitfall) to gather data on small mammals and herpetofauna found. This is a passive sampling method in which 2 gallon, plastic buckets (22 cm deep) are buried slightly below ground level. The buckets are sheltered using a 30 cm by 30 cm wooden shake or piece of plywood which was elevated above the opening providing a narrow cover space attractive to small animals. When an animal attempts to use the artificial cover, it falls into the bucket and is trapped (see Welsh 1987 for details).

Pitfall buckets were placed at most of the same stations we had conducted time-constrained samples. Ten buckets were placed at 45 of the 47 timed-search stations in a 2 x 5 grid (two stations were omitted because they were areas of relatively high human use). Each line began at water's edge and ran perpendicular to the shoreline 5m on either side of the bird census point. Pitfall traps were placed 5 m apart and within 1 m of flagging marking the trap location. Traps were placed next to a natural structure (logs, tree trunk, rock, bank, etc.) whenever possible. The traps were opened the first week of July 1990 and closed 8 weeks later, at the end of August 1990. The first four weeks the buckets were dry and the last four weeks they were filled with approximately two inches of water to increase the likelihood of catching small mammals that can jump out. Traps were checked weekly and data was taken on species, sex, age, size, and parasites (see Wilson et al. 1991, Appendix B for detailed descriptions of variables). Live animals were toe clipped and released for future identification. At the end of the field season traps were removed.

Data Analysis

We used pitfall data to describe species composition, relative abundance, habitat associations, and effectiveness of the two trap types (dry or wet). All capture rates were standardized to "captures per 1000 trap-nights". A trap-night was one trap, at one station, open for one night. If traps were disturbed (e.g., cover shake was missing or pulled out of the ground) when they were checked, they were considered "not available" for the time that had elapsed from the last check date. Removing these traps from the data set for each week allowed standardization of captures of animals to captures per 1000 trap-nights so that stations, Reaches, etc. could be compared.

Western Pond Turtle

Methods

We used two methods to gather data on western pond turtles: float surveys and mark/recapture (resighting). Float surveys consisted of two people floating downriver in inflatable kayaks counting, noting size (in three broad categories), and river habitat association of basking turtles. We did two complete float surveys of our 39 (63 km) mile study area, one in July and one in August.

For marking, we spent 7 days (one day in June and 6 days in July) hand capturing and marking turtles on Reaches 10 and 11 (6 km) (Fig. 1). For this method, several workers floated these reaches in kayaks, stopped where turtles were seen basking, and then used snorkling to find and capture as many as possible. We chose these reaches for two reasons: (1) turtles appeared to be 'in relatively high abundance here providing a high catch per effort and (2) these two Reaches were difficult for humans to access by land, thus enabling us to study a relatively undisturbed population of turtles. We recorded the following information on captured turtles: time and location, sex, age, reproductive condition, position relative to habitat, carapace length, and weight. Information on aquatic habitat (habitat type, water flow, depth, etc.; and presence/absence of several types of basking sites was also gathered for each capture. A complete description will be provided in future reports. Turtles were marked with both a permanent unique code, consisting of notches along the edge of their carapace (upper shell), and a temporary visual mark painted on the carapace with nail polish. Nail polish marks are thought to last 6-8 weeks, though it varies considerably depending on the habitat and behavior of the turtles (D. Holland, pers. comm., Department of Biology, University of Southwestern Louisiana, LaFayette, LA 70504).

Data Analvsis

Following the mark/recapture period we conducted 5 float surveys of Reaches 10 and 11 (one each week for the next five weeks) in order to estimate the population size for this section. On these surveys turtles were recorded as marked, unmarked, or unknown. If marked, their individual number was noted if possible, to glean information on movements.

We used summaries of counts of marked and unmarked turtles from all surveys 'of Reaches 10 and 11 to develop population estimates using the Lincoln-Petersen estimator (Pollack et al. 1990). Turtles visually marked during the July mark/recapture period were used as the base population of marked animals; those marked in June were not included unless recaptured and re-painted in July. Only turtles that could be definitively identified as marked or unmarked were used; unknown turtles were omitted from the estimates. We also calculated sex and size ratios for the marked population.

We then calculated the average proportion of the estimated population seen on Reaches 10 and 11 by dividing the total number seen on each survey by the population estimate for that survey. This average proportion was then used to calculate an estimate for the whole study area, under the assumption that the proportion of the actual population seen is constant along the river.

We calculated means and standard deviations for several habitat variables .and provide summaries of habitat associations, using data from the mark/recapture method on Reaches 10 and 11.

Appendix B. Variables and sampling method used to describe the vegetation at wildlife survey stations along a 39 mile stretch of the Trinity River between Lewiston Dam and the North Fork. Mnemonics listed represent GIS attributes in the station coverage TRINSTAT_VEG. (From Wilson et al. 1991)

Variable	Attribute	Description
Reach		numbered l-16
Station		numbered l-10, left or right of river
Observers		two observers initials
Date		
Site Characteristics (25 m Radius of Each Station)		
Aspect		direction in compass degrees slope faces
Slope		steepness (%) of adjacent upland slope taken with a clinometer
Upland Type		indicates dominant conifer type of associated upland (ie. Ghost Pine, or Douglas Fir)
River Mesohabitat		recorded as a glide, pool, ripple/rapid, or run (after McCain et. al. 1990)
Human Impact		visual estimate from negligable to high, indicating degrees of human access and disturbance
Beaver Impact		ranges from none to high indicating degree of beaver activity
Canopy Height	(CNPYHRP)	average canopy height in meters of the riparian and upland (if present within 25 m circle) overstory
Valley Width		floodplain width in meters measured from USGS 7.5 minute topo quads
Variables' Measured Alonn 50 m Tape, Centered on Station and Perpendicular to the River		
Macrohabitat		number of meters measured in gravel bar, riparian, upland, or river habitat
Ground Cover: The following were analyzed as percents of the total measured in each macro habitat type.		
Talus	(TALSRP)	measured in meters along 50m tape
Litter	(LTTRRP)	sticks and debris < 10 cm DBH
Bare Soil	(BARERP)	

Variable	Attribute	Description
Ground Cover: (cont.)		
Grass-Like Veg.	(GRASRP)	includes grass, rushes, and sedges
Herb	(HERBRP)	all forbes
Log	(LOGRP)	stems > 10 cm DBH
Water		includes river water, side channels, ponds, and streams
River Rock		gravel, pebble, cobbles, and boulders
Bedrock	(BDRKRP)	
Sand	(SANDRP)	
Total Vegetation	(VEG)	grass-like veg. and herb combined.
Total Rock	(TOTROCK)	talus, river rock and bedrock combined.

Under and Overstory: All vegetation between 0.5 m and **2.0** m; and taller than 2.0 m that intersects the 50 m tape was measured and analyzed as percent of the total for each macrohabitat type. Each mnemonic in the "info" file is followed by an "_1" (understory) or an "_2" (overstory).

Ferns & Horsetails	(FHRIP)	
Shrubs	(SHRIP)	includes blackberries and wild grape
Willows	(WLRIP)	Salix species
Alders	(ALDRIP)	Alnus species
Cottonwood	(COTRIP)	Populus species
Other rip.hdwds.	(OHWRIP)	Oregon ash, Big-leaf Maple, etc.
Upland hardwoods	(uHWRIP)	Oaks, Madrone, Bay, etc.
Conifers	(CONRIP)	Ponderosa pine, Digger pine, Sugar pine, Douglas fir
Open	(OPNRIP)	no-vegetation present
Grass/herb	(GHRIP)	grasses and herbs
Canopy Cover	(CCRIP)	

Band Tree Counts: Mnemonics listed under 'small to medium size trees" are GIS attributes and are identical to the large trees. The mnemonics ending in "_1" are for trees less than or equal to 40cm DBH; those ending in "_2_ are trees greater than 40cm DBH.

Small to medium size trees		numbers of trees by species between 10-40 cm DBH within a 5 m band on either side of the 50 m transect line in both riparian and upland habitats.
Willows	**(WIRIP1)**	Salix species
Alders	**(ALRIP1)**	Alnus species
Cottonwood	**(CTRIP1)**	Populus species
Other rip.hdwds.	**(OHWRP1)**	Oregon ash, Big-leaf Maple, etc.
Upland hardwoods	**(UHWRP1)**	Oaks, Madrone, Bay, etc.
Ponderosa Pines	(PPRIP1)	
Douglas-fir	(DFRIP!)	

Appendix B. (cont.)

Variable	Attribute	Description
Digger Pine	(DPRIP1)	
Total Trees	**(TTRRIP1)**	
Large trees		numbers of trees greater than 40 cm DBH within a 10 m band on either side of the transect line. Analyzed by species in both riparian and upland habitats (when present).
Willows	(WIRIP2)	Salix species
Alders	**(ALRIP2)**	Alnus species
Cottonwood	(CTRIP2)	Populus species
Other rip.hdwds.	**(OHWRP2)**	Oregon ash, Big-leaf Maple, etc.
Upland hardwoods	**(UHWRP2)**	Oaks, Madrone, Bay, etc.
Ponderosa Pines	(PPRIP2)	
Douglas Fir	(DFRIP2)	
Digger Pine	(DPRIP2)	
Total Trees	(TTRRIP2)	
Snags	(SNAGRP)	number of snags > 10 cm DBH within a 10 m band on either side of the transect line.
Debris piles	**(DBRRP)**	number of debris piles (> 1 m diameter) within 10 m band on either side of the transect line.
Logs	**(LOGRIP)**	number of logs > 10 cm DBH within 10 m band on either side of the transect line.

Appendix C. Technical aspects of methods used to digitize riparian vegetation into a GIS (Arc/Info). This includes a discussion of transformation and rubber sheeting (two critical steps necessary in spatially aligning the 1960 and 1989 coverages),as well as Dataset Errors (inherent in any GIS work), and comparisons of habitat categories for the 1960 and 1989coverages.

Digitizing into GIS

Registration tics were established for each of the eight coverages from the known UTM coordinates that bordered two sides of the ortho-photos. Once the mylar maps were registered (with an RMS error of no more that 0.005; or less than 2.5 meters), I added the other tics digitally as described above (in methods). Then the digitizing could begin. This was the easy part of the process. To smooth out the 'curves, the arcs were splined with vertices added every 3 meters . Once all the polygons were digitized for each map, unique label points were added to each for later attribute addition (riparian type categories). The coverages were checked for dangling nodes, node errors, and sliver polygons. Once corrected, the BUILD command was used to clean up the coverage and add topology. At this point I looked for polygon labeling errors, including polygons with more than one label, several polygons with the same label number, and un-labeled polygons.

Next on the agenda was to join the 8 coverages together into one. However, before this happened, the areas of adjoinment were examined to see if the coverages would align properly. Using one coverage as the edit-coverage, and it's neighbor as the back-coverage (arcedit), I made digitizing corrections to align the two. This also involved going back to the orthos of two adjoining areas and making sure the polygon 'interpretation was correct. Once all the coverages were aligned, I simply joined each coverage to the first one and ended up with one coverage. This coverage (called **TRINVEG_89**) contains all the vegetation polygons.

The attribute table for **TRINVEG_89** has 4 attributes, two of which are automatically added after building the coverage. These two attributes are the area and perimeter of each polygon. The two attributes which I added include a polygon identification number and RIPTYPE, which is the riparian type of each polygon. These are numbered 1 through 5: (1) gravel bar, (2) willow dominant, (3) willow/alder mix, (4) alder dominant, and (5) water (primarily the river itself with a few side-channels and ponds).

Transformation and Rubber Sheeting

Once the digitizing of polygons and tics was completed for both 1989 and 1960 coverages, it was necessary to transform the 1960 coverages (sections of river) to the same scale as the 1989 coverage. The Arc/Info TRANSFORM command does this by changing coverage coordinates of one coverage to another based on a set of control points (tics). As described above, these control points have the same Tic-ID number and are of objects of identical locations in both year's aerial photos. A Root Mean Square (RMS) error was calculated for each transformation and indicated how good the derived transformation was. The average RMS error for the 17 coverages was 5.87 m, S.D.= 2.49, range = 3.2-11.76. I tried to keep the RMS errors under 10 m, though 3 .of the 17 were slightly over. For those coverages with RMS errors over 15 m, I removed the tic or tics with the highest individual error and redid the transformation. My defense for doing this was that I may well have mis-identified the tree or shrub I believed to be identical between the two sets of aerial photos.

To eliminate further error, a Rubber Sheeting process in Arc/Info was used. Transform uses a simple x,y linear transformation and thus gives the best fit possible of the entire coverage to be transformed. Rubber sheeting corrects flaws through geometric adjustment of coordinates and actually stretches digitized features. Links are the special feature class created and used in Arc/Info to perform rubber sheeting. Each link has two points, a from-point and a to-point, that are used for adjusting coverage coordinates. Features on our inaccurate source map (1960 coverage) needed to be adjusted to more accurately depict the study area. As described above, identical points (and hereafter referred to as links) were identified on both the 1960 and 1989 coverages. Links were used to connect the inaccurate (1960) points to the "more accurate" location (1989 coverage). When a coverage was adjusted, these links were used to move the from-point on each line to the to-point on each link, and coordinates around each link were adjusted. The coordinates were stretched and this is the main difference between the transform command and rubber sheeting. The resilience, or stretching, is dependent on the location of each link. The farther a coordinate is away from a link, the less that coordinate is displaced. To be able to assess the RMS error for the rubber sheeting of each coverage, I used the ARC command called LLSFIT. This command performs a linear least squares fit to the link coverage and the values for the 1960 coverages averaged 1.06 m, with a Standard Deviation of 0.36 m).

Dataset Errors

There is error in the process of transferring spatial data from maps into a GIS system. There are many places along the way to make mistakes. The first error I noticed in this project was on the ortho-photos of the 1989 aerial photos. UTM coordinates were placed on two sides of the ortho-photos. A tic coverage was created from the keyboard using the UTM coordinate values identified on the ortho-photos. These UTM tics on the orthos, along with the polygons to be digitized, were transferred as accurately as possible onto mylar. Coverage #1 registered very nicely, with an RMS error of less that .005 or 5 m. This meant that the tics on the orthos were accurately placed. Coverage #2 was off by 20 meters and necessitated moving the tics to be able to register the map for digitizing. My analysis led me to believe that this error on the ortho was approximately the width of a pencil and could have happened when the UTM lines were originally drawn. A few other coverages had tics off as much as 10 m which I adjusted to fit the maximum allowable RMS error rate of 0.005, or 5 m. What does this mean? That the absolute level of accuracy is no greater than 20 m. However, this does not mean that polygon sizes are not accurate, or riparian widths are not accurate. It does mean that coordinates could be off of their "true" UTM location by as much as 20 m.

Another source of error is digitizing error. Whenever I registered a map to be digitized, I made sure the RMS error was less than .003 as recommended. Tracing error is also expected when transferring spatial data onto mylar for later digitizing. My pen width represented a width of approximately 5 m and so, digitizing on one side or the other of it could cause error. I tried my best to digitize in the middle of the line.

One feature that will definitely be under-represented in the 1989 coverage is the width of the river course. Streamside alder and willows often extend out over the river and sometimes as much as 10 m. Since I couldn't tell this distance by looking at aerial photos, I traced the river as beginning at the edge of the vegetation. Though the vegetation width is accurately represented, the river width is often not.

Transformation error and rubber sheeting error were talked about above and add to the already potential error incorporated into the more accurate "1989" coverage. However, thanks to the transformation capabilities of Arc/Info, the 1960 coverage is scaled as close as possible (within 10 m) to the 1989 coverage. So, however far off the 1989 coverage is, so is the 1960 coverage. We must remember that our main questions are at a fairly gross scale. Due' to the courseness and lack of ortho-photos of the 1960 coverage, I am very satisfied with how close we could scale the two coverages.

Habitat Category Differences between 1960 and 1989 Coverages

Some explanation is required to indicate why three categories of riparian habitats were mapped on the 1960 aerial photos and not the 1989 ortho-photos. My original intent was to map the same riparian vegetation types along the river for both sets of aerial photos. I completed the 1989 mapping first and only 5 categories were mapped as described above. Work on the 1960 photos involved enlarging them to enhance tracing accuracy. At this point in the process it became apparent that any future riparian mapping additions would necessitate the same enlargement. Due to the 'roughness' of the Map-O-Graph device, it would be near impossible to duplicate this process. So, I chose to map three additional habitat types as listed above.

Another factor determining why I mapped a broader array of habitats in the 1960 coverage is because the line between riparian and upland vegetation types was much more distinguishable in 1960. The vegetation amongst the mining tailings then was predominantly riparian willow species. In areas away from the riparian corridors in the 1989 photos (such as mining tailings) there was a tremendous mix of upland tree and shrub species with the riparian vegetation. However, one could easily go back to the 1989 ortho-photos and add polygons of those areas adjacent to that which was mapped to equal the areas mapped from the 1960 photos. The process of adding these categories to the 1989 coverage can be done with accuracy since ortho-photos exist at a scale of 1:6,000. However, one would have to define new habitat categories that included the "upland/riparian vegetation mixes", "above annual floodplain gravel bar/ shrub mixes", and "upland-riparian-shrub-mining tailings mixes".

Appendix D. Bird species from the Trinity River between Lewiston Dam and the North Fork, Trinity County, California. Mnemonics, residency status, riparian affinity, nest type and frequency of occurrence are listed for all species. Frequency of occurrence indicates the percent of all stations (292) that a species was detected (a + sign indicates only 1 individual recorded, * indicates opportunistic sighting). Bird species are listed in taxonomic order.

SPECIES[1]	MNEMONIC CODE	RES.[2]	RIP[3] AFF.	NEST[4] TYPE	HABITAT' RI	RO	UP
Great Blue Heron (<u>Ardea herodias</u>)	GBHE	R	P	tree	1.0	2.1	+
Green-backed heron (<u>Butorides virescens</u>)	GRHE	R	P	tree	6.6	7.6	0.0
Great Egret (<u>Casmerodius albus</u>)	GREG	M/W	P			*	
Black-Crowned Night Heron (<u>Nvcticorax nvcticorax</u>)	BCNH	U	S		0.0	+	0.0
Canada Goose (<u>Branta canadensis</u>)	CAGO	R	S	ground		*	
Mallard (<u>Anas platvrhvnchos</u>)	MALL	R	P	ground	1.0	1.4	0.0
Green-Winged Teal (<u>Anas crecca</u>)	GWTE	M	S		+	0.0	0.0
Wood Duck (<u>Aix sponsa</u>)	WODU	R	P	cavity	4.5	3.1	0.0
Hooded Merganser (<u>Lophodvtes cucullatus</u>)	HOME	W	P			*	
Common Merganser (<u>Merqus merganser</u>)	COME	R	P	cavity	3.8	4.8	+
Red-Breasted Merganser (<u>Merqus serrator</u>)	RBME	W	S			*	
Turkey Vulture (<u>Cathartes aura</u>)	TUVU	S		cavity	0.7	0.0	+
Sharp-Shinned Hawk (<u>Accipiter striatus</u>)	SSHA	R		tree	0.0	0.0	+
Cooper's Hawk (<u>Accioiter coooerii</u>)	COHA	R	P	tree		*	*
Red-Tailed Hawk (<u>Buteo iamaicensis</u>)	RTHA	R		tree	+	0.0	1.4
Golden Eagle (<u>Aquila chrvsaetos</u>)	GOEA	R		tree		*	*
Bald Eagle (<u>Haliaeetus leucoceohalus</u>)	BAEA	R	P	tree	6.7	+	+
Osprey (<u>Pandion haliaetus</u>)	OSPR	R	P	tree	1.0	1.4	+
Merlin (<u>Falco columbarius</u>)	MERL	W			+	0.0	0.0

Appendix D. (cont.)

SPECIES[1]	MNEMONIC CODE	RES.[2]	RIP[3] AFF.	NEST[4] TYPE	HABITAT[5] RI	RO	UP
California Quail (*Callipepla califomica*)	CAQU	R		ground	4.5	16.9	8.3
Mountain Quail (*Oreortvx pictus*)	MOQU	R		ground	+	1.4	14.1
Virginia Rail (*Rallus limicola*)	VIRA	R	P	ground		*	
Kildeer (*Charadrius vociferus*	KILL	S	P	ground	1.0	1.4	0.0
Common Snipe (*Gallinago gallinaeo*)	COSN	W/S	P	ground		*	
Spotted Sandpiper (*Actitis macularia*)	SPSA	S	P	ground	2.8	13.5	0.0
Greater Yellowlegs (*Tringa melanoleuca*)	GRYE	M/W	P			*	
Mourning Dove (*Zenaida macroura*)	MODO	S	S	tree	2.1	4.5	6.9
Western Screech Owl (*Otus kennicottii*)	wsow	R	S	cavity		*	
Common Nighthawk (*Chordeiles minor*)	CON1	S		ground		*	*
Black-Chinned Hummingbird (*Archilochus alexandri*)	BCHU	S	P	tree	0.0	+	0.0
Anna's Hummingbird (*Calypte anna*)	ANHU	R		tree	4.5	2.1	0.0
Belted Kingfisher (*Cervle alcyon*)	BEKI	R	P	bank	3.8	6.6	0.0
Northern Flicker (*Colaptes auratus*)	NOFL	R	P	cavity	+	2.4	10.4
Pileated Woodpecker (*Drvocopus pileatus*	PIWO	R		cavity	0.0	0.0	1.4
Acorn Woodpecker (*Melanerpes formicivorus*)	ACWO	R		cavity	0.0	1.4	3.8
Red-Breasted Sapsucker (*Sphvrapicus ruber*)	RBSA	R		cavity	3.8	2.8	0.7
Hairy Woodpecker (*Picoides villosus*)	HAWO	R		cavity	1.4	2.4	3.5
Downy Woodpecker (*Picoides pubescens*	DOWO	R	P	cavity	1.7	3.1	2.4
Western Kingbird (*Tvrannus verticalis*)	WEKI	S	-	tree	1.0	0.7	0.7
Ash-Throated Flycatcher (*Mviarchus cinerascens*)	ATFL	S	-	cavity	2.8	8.6	3.8
Black Phoebe (*Savornis nigricans*)	BLPH	R	S	platform	1.7	4.1	1.0
Say's Phoebe (*Savornis sava*)	SAPH	M				*	

Appendix D. (cont.)

SPECIES[1]	MNEMONIC CODE	RES.[2] AFF.	RIP[3]	NEST[4] TYPE	HABITAT[5] RI	RO	UP
Willow Flycatcher (Empidonax traillii)	WIFL	S	P	tree	1.7	5.5	O.O
Gray Flycatcher (Empidonax wriehtii)	GRFL	M	P			*	
Pacific slope Flycatcher (Empidonax difficilis)	WEFL	S	S	tree	4.8	11.0	29.0
Western Wood Peewee (Contopus sordidulus)	WWPE	S		tree	18.6	52.8	26.6
Olive-Sided Flycatcher (Nuttallomis borealis)	OSFL	S		tree	0.0	0.0	1.0
Tree Swallow (Tachvcineta bicolor)	TRSW	S	P	cavity	15.2	22.1	1.0
Northern Rough-Winged Swallow (Steleidootervx serripennis)	NRWS	S	S	bank	4.8	4.5	+
Barn Swallow (Hirundo rustica)	BASW	S		platform	0.0	+	0.0
Cliff Swallow (Hirundo pvrrhonota)	CLSW	S		platform	1.0	1.0	0.0
Steller's Jay (Cvanocitta stelleri)	STJA	R		tree	7.2	14.5	24.8
Scrub Jay (Aphelocoma coerulescens)	SCJA	R		tree	8.3	9.7	7.6
Common Raven (Corvus corax)	CORA	R		tree	0.7	2.8	3.8
American Crow (Corvus brachvrhvnchos)	AMCR	R	P	tree	+	2.1	2.8
Black-Capped Chickadee (Parus atricapillus)	BCCH	R	P	cavity	+	0.0	0.0
Chestnut-Backed Chickadee (Parus rufescens)	CBCH	R	S	cavity	1.0	0.0	+
Bushtit (Psaltriparus minimus)	BUSH	R		tree	9.7	4.8	0.7
White-Breasted Nuthatch (Sitta carolinensis)	RBNU	R		cavity	+	1.0	2.4
Red-Breasted Nuthatch (Sitta candensis)		R		cavity	0.7	+	0.7
Brown Creeper (Certhia americana)	BRCR	R		tree	0.0	0.0	0.7
Wrentit (Chamaea fasciata)	WREN	R		shrub	1.0	1.7	5.2
American Dipper (Cinclus mexicanus)	AMDI	R	P	platform	0.7	1.0	0.0
House Wren (Troglodytes aedon)	HOWR	S	S	cavity	0.7	2.8	1.4
Winter Wren (Troelodvtes tronlodvtes)	WIWR	R		cavity			*

Apendix D. (cont.)

SPECIES[1]	MNEMONIC	RES.[2] CODE	RIP[3] AFF.	NEST[4] TYPE	HABITAT' RI	RO	UP
Beswick's Wren (<u>Thrvomanes bewickii</u>)	BEWR	R	S	cavity	6.9	17.6	4.1
Marsh Wren (<u>Cistothorus nalustris</u>)	MAWR	R	P	shrub		*	
American Robin (<u>Turdus minratorius</u>)	AMRO	R	-	tree	7.6	7.9	19.7
Hermit Thrush (<u>Catharus guttatus</u>)	HETH	w	-	tree	+	0.0	0.0
Western Bluebird (<u>Sialia mexicana</u>)	WEBL	W?	-	cavity			*
Blue-Gray Gnatcatcher (<u>Polioptila caerulea</u>)	BGGN	s	-	tree	3.5	1.7	0.7
Ruby-Crowned Kinglet (<u>Regulus calendula</u>)	RCKI	w	-	tree		*	*
Cedar Waxwing (<u>Bombvcilla cedrorum</u>)	CEWA	S/W	P	tree	+	+	0.0
European Starling (<u>Sturnus vulgaris</u>)	EUST	R	-	cavity	0.7	2.1	0.0
Hutton's Vireo (<u>Vireo huttoni</u>)	H W I	R	S	tree	1.0	+	2.4
Solitary Vireo (<u>Vireo solitarius</u>)	SOVI	s	s	tree	4.8	7.9	37.9
Warbling Vireo (<u>Vireo gilvus</u>)	WAVI	s	P	tree	17.9	28.6	11.0
Orange-Crowned Warbler (<u>Vermivora celata</u>)	OCWA	s	s	ground	12.1	33.5	22.1
Nashville Warbler (<u>Vermivora ruficapilla</u>)	NAWA	s	-	ground	9.0	12.4	25.9
Yellow Warbler (<u>Dendroica netechia</u>)	YEWA	s	P	tree	56.2	77.9	4.1
Yellow-Rumped Warbler (<u>Dendroica coronata</u>)	YRWA	S/W	-	tree	1.0	0.7	1.0
Black-Throated Gray Warbler (<u>Dendroica nigrescens</u>)	BTGW	s	-	tree	3.5	6.9	49.3
Townsend's Warbler (<u>Dendroica townsendi</u>)	TOWA	S/W	-	tree	+	0.0	+
Hermit Warbler (<u>Dendroica occidentalis</u>)	HEWA	s	-	tree	0.7	+	3.8
MacGillivray's Warbler (<u>Oporornis tolmiei</u>)	MAWA	s	s	shrub	9.3	18.3	2.8
Common Yellowthroat (<u>Geothlwis trichas</u>)	COYE	s	P	shrub	0.0	+	0.0
Yellow-Breasted Chat (<u>Icteria virens</u>)	YBCH	s	P	shrub	19.3	54.8	0.7
Wilson's Warbler (<u>Wilsonia pusilla</u>)	WIWA	s	P	ground	9.3	14.8	2.4

Appendix D. (cont.)

SPECIES[1]	MNEMONIC CODE	RES. AFF.[2]	RIP[3]	NEST TYPE[4]	HABITAT[5] RI	RO	UP
Red-Winged Blackbird (Agelaius nhoeniceus)	RWBL	R	P	shrub	3.5	10.7	1.0
Brewer's Blackbird (Euphagus cvanoceohalus)	BRBL	S	-	tree	4.8	4.8	+
Northern Oriole (Icterus galbula bullockii)	NOOR	S	P	tree	4.5	12.1	2.4
Brown-Headed Cowbird (Molothrus ater)	BHCO	S	P		5.5	7.9	3.1
Western Tananger (Piranga ludoviciana)	WETA	S	-	tree	3.8	9.7	49.0
Black-Headed Grosbeak (Pheucticus melanocephalus)	BHGR	S	P	tree	19.0	34.5	36.6
Lazuli Bunting (Passerina amoena)	LABU	S/M	S	shrub	3.1	4.8	3.1
Purple Finch (Carpodacus purpureus)	PUFI	S/W	-	tree	3.5	5.5	11.0
House Finch (Carpodacus mexicanus)	HOFI	R	-	tree	+	+	+
Lesser Goldfinch (Soinus osaltria)	LEGO	S	-	tree	15.9	34.8	20.0
Rufous-Sided Towhee (Pipilo erythrophthalmus)	RSTO	R	S	ground	22.1	44.5	11.4
California Towhee (Pipilo crissalis)	CATO	R	S	shrub	1.0	3.5	1.0
Dark-Eyed Junco (Junco hvemalis)	DEJU	R	-	ground	1.4	+	8.6
Chipping Sparrow (Spizella nasserina)	CHSP	S	-	shrub	+	+	1.0
White-Crowned Sparrow (Zonotrichia leucophrvs)	WCSP	W	-			*	
Golden-Crowned Sparrow (Zonotrichia atricapilla)	GCSP	W	-		0.7	+	0.0
Lincoln's Sparrow (Melosniza lincolnii)	LISP	M	P			*	
Song Sparrow (Melospiza melodia)	SOSP	R	P	shrub	63.8	78.3	0.7

'Bird species highlighted and with a * are those attributes included in the GIS database.

2/Residence codes: R) resident-year round; W) winter resident; S) Spring/summer resident; M) migrant, spring or fall; U) unknown.

3/Riparian affinity: P indicates a primary affinity for riparian or aquatic habitat (lacustrine, fluviatile, or marsh); S indicates a ranking of 2 or 3 with regards to use of riparian, lacustrine, fluviatile or marsh habitat (Miller 1951).

[4]Nesting: trees, shrubs and ground indicate preferred substrate for open nests; cavity nesters are both primary excavators (woodpeckers) and secondary cavity nesters. Bank nesters dig nest holes in soft soil along the river. Platform nesters include those using ledges on cliffs, bridges, or vertical surfaces.

[5]Habitat: RI is the area within a 25-m-radius circle centered at each station; RO indicates riparian habitat, though outside the 25 m circle; UP indicates upland habitat.

Appendix E. Abundance of wildlife ● ptcltt by Reach on the Trinity River **between Lewiston** Dam and the North **Fork** of **the** Trinity. California. **Mean** number **of** individual8 **detected per** float **survey** art prtttnttd **for each** Reach. **Totals indicate mean number** of dtttctiont **per** turrty **across all** Rtachtt. Range **is** indicated **in** partnthtttt. **(* tndicttt species** detected **opportunistically** not during **the surveys).** Mnemonic8 **used** in **GIS database** trt highlighted following common **names.**

	REACH[a]														
Species[b]	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	**Totals**
Birds																
Great-blue **heron (GBHE)**	1.2 (0-3)	**0.2 (0-1)**	0.8 (0-l)	0.4 (0-2)	0.2 (0-l)	0.4 (0-10	**0.0 (0)**	**0.4 (0-1)**	**0.2 (0-1)**	**0.4 (0-1)**	0.2 (0-l)	**0.6 (0-1)**	**0.0 (0)**	**0.4 (0-1)**	**0.8 (0-2)**	**6.6 (4-9)**
Green-backed heron **(GRHE)**	6.4 (4-13)	**3.8 (3-6)**	**2.6 (1-5)**	**2.6 (1-4)**	**0.8 (0-3)**	3.8 (3-6)	**1.6 (0-3)**	2.0 (l-3)	**1.0 (0-2)**	**1.4 (0-3)**	1.2 (0-I)	3.0 (1-S)	2.6 (l-4)	**2.4 (0-5)**	**1.8 (1-3)**	**39.8 (34-54)**
Great egret	*	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	
tllallard **(MALL)**	**2.4 (0-11)**	5.6 (0-23)	**0.2 (0-1)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.4 (0-2)**	**0.2 (0-1)**	**2.2 (0-6)**	**0.2 (0-1)**	1.8 (0-S)	**1.0 (0-2)**	**0.8 (0-3)**	**0.0 (0)**	15.6 (l-31)
Wood duck **(WODU)**	**0.2 (0-1)**	2.0 (0-7)	**0.2 (0-1)**	**0.6 (0-2)**	0.2 (0-l)	0.0 **(0)**	**0.0 (0)**	0.4 **(0-1)**	**0.0 (0)**	**0.6 (0-1)**	2.2 (0-10)	2.6 (0-6)	0.0 (0)	**0.2 (0-1)**	0.4 (0-2)	11.0 (7-18)
Common **(COME) merganser**	**5.8 (3-9)**	11.0 (1-21)	**4.4 (0-12)**	**8.0 (0-18)**	**3.2 (1-7)**	0.2 (l-23)	**0.8 (0-4)**	**5.0 (1-14)**	**6.6 (0-15)**	**0.2 (0-1)**	1.4 (0-3)	13.4 (0-25)	0.2 (0-l)	**3.8 (0-15)**	**0.0 (0)**	74.2 (61-89)
Sharp-shinned hawk	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	•	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	0.2 (0-l)	0.2
Cooper's hawk	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	•	**0.0 (0)**	•	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	*	
Red-tailed hawk **(RTHA)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.2 (0-1)**	**0.0 (0)**	0.0 **(0)**	0.0 **(0)**	0.0 **(0)**	**0.2** (0-l)	**0.0 (0)**	**0.0 (0)**	**0.6**
Qoldtn **eagle (GOEA)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	•	**0.0 (0)**	**0.0 (0)**	**0.2 (0-1)**	0.2
Bald ttglt **(BAEA)**	**0.4 (0-2)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	0.2 (0-1)	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	0.6
Osprey (OSPR)	*	**0.2 (0-1)**	*	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	*	**0.0 (0)**	**0.0 (0)**	**0.2 (0-1)**	0.6 (0-l)	0.0 **(0)**	**0.4 (0-2)**	**0.0 (0)**	1.8
Killdeer (KILL)	**1.0** (0-5)	0.4 (0-l)	0.0 **(0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0 (0)**	**0.0** (0)	*	0.0 **(0)**	0.2 (0-l)	**0.0 (0)**	**0.0 (0)**	1.6
Spotted **(SPSA) tandpiptr**	**1.0** (0-4)	1.0 (0-4)	1.6 (0-3)	1.0 (0-3)	0.6 **(0-2)**	2.0 (0-7)	1.0 **(0-6)**	1.2 (0-3)	2.0 **(0-8)**	2.4 **(1-6)**	1.8 (0-5)	3.4 **(0-6)**	5.8 **(3-9)**	3.0 (0-5)	2.6 **(1-4)**	32.8 (28-50)

Appendix E. (cont.)

	REACH[a]															
Species	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	Totals
Lesser yellowlegs	0.0 (0)	0.0 (0)	0.0 (0)	*	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	-
Belted (BEKI) kingfisher	5.2 (2-8)	4.4 (2-10)	2.6 (1-5)	3.0 (0-4)	2.0 (0-4)	0.2 (0-1)	0.4 (0-1)	1.8 (0-4)	1.0 (0-2)	0.6 (0-1)	1.4 (0-4)	3.6 (2-5)	0.2 (0-1)	1.2 (0-5)	2.8 (0-5)	31.8 (20-48)
American dipper (AMDI)	0.6 (0-2)	3.0 (2-4)	1.4 (0-3)	0.2 (0-1)	0.0 (0)	1.2 (0-4)	0.0 (0)	0.2 (0-1)	0.0 (0)	0.0 (0)	0.2 (0-1)	0.0 (0)	0.8 (0-2)	1.0 (0-2)	0.4 (0-1)	9.4 (5-15)
Reptiles																
Western pond turtle (POTU) (*Clemmys marmorata*)	0.0 (0)	0.2 (0-1)	4.6 (0-8)	0.8 (0-2)	2.2 (0-5)	2.0 (0-3)	1.2 (0-3)	0.4 (0-2)	3.2 (0-11)	11.4 (1-40)	4.6 (0-12)	5.6 (0-14)	0.4 (0-2)	0.0 (0)	0.6 (0-3)	42.6 (23-68)
Mammals																
Beaver (BEAV) (*Castor canadensis*)	0.0 (0)	*	0.4 (0-2)	0.8 (0-3)	1.8 (0-6)	1.0 (0-5)	0.0 (0)	*	0.4 (0-1)	0.0 (0)	0.0 (0)	0.4 (0-1)	0.4 (0-1)	0.6 (0-3)	*	6.0 (2-12)
Raccoon (*Procyon lotor*)	0.0 (0)	0.0 (0)	0.6 (0-3)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	*	0.0 (0)	0.0 (0)	0.6
Mink (MINK) (*Mustela vison*)	0.0 (0)	0.2 (0-1)	0.2 (0-1)	*	0.0 (0)	0.0 (0)	0.0 (0)	*	*	0.0 (0)	*	0.0 (0)	*	*	0.2 (0-1)	0.6
Skunk (*Spilogale putorius*)	0.0 (0)	0.2 (0-1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.2
River otter (*Lutra* (RIOT) *canadensis*)	0.4 (0-1)	*	1.2 (0-6)	1.0 (0-3)	*	0.0 (0)	0.0 (0)	*	0.8 (0-4)	0.0 (0)	0.8 (0-4)	1.0 (0-5)	0.0 (0)	0.2 (0-1)	0.2 (0-1)	5.8 (3-15)
Deer (DEER) (*Odocoileus hemionus*)	0.2 (0-1)	0.6 (0-2)	3.2 (0-9)	0.2 (0-1)	0.0 (0)	0.2 (0-2)	0.2 (0-1)	0.2 (0-1)	0.0 (0)	0.0 (0)	0.4 (0-1)	0.0 (0)	0.0 (0)	0.2 (0-1)	0.0 (0)	5.6 (1-12)

[a] Reaches are shown in fig. 1; each is approximately 2 miles long, and indicates increasing distance from Lewiston Dam.

[b] Scientific names of birds are listed in table 1.