Revised Draft Environmental Impact Statement/
Environmental Impact Report

Truckee River Operating Agreement

Biological Resources Appendix

California and Nevada

August 2004

United States Department of the Interior
Bureau of Reclamation
Fish and Wildlife Service
Bureau of Indian Affairs

State of California
Department of Water Resources

Biology Appendix

PART A

COMMON AND SCIENTIFIC NAMES OF PLANT AND ANIMAL SPECIES IN THE TRUCKEE RIVER STUDY AREA

Common Name	Scientific Name
Plants	
Trees	
black cottonwood	*Populus balsamifera* spp. *trichocarpa*
Fremont cottonwood	*P. fremontii*
lodgepole pine	*Pinus contorta* ssp. *murrayana*
Jeffrey pine	*P. jeffreyi*
ponderosa pine	*P. ponderosa*
quaking aspen	*P. tremuloides*
red fir	*Abies magnifica*
Shrubs	
American dogwood	*Cornus sericea*
antelope bitterbrush	*Purshia tridentata*
low sagebrush	*Artemisia arbuscula*
big sagebrush	*A. tridentata*
buffaloberry	*Sheperdia argentea*
coyote willow	*Salix exigua*
dusky willow	*S. melanopsis*
greasewood	*Sarcobatus vermiculatus*
interior rose	*Rosa woodsii* var. *ultramontana.*
mountain alder	*Alnus incana* spp. *tenuifolia*
saltbush	*Atriplex confertifolia*
serviceberry	*Amelanchier alnifolia* var. *pumila*
shining willow	*Salix lucida* spp. *lasiandra*
tamarisk	*Tamarix sp.*
Truckee barberry	*Berberis (=Mahonia) sonnei*
yellow willow	*Salix lutea*
Grasses and Graminoids	
annual beard grass	*Polypogon monspeliensis*
beaked sedge	*Carex utriculata*
broad-leaved cattail	*Typha latifolia*
common reed	*Phragmites australis*
hardstem bulrush	*Scirpus acutus*
Kentucky bluegrass	*Poa pratensis*
least spikerush	*Eleocharis acicularis*
mannagrass	*Glyceria striata*
Olney's bulrush	*Scirpus americanus*
rusty sedge	*Carex subfusca*
slender wheatgrass	*Elymus trachycaulus*
slender-beak sedge	*Carex athrostachya*
soft rush	*Juncus effusus*
water sedge	*Carex aquatilis*

Herbs	
altered andesite buckwheat	*Eriogonum robustum*
altered andesite popcornflower	*Plagiobothrys glomeratusa.*
bigleaf lupine	*Lupinus polyphyllus*
common horsetail	*Equisetum arvense*
Cup Lake draba	*Draba asterophora* var. *macrocarpa*
Cusick's speedwell	*Veronica cusickii*
Dog Valley ivesia	*Ivesia aperta* var. *canina*
Donner Pass buckwheat	*Eriogonum umbellatum* var. *torreyanum*
Dune sunflower	*Helianthus deserticola*
English sundew	*Drosera anglica*
Lemmon's clover	*Trifolium lemmonii*
long-petaled lewisia	*Lewisia longipetala*
Margaret's rushy milkvetch	*Astragalus convallarius* var. *margaretiae*
marsh willowherb	*Epilobium palustre*
marsh skullcap	*Scutellaria galericulata*
monkey flower	*Mimulus gluttatus*
Munroe's desert mallow	*Sphaeralcea munroana*
Nevada dune beardtongue	*Penstemon arenarius*
Nevada oryctes	*Oryctes nevadensis*
Plumas ivesia	*Ivesia sericoleuca*
playa phacelia	*Phacelia inundata*
Ranger's buttons	*Sphenosciadium capitellatum*
russian thistle	*Salsola kali*
round-leaved sundew	*Drosera rotundifolia*
sagebrush pygmyleaf	*Loeflingia squarrosa* ssp. *artemisiarum*
sand cholla	*Opuntia pulchella*
scalloped moonwort	*Botrychium crenulatum*
Sierra Valley ivesia	*Ivesia aperta* var. *aperta*
starved daisy	*Erigeron miser*
steamboat monkeyflower	*Mimulus ovatus*
subalpine fireweed	Epilobium howellii
Tahoe draba	*Draba asterophora* var. *asterophora*
Tahoe yellow cress	*Rorippa subumbellata*
tall whitetop	*Lepidium latifolium*
Tiehm's rock cress	*Arabis tiehmii*
upswept moonwort	*Botrychium ascendens*
Washoe pine	*Pinus washoensis*
Washoe tall rockcress	*Arabis rectissima* var. *simulans*
western goblin	*Botrychium montanum*
white sweet-clover	*Melilotus alba*
white clover	*Trifolium repens*
whitetop	*Cardaria pubescens*
Williams combleaf	*Polyctenium williamsiae*
willow herb	*Epilobium ciliatum*

Aquatic	
nodularia	*Nodularia spumigena*
blue-green algae	*Aphanizomenon flos-aquae*
Common waterweed	*Elodea canadensis*
pondweed	*Potomogeton sp.*

Common Name	**Scientific Name**
Invertebrates	
California floater	*Anodonta californiensis*
Lake Tahoe benthic stonefly	*Capnia lacustra*
Nevada viceroy	*Limenitus archippus lahontani*
Fishes	
goldfish	*Carassius auratus*
carp	*Cyprinus carpio*
tui-chub	*Gila bicolor*
golden shiner	*Notemigonus crysoleucas*
Sacramento blackfish	*Orothodon microlepidotus*
fathead minnow	*Pimephales promelas*
speckled dace	*Rhinichthys osculus*
Lahontan redside shiner	*Richardsonius egregius*
mountain sucker	*Catostomus platyrhynchus*
Tahoe sucker	*C. tahoensis*
cui-ui	*Chasmistes cujus*
white catfish	*Ameiurus catus*
brown bullhead	*A. nebulosus*
channel catfish	*ctularus punctatus*
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*
rainbow trout	*O. mykiss*
kokanee	*O. nerka*
mountain whitefish	*Prosopium williamsoni*
brown trout	*Salmo trutta*
brook trout	*Salvelinus fontinalis*
lake trout	*S. namaycush*
western mosquitofish	*Gambusia affinis*
Paiute sculpin	*Cottus beldingi*
white bass	*Morone chrysops*
Sacramento perch	*Archoplites interruptus*
green sunfish	*Lepomis cyanellus*
largemouth bass	*Micropterus salmoides*
white crappie	*Pomoxis annularis*
black crappie	*P. nigromaculatus*
yellow perch	*Perca flavescens*
walleye	*Stizostedion vitreum*
Amphibians	
long-toed salamander	*Ambystoma macrodactylum*
Great Basin spadefoot toad	*Spea intermontana*
western toad	*Bufo boreas*
Yosemite toad	*B. canorus*
Pacific treefrog	*Pseudacris (Hyla) regilla*
mountain yellow-legged frog	*Rana muscosa*
northern leopard frog	*R. pipiens*
bullfrog	*R. catesbeiana*

Reptiles

northwestern pond turtle	*Clemmys marmorata marmorata*
long-nosed leopard lizard	*Gambelia wislizenii*
desert spiny lizard	*Sceloporus magister*
western fence lizard	*S. occidentalis*
northern sagebrush lizard	*S. graciosus graciosus*
side blotched lizard	*Uta stansburiana*
northern alligator lizard	*Elgaria coerulea*
southern alligator lizard	*E. multicarinata*
western skink	*Eumeces skiltonianus*
western whiptail lizard	*Cnemidophorus tigris*
rubber boa	*Charina bottae*
racer	*Coluber constrictor* ssp.
coachwhip	*Masticophis flagellum*
striped whipsnake	*M. taeniatus*
gopher snake	*Pituophis catenifer*
common kingsnake	*Lampropeltis getula*
California mountain kingsnake	*L. zonata*
common garter snake	*Thamnophis sirtalis*
western terrestrial garter snake	*T. e. elegans*
western aquatic garter snake	*T. couchi*
ground snake	*Sonora semiannulata*
western rattlesnake	*Crotalus viridis* ssp.

Birds

common loon	*Gavia immer*
Arctic loon	*Gavia arctica*
Clark's grebe	*Aechmophorus clarki*
western grebe	*A. occidentalis*
red-necked grebe	*Podiceps grisegena*
horned grebe	*P. auritus*
eared grebe	*P. nigricollis*
pied-billed grebe	*Podilymbus podiceps*
American white pelican	*Pelecanus erythrorhynchos*
double-crested cormorant	*Phalacrocorax auritus*
least bittern	*Ixobrychus exilis*
American bittern	*Botaurus lentiginosus*
black-crowned night heron	*Nycticorax nycticorax*
green-backed heron	*Butorides striatus*
snowy egret	*Egretta thula*
great egret	*Ardea albus*
great blue heron	*Ardea herodias*
white-faced ibis	*Plegadis chihi*
sandhill crane	*Grus canadensis*
tundra swan	*Cygnus columbianus*
greater white-fronted goose	*Anser albifrons*
snow goose	*Chen caerulescens*
Ross' goose	*C. rossii*
Aleutian Canada goose	*Branta canadensis leucopareia*
Canada goose	*Branta canadensis*
mallard	*Anas platyrhynchos*

gadwall	*A. strepera*
green-winged teal	*A. crecca*
American wigeon	*A. americana*
northern pintail	*A. acuta*
northern shoveler	*A. clypeata*
blue-winged teal	*A. discors*
cinnamon teal	*A. cyanoptera*
ruddy duck	*Oxyura jamaicensis*
wood duck	*Aix sponsa*
canvasback	*Aythya valisineria*
redhead	*A. Americana*
ring-necked duck	*A. collaris*
greater scaup	*A. marila*
lesser scaup	*A. affinis*
surf scoter	*Melanitta perspicillata*
Harlequin duck	*Histrionicus histrionicus*
Barrow's goldeneye	*Bucephala islandica*
common goldeneye	*B. clangula*
bufflehead	*B. albeola*
common merganser	*Mergus merganser*
red-breasted merganser	*M. serrator*
hooded merganser	*Lophodytes cucullatus*
Virginia rail	*Rallus limicola*
sora	*Porzana carolina*
common moorhen	*Gallinula chloropus*
American coot	*Fulica americana*
American avocet	*Recurvirostra americana*
black-necked stilt	*Himantopus mexicanus*
snowy plover	*Charadrius alexandrinus*
semipalmated plover	*C. semipalmatus*
killdeer	*C. vociferus*
mountain plover	*Charadrius montanus*
black-bellied plover	*Pluvialis squatarola*
marbled godwit	*Limosa fedoa*
long-billed curlew	*Numenius americanus*
willet	*Catoptrophorus semipalmatrus*
greater yellowlegs	*Tringa melanoleuca*
lesser yellowlegs	*T. flavipes*
solitary sandpiper	*T. solitaria*
spotted sandpiper	*Actitis macularia*
Wilson's phalarope	*Phalaropus tricolor*
red-necked phalarope	*P. lobatus*
long-billed dowitcher	*Limnodromus scolopaceus*
common snipe	*Gallinago gallinago*
dunlin	*Calidris alpina*
sanderling	*C. alba*
western sandpiper	*C. mauri*
least sandpiper	*C. minutilla*
Heermann's gull	*Larus heermanni*
Bonaparte's gull	*L. philadelphia*
ring-billed gull	*L. delawarensis*

herring gull	*L. argentatus*
California gull	*L. californicus*
Forster's tern	*Sterna forsteri*
black tern	*Chlidonias niger*
caspian tern	*Sterna caspia*
turkey vulture	*Cathartes aura*
golden eagle	*Aquila chrysaetos*
bald eagle	*Haliaeetus leucocephalus*
northern harrier	*Circus cyaneus*
sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*A. cooperii*
northern goshawk	*A. gentilis*
red-tailed hawk	*Buteo jamaicensis*
Swainson's hawk	*B. swainsoni*
rough-legged hawk	*Buteo lagopus*
osprey	*Pandion haliaetus*
American kestrel	*Falco sparverius*
merlin	*F. columbarius*
prairie falcon	*F. mexicanus*
peregrine falcon	*F. peregrinus*
blue grouse	*Dendragapus obscurus*
California quail	*Callipepla californica*
mountain quail	*Oreortyx pictus*
chukar	*Alectoris chukar*
ring-necked pheasant	*Phasianus colchicus*
band-tailed pigeon	*Columba fasciata*
rock dove	*C. livia*
mourning dove	*Zenaida macroura*
yellow-billed cuckoo	*Coccyzus americanus*
barn owl	*Tyto alba*
short-eared owl	*Asio flammeus*
long-eared owl	*A. otus*
great horned owl	*Bubo virginianus*
California spotted owl	*Strix occidentalis*
western screech-owl	*O. kennicottii*
flammulated owl	*O. flammeolus*
northern pygmy-owl	*Glaucidium gnoma*
northern saw-whet Owl	*Aegolius acadicus*
burrowing owl	*Athene cunicularia*
common poorwill	*Phalaenoptilus nuttallii*
common nighthawk	*Chordeiles minor*
black swift	*Cypseloides niger*
Vaux's swift	*Chaetura vauxi*
white-throated swift	*Aeronautes saxatalis*
black-chinned hummingbird	*Archilochus alexandri*
Anna's hummingbird	*Calypte anna*
calliope hummingbird	*Stellula calliope*
broad-tailed hummingbird	*Selasphorus platycercus*
rufous hummingbird	*S. rufus*
belted kingfisher	*Ceryle alcyon*
northern flicker	*Colaptes auratus*

white-headed woodpecker	*Picoides albolarvatus*
Lewis' woodpecker	*Melanerpes lewis*
Williamson's sapsucker	*Sphyrapicus thyroideus*
red-breasted sapsucker	*S. ruber*
red-naped sapsucker	*S. nuchalis*
downy woodpecker	*Picoides pubescens*
hairy woodpecker	*P. villosus*
black-backed woodpecker	*P. arcticus*
western kingbird	*Tyrannus verticalis*
ash-throated flycatcher	*Myiarchus cinerascens*
olive-sided flycatcher	*Contopus borealis*
western wood-pewee	*C. sordidulus*
black phoebe	*Sayornis nigricans*
Say's Phoebe	*S. saya*
gray flycatcher	*Empidonax wrightii*
dusky flycatcher	*E. oberholseri*
Hammond's flycatcher	*E. hammondii*
willow flycatcher	*E. traillii*
western flycatcher	*E. difficilis*
horned lark	*Eremophila alpestris*
tree swallow	*Tachycineta bicolor*
violet-green swallow	*T. thalassina*
purple martin	*Progne subis*
bank swallow	*Riparia riparia*
northern rough-winged swallow	*Stelgidopteryx serripennis*
cliff swallow	*Hirundo pyrrhonota*
barn swallow	*H. rustica*
western scrub-jay	*Aphelocoma californica*
Steller's jay	*Cyanocitta stelleri*
Clark's nutcracker	*Nucifraga columbiana*
black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhynchos*
common raven	*Corvas corax*
plain titmouse	*Parus inornatus*
mountain chickadee	*Parus gambeii*
bushtit	*Psaltriparus minimus*
brown creeper	*Certhia americana*
white-breasted nuthatch	*Sitta carolinensis*
red-breasted nuthatch	*S. canadensis*
pygmy nuthatch	*S. pygmaea*
house wren	*Troglogytes aedon*
winter wren	*T. troglogytes*
Bewick's wren	*Thryomanes bewickii*
marsh wren	*Astothorus palustris*
canyon wren	*Catherpes mexicanus*
rock wren	*Salpinctes obsoletus*
golden-crowned kinglet	*Regulus satrapa*
ruby-crowned kinglet	*R. calendula*
blue-gray gnatcatcher	*Polioptila caerulea*
western bluebird	*Sialia mexicana*
mountain bluebird	*S. currucoides*

Townsend's solitaire	*Myadestes towndsendi*
Swainson's thrush	*Catharus ustulatus*
hermit thrush	*C. guttatus*
varied thrush	*Ixoreus naevius*
American robin	*Turdus migratorius*
loggerhead shrike	*Lanius ludovicianus*
northern shrike	*L. excubitor*
northern mockingbird	*Mimus polyglottus*
sage thrasher	*Oreoscoptes montanus*
water pipet	*Anthus spinoletta*
American dipper	*Cinclus mexicanus*
Bohemian waxwing	*Bombycilla garrulus*
cedar waxwing	*B. cedrorum*
European starling	*Sturnus vulgaris*
Hutton's vireo	*Vireo huttoni*
solitary vireo	*V. solitarius*
warbling vireo	*V. gilvus*
orange-crowned warbler	*Vermivora celata*
Nashville warbler	*V. ruficapilla*
yellow-rumped warbler	*Dendroica coronata*
black-throated gray warbler	*D. nigrescens*
hermit warbler	*D. occidentalis*
yellow warbler	*D. petechia*
MacGillivray's warbler	*Oporornis tolmiei*
Wilson's warbler	*Wilsonia pusilla*
common yellowthroat	*Geothlypis trichas*
yellow-breasted chat	*Icteria virens*
black-headed grosbeak	*Pheucticus melanocephalus*
blue grosbeak	*Guiraca caerulea*
indigo bunting	*Passerina cyanea*
lazuli bunting	*P. amoena*
green-tailed towhee	*Pipilo chlorurus*
spotted towhee	*P. maculatus*
vesper sparrow	*Pooecetes gramineus*
savannah sparrow	*Passerculus sandwichensis*
song sparrow	*Melospiza melodia*
lark sparrow	*Chondestes grammacus*
black-throated sparrow	*Amphispiza bilineata*
sage sparrow	*A. belli*
chipping sparrow	*Spizella passerina*
Brewer's sparrow	*S. breweri*
dark-eyed junco	*Junco hyemalis*
white-crowned sparrow	*Zonotrichia leucophrys*
golden-crowned sparrow	*Z. atricapilla*
fox sparrow	*Passerella iliaca*
Lincoln's sparrow	*Melospiza lincolnii*
western meadowlark	*Sturnella neglecta*
yellow-headed blackbird	*Xanthocephalus xanthocephalus*
red-winged blackbird	*Agelaius phoeniceus*
tricolored blackbird	*A. tricolor*
Brewer's blackbird	*Euphagus cyanocephalus*

brown-headed cowbird	*Molothrus ater*
Bullock's oriole	*Icterus bullockii*
western tanager	*Piranga ludoviciana*
house sparrow	*Passer domesticus*
pine siskin	*Carduelis pinus*
American goldfinch	*C. tristis*
lesser goldfinch	*C. psaltria*
red crossbill	*Loxia curvirostra*
purple finch	*Carpodacus purpureus*
Cassin's finch	*C. cassinii*
house finch	*C. mexicanus*
evening grosbeak	*Coccothraustes vespertinus*

Mammals

vagrant shrew	*Sorex vagrans*
Preble's shrew	*S. preblei*
Merriam's shrew	*S. merriami*
Trowbridge's shrew	*S. trowbridgii*
montane shrew	*S. monticolus*
water shrew	*S. palustris*
broad-footed mole	*Scapanus latimanus*
little brown myotis	*Myotis lucifugus*
Yuma myotis	*M. yumanensis*
long-eared myotis	*M. evotis*
fringed myotis	*M. thysanodes*
long-legged myotis	*M. volans*
California myotis	*M. californicus*
western small-footed myotis	*M. ciliolabrum*
silver-haired bat	*Lasionycteris noctivagans*
western pipistrelle	*Pipistrellus hesperus*
big brown bat	*Eptesicus fuscus*
western red bat	*Lasiurus blossevillii*
hoary bat	*L. cinereus*
spotted bat	*Euderma maculatum*
Townsend's big-eared bat	*Plecotus townsendii*
pallid bat	*Antrozous pallidus*
Brazilian free-tailed bat	*Tadarida brasiliensis*
white-tailed hare	*Lepus townsendii*
Sierra Nevada snowshoe hare	*L. americanus tahoensis*
black-tailed jackrabbit	*L. californicus*
mountain cottontail	*Sylvilagus nuttallii*
pygmy rabbit	*Brachylagus idahoensis*
mountain beaver	*Aplodontia rufa*
Sierra Nevada mountain beaver	*A. rufa californica*
yellow-bellied marmot	*Marmota flaviventris*
Townsend's ground squirrel	*Spermophilus townsendii*
Belding's ground squirrel	*S. beldingi*
California ground squirrel	*S. beecheyi*
white-tailed antelope ground squirrel	*Ammospermophilus leucurus*
golden-mantled ground squirrel	*Spermophilus lateralis*
least chipmunk	*Tamias minimus*

yellow-pine chipmunk	*T. amoenus*
lodgepole chipmunk	*T. speciosus*
Townsend's chipmunk	*T. townsendii*
long-eared chipmunk	*T. quadrimaculatus*
western gray squirrel	*Sciurus griseus*
Douglas' squirrel	*Tamiasciurus douglasii*
northern flying squirrel	*Glaucomys sabrinus*
Botta's pocket gopher	*Thomomys bottae*
northern pocket gopher	*T. talpoides*
mountain pocket gopher	*T. monticola*
little pocket mouse	*Perognathus longimembris*
Great Basin pocket mouse	*P. parvus*
long-tailed pocket mouse	*Chaetodipus formosus*
Merriam's kangaroo rat	*Dipodomys merriami*
Ord's kangaroo rat	*D. ordii*
chisel-toothed kangaro rat	*D. microps*
dark kangaroo mouse	*Microdipodops megacephalus*
American beaver	*Castor canadensis*
western harvest mouse	*Reithrodontomys megalotis*
canyon mouse	*Peromyscus crinitus*
deer mouse	*P. maniculatus*
brush mouse	*P. boylii*
pinon mouse	*P. truei*
northern grasshopper mouse	*Onychomys leucogaster*
bushy-tailed woodrat	*Neotoma cinerea*
desert woodrat	*N. lepida*
heather vole	*Phenacomys intermedius*
montane vole	*Microtus montanus*
long-tailed vole	*M. longicaudus*
sagebrush vole	*Lemmiscus curtatus*
common muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
house mouse	*Mus musculus*
western jumping mouse	*Zapus princeps*
common porcupine	*Erethizon dorsatum*
coyote	*Canis latrans*
Sierra Nevada red fox	*Vulpes vulpes necator*
kit fox	*V. velox*
common gray fox	*Urocyon cinereoargenteus*
black bear	*Ursus americanus*
common raccoon	*Procyon lotor*
American marten	*Martes americana*
fisher	*M. pennanti*
ermine	*Mustela erminea*
long-tailed weasel	*M. frenata*
mink	*M. vison*
California wolverine	*Gulo gulo luteus*
American badger	*Taxidea taxus*
western spotted skunk	*Spilogale gracilis*
stripped skunk	*Mephitis mephitis*
northern river otter	*Lutra canadensis*

mountain lion	*Felis concolor*
bobcat	*Lynx rufus*
mule deer	*Odocoileus hemionus*

Scientific and vernacular names follow the checklists in:

American Fisheries Society. 1991. Common and scientific names of fishes from the United States and Canada, 5th edition. Spec. Pub. No. 20. Bethesda, Maryland.

American Ornithologists's Union. 1983. Checklist of North American birds, 6th edition. Allen Press, Lawrence, Kansas.

Collins, J. T. 1990. Standard common and current scientific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Herpetological Circular No. 19.

Hickman, J. C., Jr. 1992. The Jepson Manual: higher plants of California. University of California Press, Berkeley and Los Angeles. 1,400 pp.

Jones, J. K., R. S. Hoffmann, O. W. Rice, C. Jones, R. J. Baker, and M. D. Engstrom. 1992. Revised checklist of North American mammals north of Mexico, 1991. Occasional Papers Museum Texas Tech. University.

Reed, P. B., Jr. 1988. National list of plant species that occur in wetlands: Intermountain (Region 8). U.S. Dept. of Interior, Fish and Wildlife Service Biological Report 88 (26.8). Washington, D.C. 76 pp.

PART B. LIST OF SPECIAL STATUS SPECIES KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA THAT ARE NOT LIKELY TO BE AFFECTED BY ALTERNATIVES UNDER CONSIDERATION.

SPECIES	SCIENTIFIC NAME	STATUS[1]	LOCATION AND HABITAT
Plants			
Altered andesite buckwheat	*Eriogonum robustum*	NNHP S2S3	NV endemic, Storey and Washoe Counties. Dry, shallow, highly acidic gravelly clay soils on ridges, knolls and steep slopes usually in stunted pine woodlands; 4,410-7,325 ft.
Altered andesite popcornflower	*Plagiobothrys glomeratus*	NNHP S2S3	NV endemic, Storey and Washoe Counties. Dry, shallow, highly acidic gravelly clay soils on ridges, knolls and steep slopes usually in stunted pine woodlands 4,850-6,650 ft.
Ames milkvetch	*Astragalus pulsiferae* var. *pulsiferae*	NNHP S1	Washoe County, NV; in CA from Lassen to Sierra Counties. Loose, porous volcanic gravels and sands in open ponderosa pine forests, sagebrush plains, or valley floors. 4,265-5,512 ft.
Cup Lake draba	*Draba asterophora* var. *macrocarpa*	FSS CNPS 1B	CA endemic, El Dorado County. Rocky soil in coniferous subalpine forest; 8,200-9,236 ft.
Dog Valley ivesia	*Ivesia aperta var. canina*	FSS CNPS 1B	CA endemic, known only from Dog Valley, Sierra Co.. Vernally wet, shallow rocky soil of volcanic origin in openings of yellow pine forest; 5,700-6,150 ft.
Donner Pass buckwheat	*Eriogonum umbellatum* var. *torreyanum*	FSS CNPS 1B	CA endemic from Placer, Nevada, and Sierra Counties; historic collection on Squaw Creek. Rocky meadows and outcrops, often on ridgetops and steep slopes; 6,000 to 8,000 ft.
Dune sunflower	*Helianthus deserticola*	NNHP S2	Churchill, Clark, Lyon(?), and Mineral Counties, NV; also in UT and AZ. Dry, open, deep sands, often on dunes; 1,345-4,880 ft.
English sundew	*Drosera anglica*	CNPS 2	Nevada, Sierra, and other northern CA counties; circumboreal; known from Sagehen Creek, a tributary to Stampede Reservoir. Bogs and fens, often on sphagnum; 4,264-6,560 ft.
Galena Creek rockcress	*Arabis rigidissima* var. *demota*	FSS CNPS 1B NNHP S2	Placer and Nevada Counties, CA and Washoe County, NV; Apparently restricted to northern Carson Range. Sandy to rocky soils, generally in forest openings; 7,020 to 10,020 ft.
Lemmon's clover	*Trifolium lemmonii*	NNHP S1 CNPS 1B	Nevada, Sierra, and Plumas Counties, CA and Washoe County, NV; dry soils near pine forests or sagebrush flats; 4,920-6,000 ft.

long-petaled lewisia	*Lewisia longipetala*	FSS CNPS 1B	CA endemic from Nevada, El Dorado, Placer, and Fresno Counties. Alpine boulder and rock fields; 8,200-9,595 ft.
Margaret's rushy milkvetch	*Astragalus convallarius* var. *margaretiae*	NNHP S2	NV endemic in Carson City, Douglas, Lyon and Storey Counties. Rocky slopes and flats among sagebrush in the pinyon-juniper and sagebrush zones. 4,700-7,800 ft.
marsh willowherb	*Epilobium palustre*	CNPS 2	Known in CA only from Grass Lake (El Dorado Co.) and Willow Lake (Plumas Co.), circumboreal. Bogs and fens; ±7,218 ft.
Munroe's desert mallow	*Sphaeralcea munroana*	CNPS 2	Placer County, CA (Squaw Creek); to WA, MT, WY, and UT. Dry, open places usually with sagebrush. ±6,560 ft.
Nevada dune beardtongue	*Penstemon arenarius*	NNHP S2S3	NV endemic in Churchill, Mineral, and Nye Counties. Deep, loose soils of valley floors, Aeolian deposits, and dune skirts, often on dunes; 3,920-5,960 ft.
Nevada oryctes	*Oryctes nevadensis*	NNHP S2S3	Western NV including Washoe, Storey, and Churchill Counties; also in CA. Deep sands of stabilized dune washes, and valley flats. 3,900-5,960 ft.
Nevada waterweed	*Elodea nevadensis*	NNHP SH	Originally described from a specimen along the lower Truckee River near Wadsworth. Now not considered to be a valid species.
playa phacelia	*Phacelia inundata*	NNHP S2?	Washoe and Humboldt Counties, NV; also in CA and OR. Alkali playas and seasonally inundated areas with clay soils. 5,030-5,640 ft.
sagebrush pygmyleaf	*Loeflingia squarrosa* ssp. *artemisiarum*	NNHP S1S2	???????????
sand cholla	*Opuntia pulchella*	NNHP S2S3	Western NV including Washoe and Churchill Counties; also in AZ, CA, and UT. On deep sand dunes or deep sand in NV. 3,950-6,300 ft.
scalloped moonwort	*Botrychium crenulatum*	FSS CNPS 2 NNHP S1?	Widespread but uncommon in CA and possibly NV, where currently known only from Spring , Clark County; confined to western North America. Mainly in wet meadows. Not reported from Truckee River Basin.
Sierra Valley mousetails	*Ivesia aperta* var. *aperta*	CNPS 1B NNHP S1	Sierra, Plumas, and Lassen Counties, CA; Washoe and Storey Counties, NV; eastern base of Sierra Nevada; shallow, vernally wet meadows and along rocky streams; 4,500-6,600 ft.
starved daisy	*Erigeron miser*	FSS CNPS 1B	CA endemic in Nevada and Placer Counties. Known from Donner Pass/Lake area. Rocky granitic ledges. 8,200-9,236 ft.
Steamboat monkeyflower	*Mimulus ovatus*	NNHP S1S2	NV endemic in Storey, Washoe, Douglas(?), and Carson City(?) Counties. Dry, gravelly places in sagebrush or pinyon-juniper zones. 4,580-6,200 ft.

Steamboat buckwheat	*Eriogonum ovalifolium* var. *williamsii*	E/NE	Steamboat Springs, Washoe Co., NV; hot spring soil deposits
Subalpine fireweed	*Epilobium oreganum*	FSS CNPS 1B	CA endemic in Sierra, Mono, and Fresno Counties, CA. Meadows and seeps, subalpine coniferous forest. 6,560-8,856 ft. Not reported from Truckee River Basin.
Tahoe draba	*Draba asterophora* var. *asterophora*	FSS CNPS 1B NNHP S1	El Dorado, Alpine, Mono and Tuolumne Counties, CA, and Washoe County, NV. Decomposed granite near timberline. 8,000-10,200 ft.
Tiehm's rockcress	*Arabis tiehmii*	NNHP S1	Washoe County, NV, and Mono County, CA; subalpine to decomposed granite outcrops. 9,820-10,560 ft.
upswept moonwort	*Botrychium ascendens*	FSS CNPS 2	Eldorado, Butte, Tehama, and Shasta Counties, CA and Clark County, NV (Spring Mts.); confined to western North America. Grassy field coniferous forests near streams. 8,891-11,155 ft.
Washoe pine	*Pinus washoensis*	NNHP S1	Washoe County, NV, much of northeastern CA, into PNW? Montane and subalpine coniferous forests. 6,240(?)-8,500 ft.
Washoe tall rockcress	*Arabis rectissima* var. *simulans*	NNHP S1	Douglas and Washoe Counties, NV, possibly in CA; endemic to northern Carson Range. Dry, sandy soils in pine or fir forests. 6,035-7,350 ft.
Western goblin	*Botrychium montanum*	FSS	Butte, Plumas, and Tehama Counties, CA, and other western states. Shaded coniferous forests. 4,920-6,248 ft. Not reported from Truckee River Basin.
Williams combleaf	*Polyctenium williamsiae*	NNHP S2	Western NV including Washoe County. Shoreline of vernal pools in sagebrush and pinyon-juniper zones. 5,700-7,467 ft.
Invertebrates			
Western Lahontan springsnail	*Pyrgulopsis longiglans*	NNHP S2S3	Springs.
Lake Tahoe benthic stonefly	*Capnia lacustra*	NNHP G1/S1	Only at Lake Tahoe; 100-400 feet deep water
Carson Valley silverspot butterfly	*Speyeria nokomis carsonensis*	NNHP S1	Only in Carson River drainage in Alpine County, CA, and Walker River drainage in Mono County, CA.
Birds			
common loon	*Gavia immer*	S/CSSC NNHP S2/S3	BR, LT, LR, PCR, PL, SR; large bodies of water with fish; regular migrant
Sandhill crane	*Grus canadensis*	CT	Tahoe Basin; wet meadows and open areas; migrant; historic nesting LTR
Harlequin duck	*Histrionicus histrionicus*	CSSC	Rare sightings LT, PL, UTR; mountain streams; transient

golden eagle	*Aquila chrysaetos*	CSSC	SA; open terrain; resident
northern goshawk	*Accipiter gentilis*	FSS/CSSC NNHP S3	Tahoe Basin; conifer and aspen forest; resident
prairie falcon	*Falco mexicanus*	CSSC	SA; open terrain; resident
mountain plover	*Charadrius montanus*	S	Great Basin; shortgrass prairies and arid plains; transient
California spotted owl	*Strix occidentalis occidentalis*	FSS/CSSC NNHP S1	Tahoe Basin; coniferous forest; resident
western burrowing owl	*Athene cunicularia hypugaea*	CSSC NNHP S3	LOTR, LR, PL; open terrain; resident
black swift	*Cypseloides niger*	CSSC	Central to southern Sierra; nest near waterfalls; migrant in Tahoe Basin
rufous hummingbird	*Selaphorus rufus*	BCC	Common, often a transient in spring and fall; breeding range is Pacific NW north to Alaska.
Lewis' woodpecker	*Melanerpes lewis*	BCC	Resident breeder in isolated pockets of the Sierra Nevada and other areas of California and northern Nevada.
red-breasted sapsucker	*Sphyrapicus ruber*	S	Sierra Nevada; cavity nesters in cottonwood, willow, aspen, alder, fir and birch trees; resident
gray flycatcher	*Empidonax wrightii*	S	Migrant and breeding species in Great Basin; inhabits sagebrush, pinon-juniper, very open pine woodlands
bank swallow	*Riparia riparia*	CT	LOTR, LR; nest in excavated burrows in vertical banks of fine textured soils
loggerhead shrike	*Lanius ludovicianus*	S	LOTR, LR, PL; open terrain with scattered shrubs; resident
hermit warbler	*Dendroica occidentalis*	S	Summer resident in the Sierra Nevada; uses upper canopies of scattered groups of tall trees
Virginia's warbler	*Vermivora virginiae*	CSSC, BCC	Pinyon-juniper woodlands, mountain mahogany thickets, and brushy areas along streams. No known breeding localities north of the Wassuk Range, NV, and Mono Co., CA.
Brewer's sparrow	*Spizella breweri*	S	Summer resident throughout Nevada; inhabits open, shrub habitats
lark sparrow	*Chondestes grammacus*	S	Summer resident in Great Basin; open shrublands in valleys and foothills
sage sparrow	*Amphispiza belli*	S	Summer resident in Great Basin; sagebrush and chaparral
tricolored blackbird	*Agelaius tricolor*	CCE	Migrant throughout study area; rests in tall, dense cattails or willows, forages on muddy shores

Fish			
Lahontan lake tui chub	*Siphateles bicolor* ssp. *pectinifer*	CSSC FSS	Abundant in Pyramid Lake. Also in Lake Tahoe and Stampede Reservoir where threatened by kokanee and opossum shrimp which have deplete zooplankton on which tui chub feed and largemouth bass which prey on juvenile chubs in rearing areas (Moyle, 2002).
Mammals			
Preble's shrew	*Sorex preblei*	NNHP S2	Nearest known sightings NW Nevada (Sheldon NWR) and Warner mountains; montane sagebrush communities, and brushy riparian areas
Trowbridge's shrew	*Sorex trowbridgii*	NNHP S2	Common and widespread in Sierra Nevada in both wet and dry habitats at mid-elevations (3800-7500 feet). Optimal habitat is mature stages of ponderosa pine and mixed-conifer forests. Distribution not closely tied to availability of water.
Western small-footed myotis	*Myotis ciliolabrum*	NNHP S3	Western U.S.; roosts under rock slabs and crevices, eats flies and insects
western white-tailed hare	*Lepus townsendii*	CSSC	Crest and eastern slope of Sierra Nevada; sagebrush, meadows, and conifer forest
pygmy rabbit	*Brachylagus idahoensis*	NSSC	Northwestern, northern, and eastern two-thirds of the state of Nevada; in association with tall, dense sagebrush
Sierra Nevada mountain beaver	*Aplodontia rufa californica*	CSSC	Dense riparian-deciduous and open, brushy stages of most forest types in Sierra Nevada
Sierra Nevada red fox	*Vulpes vulpes*	CT	May occur within the upper Truckee Basin within coniferous forests
American marten	*Martes americana*	FSS	Tahoe Basin; coniferous forests
Pacific fisher	*Martes pennanti pacifica*	FSS/CSSC	Tahoe Basin; high elevation coniferous forest
Wolverine	*Gulo gulo*	CT	Sierra crest; open terrain above timberline
American badger	*Taxidea taxus*	CSSC	Most of California and Nevada; open terrain

[1] **Federal** - E = endangered; T = threatened; S = Fish and Wildlife Region 1 species of management concern; FSS = Forest Service sensitive species; FSW = Forest Service watch species
State - NE = Nevada endangered; NSSC = Nevada species of special concern; CT = California threatened; CCE = California candidate for endangered species; CSSC = California Department of Fish and Game species of special concern
Location: BR = Boca Reservoir; LT = Lake Tahoe; IL = Independence Lake; LTR = Little Truckee River; LOTR = Lower Truckee River; LR = Lahontan Reservoir; PCR = Prosser Creek Reservoir; PL = Pyramid Lake; SA = Study Area; SR = Stampede Reservoir; UTR = Upper Truckee River

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

TRUCKEE RIVER RIPARIAN VEGETATION AND FLUVIAL GEOMORPHOLOGY STUDY

Final Report
September 30, 1993

REGION ONE

U. S. Department of the Interior
Mission Statement

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

U. S. Fish and Wildlife Service
Mission Statement

It is the mission of the U.S. Fish and Wildlife Service to provide leadership to achieving a national net gain of fish and wildlife and the natural systems which support them.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

September 30, 1993

Memorandum

To: Field Supervisor, Ecological Services
Reno Field Office, Reno, Nevada (ES)

From: Acting Field Supervisor, Ecological Services
Sacramento Field Office, Sacramento, California (ES)

Subject: Truckee River Riparian Vegetation and Fluvial Geomorphology Hydrology Study: Final Report

This memorandum transmits three copies of our final report on the Truckee River Riparian Vegetation and Fluvial Hydrology Study. An additional 43 copies will be hand-delivered at our next meeting, scheduled for October 22 at the Sacramento Field Office. The attached report provides an overview of the methods and results of the study. It also includes preliminary models to be used in assessing the effects of changes in hydrologic regime on riparian vegetation. Also included, under separate cover, is a set of cover type maps prepared for the entire study area.

Per our agreement, we will continue to assist the Reno Field Office in using the information provided in this report to prepare an Environmental Impact Statement for the Truckee River Operating Agreement. We look forward to continued cooperation. Should you have any questions regarding the attached report, please contact Steve Caicco of my staff at (916) 978-4613.

Dale A. Pierce

attachments (3 copies)

cc: (w/attachments)
ARD-ES, Portland, OR

TRUCKEE RIVER RIPARIAN VEGETATION

AND

FLUVIAL GEOMORPHOLOGY STUDY

Final Report
September 30, 1993

Prepared for:
U.S Fish and Wildlife Service
Reno Field Office - Ecological Services
Reno, Nevada

Prepared by:
Steve Caicco, Mitchell Swanson, and Marla Macoubrie
U.S. Fish and Wildlife Service
Sacramento Field Office - Ecological Services
Sacramento, California

TABLE OF CONTENTS

List of Figures

List of Tables

Technical Appendices

INTRODUCTION

This report describes the results of an investigation of riparian vegetation and fluvial dynamics on the Truckee River in California and Nevada. The objectives of the study were to gain an understanding of the influence of geomorphology, hydrology, and land use on the character and distribution of riparian vegetation and wildlife habitat, and to develop a preliminary model of the relationship between riparian vegetation and fluvial hydrology.

Riparian vegetation and geomorphic processes in streams interact and influence the development of channel morphology and riparian cover. Riparian vegetation thrives where it is high enough in the channel to survive winter/spring scouring floods but low enough to tap summer water supply. Such sites typically occur on gravel bars, channel banks, and on floodplains. Dense, established vegetation is often a significant hydraulic feature in the channel and on the floodplain. By increasing hydraulic drag on flood flows, vegetation can reduce flow velocities and induce fine sediment deposition. This in turn enhances substrate conditions for the establishment and growth of some plant species, resulting in a "positive feedback" loop. The hydraulic roughness of vegetation and the woody debris it produces can also reduce channel flow capacity causing lateral erosion and a lateral shift in the channel pattern. This meandering process, often referred to as the point bar riparian succession model, may destroy existing vegetation while creating new opportunities for regeneration.

The hydrologic influences on riparian vegetation include water supply during the growing season, particularly in arid areas, and surface/groundwater interaction. In addition, the depth, force, and frequency of flood flows are major factors in shaping the physical environment in which riparian vegetation occurs. The importance of these factors can be evaluated by statistical analysis of streamflow records, and by field observation and measurement of hydraulic factors. Such an analysis determines how much water is available at given times for the growth, establishment, and maintenance of riparian plants, and how often floods sufficient to erode and destroy vegetation occur.

Geomorphic factors affecting riparian vegetation include bedrock and surficial geology, the nature and mobility of channel sediments, the influence of the interactive processes of flooding and sediment transport on channel morphology (channel width, depth, slope and pattern, and floodplain topography), and geomorphic change through time. These factors are analyzed by the characterization of geomorphic features through field measurement and by map and aerial photograph analysis. A qualitative channel/vegetation response model is developed through the documentation of historical geomorphic changes and sedimentological features in the field correlated to specific hydrologic flood events.

Human land use near rivers often has a profound effect upon river hydrology, geomorphology and, consequently, riparian vegetation. Water resources development (diversion and damming), agricultural conversion, domestic livestock grazing, the introduction of non-native plant species, road and bridge construction, and watershed and floodplain urbanization physically alter the river landscape and the hydrologic and geomorphic processes that influence riparian vegetation. In some cases, activities such as flow diversion, fill placement or grazing destroy vegetation and the conditions that support it. In other cases, particularly with excess agricultural and/or domestic irrigation runoff, human activities may locally enhance conditions for vegetation. The effects of human activities are evaluated through historical and field observations.

Despite the complexity introduced by the many possible combinations of these factors, there remains an underlying correlation between fluvial hydrology and riparian vegetation. Our responsibility to balance our water resource development with conservation of the Nation's biological resources depends on our understanding of basic ecosytem process. It is the hope of the authors that the information we present in this report furthers that understanding.

FLUVIAL GEOMORPHOLOGY

Overview

The Truckee River drains a 1,200 mi^2 drainage basin from the Lake Tahoe Basin in the Sierra Nevada into the Great Basin at Pyramid Lake, Nevada (**Figure 1**). From the outlet dam at Lake Tahoe, the River flows 108 miles through steep mountain canyons and narrow valleys over 6,000 feet in elevation, highly urbanized areas in and around the city of Reno, agricultural areas irrigated with diverted flow, and high desert canyons and valleys above 4,000 feet.

The present Truckee River was formed concordantly with the uplift of the Sierra Nevada during the Quaternary period (past 5 million years). The upstream boundary of our study area is Lake Tahoe, which lies in a deep "graben" basin formed by subsidence along faults separating the Carson Range to the east from the Sierra Nevada crest to the west. Granitic rocks underlie most of the Tahoe Basin, but younger volcanic rocks top the surrounding peaks and line the canyon through which the Truckee River flows out of the Tahoe Basin from Tahoe City to the town of Truckee.

While the Sierra Nevada uplifting continues, the Great Basin is undergoing extensional tectonics, the primary force that has formed the basin and range topography typical of Nevada, southeastern California, and western Utah. The greater Reno area and the vicinity of Pyramid Lake are subsiding basins while the surrounding mountains are rising. Large lakes filled many of the basins during the glacial periods of the Pleistocene Era (12,000 to 3.2 million years before present) and early Holocene (today to 12,000 years before present). Lake sediments of an earlier Pyramid Lake (once a part of the larger Lake Lahontan) are found nearly 1,000 feet higher than its present level and extend up the Truckee River to areas between Wadsworth and Reno. Truckee Meadows, i.e., the greater Reno area, was also once a glacial fed lake, although it had evaporated to an extensive system of marshes and wetlands by the time the first European settlers arrived in the early 1800s.

The headwaters of the Truckee River, located within the 500 mi^2 Lake Tahoe basin, lie in steep mountain cirques basins with numerous tributary streams and small lakes. After flowing into Lake Tahoe, waters enter the Truckee River near the natural rim at Lake Tahoe Dam, a structure that raises the level of Lake Tahoe by 6.0 feet and adds about 750,000 acre feet of water storage above the natural rim. In addition to Lake Tahoe Dam, flows on major tributaries of the Truckee River are also highly regulated by dams and reservoirs on Donner Lake, Prosser Creek, the Little Truckee River (Boca, Stampede, Independence and Weber Lakes), and Martis Creek (**Table I**). Derby Dam, Numana Dam, and Marble Bluff Dam impound waters on the main stem of the Truckee River downstream of Reno. Numerous smaller diversion structures occur on the main stem and in tributary basins.

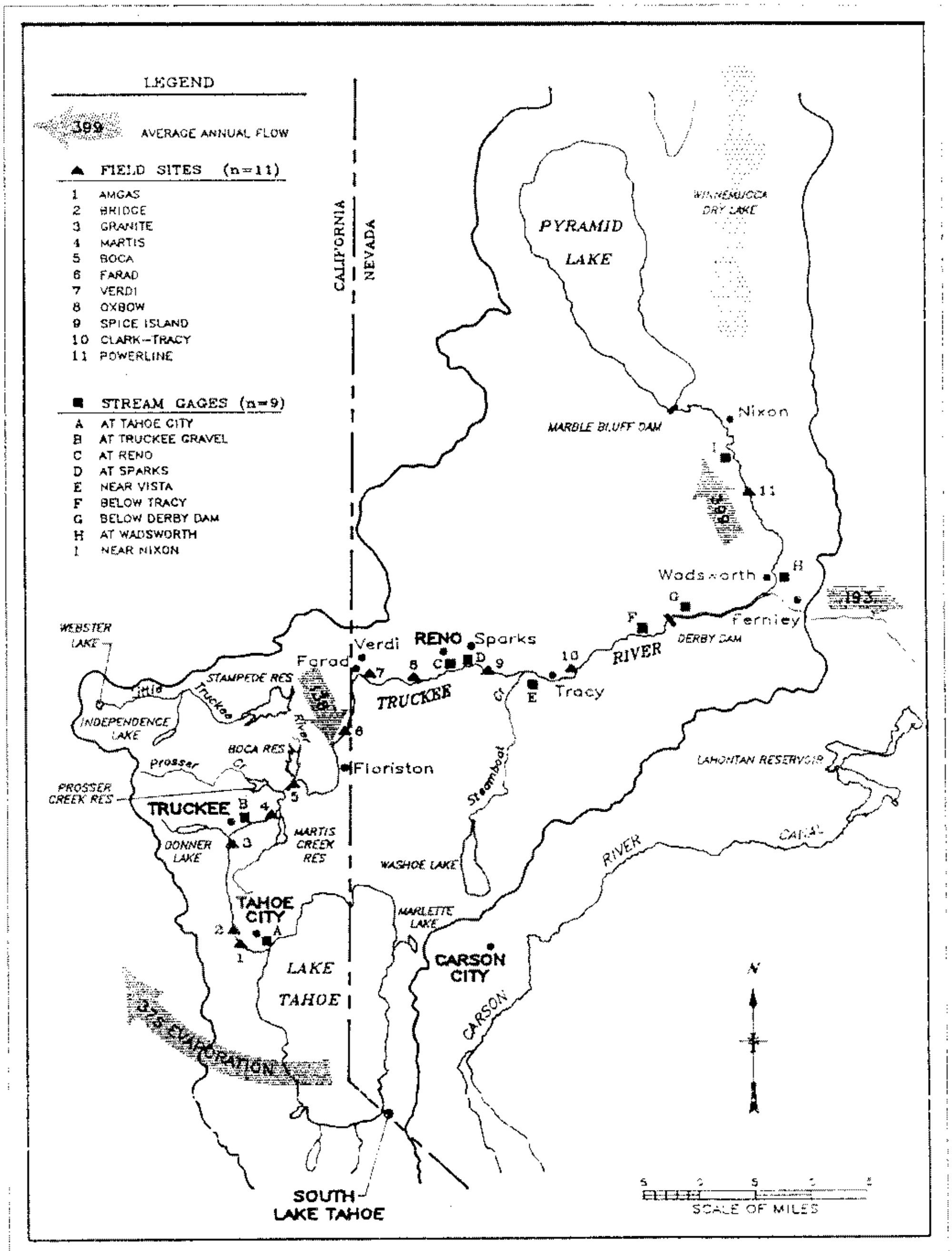

Figure 2. The Truckee River study area showing field sites, gaging stations, and major reservoirs (modified from California Department of Water Resources 1991, p. 35). Flows are in acre-feet.

Table I. Statistics for major reservoirs in the Truckee River Basin.

Reservoir Name	**Storage** *(Acre-Feet)*	**Drainage Area** *(mi²)*	**Date Closed**	**Elevation** ***(Feet MSL)***	**Function(s)**
Lake Tahoe	744,600	506	1913[1]	6227	Storage for instream flow and irrigation[2].
Donner Lake	9,500	14	1930s[3]	5900	Municipal[4] and irrigation water supply.
Martis Creek	20,300	40	1971	5760	Flood control.
Prosser Creek	29,800	50	1962	5680	Flood control, instream flow, water conservation in Lake Tahoe.
Independence Lake	17,500	8	1939[5]	6300	Municipal supply[4].
Stampede Reservoir	226,500	136	1970	5760	Pyramid Lake fish flows and flood control.
Boca Reservoir	41,100	172	1937	5600	Municipal and irrigation water supply.

1The first dam was constructed in 1871 or 1874 (DEPARTMENT OF WATER RESOURCES, 1991)

2For Newlands Project operated by Truckee Carson Irrigation District.

3Original dam was constructed in 1877.

4For Reno/Sparks, NV.

5Small dam originally constructed in 1879.

In general, the reach between Lake Tahoe and the Reno-Sparks area (i.e., the Truckee Meadows) is steep, confined and incised with limited adjacent floodplain areas for riparian vegetation. In the Truckee Meadows area, the river once meandered within a broad floodplain with extensive associated wetlands. These floodplain areas were initially converted to agricultural land, but are now predominately urban and industrial; channelization through the Reno area and below Vista de-watered many wetland areas and confined the Truckee River to a narrow corridor. Flood control has been achieved for these lands through a combination of channelization and construction of flood storage reservoirs.

Downstream to the east of the Truckee Meadows, the river is confined within a narrow desert valley. The floodplain areas have been highly altered by agricultural, commercial, urban and industrial developments. Several miles upstream of Wadsworth at Derby Dam, much of the river's flow is diverted to the Carson River Basin and Lahontan Reservoir. This has changed the hydrology of the river downstream to a highly variable regime of minimal low flows and periodic high flood flows when upstream storage is exceeded. From Wadsworth to Dead Ox Canyon, agricultural development, channelization and grazing have dramatically changed geomorphic conditions which once supported a broad meandering stream with extensive stands of cottonwood and willow thickets. From Numana Dam to Marble Bluff Dam, and to Pyramid Lake, extensive channel incision and widening was caused by a lowering of base levels at Pyramid Lake, as a result of the water diversions at Derby Dam. This channel incision and irrigation diversions have dramatically changed the original geomorphic and hydrologic conditions that supported riparian vegetation.

Floodplain and Channel Bank Mapping

Methodology. Floodplain mapping attempts to correlate flow inundation frequency and duration with the topography of channel and floodplain surfaces, geomorphic features and riparian cover. This was accomplished by statistical analysis of streamflow records to develop flood frequency and flow duration plots (**Appendix A**), hydraulic analysis, and combined topographic and vegetative mapping.

Statistical flood frequency and flow duration plots were constructed with standard USGS WATSTORE calculations for eight stream gages located along the river (**Figure 1**). Streamflow records were examined to gain an understanding of conditions that generate major floods. Channel hydraulics were calculated for cross sections at eleven field sites to relate flow rate with topographic inundation (**Figure 1**). Field sites were selected for their hydrologic and vegetative representation of larger type reaches (**Table II**). In this way, the hydraulic and geomorphic data generated at a given field site should be applicable to conditions within the reach. In addition, sites were chosen to isolate river hydrology to the extent possible as a controlling variable for vegetation growth, away from other hydrologic influences (e.g., irrigated pastures above channel banks, unlined irrigation canals, springs, significant grading and fill placement, sewage effluent runoff).

Table II. Field sites used for the Truckee River Riparian Study. See Figure 1 for locations of sites and stream gages.

Site	Elevation (feet MSL)	USGS stream gage used to characterize hydrology
American Gas	6,200	Truckee River at Tahoe City, CA
Walsh Bridge	6,000	Truckee River at Tahoe City, CA
Granite	5,880	Truckee River at Tahoe City, CA
Martis Creek	5,660	Truckee River at Truckee, CA
Boca	5,450	Truckee River at Truckee, CA
Farad	5,100	Truckee River at Farad, CA
Verdi	4,830	Truckee River at Farad, CA
Oxbow	4,600	Truckee River at Reno, NV
Spice Island	4,390	Truckee River at Sparks, NV
Clark-Tracy	4,230	Truckee River near Vista, NV
Powerline	3,960	Truckee River near Nixon, NV

Two to four channel/floodplain cross sections were surveyed at each field site using tape, rod and auto level. Vegetation cover data were simultaneously collected along the same cross sections. Topographical datums were set to arbitrary elevation datums at each site. Cross section locations were plotted on aerial photographs (scale 1 inch = 100 feet) and the hydraulic characteristics of the cross sections (high water marks, channel roughness characteristics, etc.) were noted in the field. Hydraulic calculations were carried out using the standard step backwater method in the U.S. Army Corps of Engineers HEC-2 computer simulation program. Cross-sectional and hydraulic data were plotted using Quattro Pro (**Appendix B**). An analysis of aerial photographs was also conducted to characterize the degree of alteration of the river and its hydrology based upon a percentage of modification within 1/4 mile segments. **Tables III** and **IV** show the channel bank and floodplain types. The results of the channel bank and floodplain type analyses are presented in pie and bar charts in the discussion of **Project Reaches and Field Sites** below.

Table III. Channel bank types and definitions used in assessing the degree of alteration of the Truckee River.

TYPE	**DEFINITION**	
NATURAL	No significant local modification of the channel bank noted in the aerial photographs.	
DEVELOPED	Channel bank impacted by clearing and residential and/or commercial development.	
	Minor	Less than 25 percent of the channel bank shows measurable impacts
	Moderate	Greater than 25 percent of the channel bank shows impact.
FILL RIP-RAP	Minor	Less than 25 percent of the channel bank has significant fill placement; typically associated with grading.
	Moderate	25 to 50 percent of the channel bank has fill placement or is rip-rapped. Generally is side-cast fill from road paralleling the stream channel.
	Extensive	50 to 100% of the channel bank fully rip-rapped or concrete-lined.

Table IV. Floodplain types and definitions used in assessing the degree of alteration of the Truckee River.

TYPE	DEFINITION	
NATURAL	No significant modification of the floodplain noted in the aerial photos. May include infrequently used small dirt roads.	
DEVELOPED	Modification of the floodplain surface due to local grading and construction.	
	Minor	Less than 25 percent modified; typically minor grading and clearing, but may include infrequent residences and structures.
	Moderate	Between 25 and 50 percent modified; low density homes or commercial structures; moderate to significant grading.
	Major	Greater than 50% modified; high density residential and commercial structures; extensive grading including gravel pit mining.
AGRICULTURAL	Modification of the floodplain surface due to local agricultural use.	
	Low	Less than 50 percent of the floodplain modified.
	High	Greater than 50 percent of the floodplain modified; typically high intensity use.
FILL	Placement of artificial fill on the floodplain surface.	
	Low	Minor fill side-cast along roads and/or railway alignments. Placement of fill does not significantly impede flow over the floodplain.
	High	Thick fill placed to raise road and railway beds, and/or levee alignments. Placement of fill will significantly impede natural flow over the floodplain.
AQUEDUCT	Aqueduct located on or adjacent to floodplain.	

Project Reaches and Field Sites. The Truckee River within the study area was divided into eight reaches based upon morphologic, hydrologic, geographic and ecological characteristics (**Table V**). Geomorphic and hydrologic factors that influence the development of riparian vegetation include the degree of channel confinement, the supply of surface and groundwater for plant growth, the frequency of scouring floods, the degree of sediment mobility (flow thresholds that initiate sediment movement), the frequency of mobilizing flows, and the degree of geomorphic and hydrologic alteration due to human activity and land uses. The characteristics and processes of the reaches were interpreted through field observation, analysis of recent aerial photographs, and detailed analysis of specific field sites (**Table II**).

Table V. Characteristics of project reaches defined by morphologic, hydrologic, and ecological similarities.

Reach	**River miles from Lake Tahoe**	**Elevation Change (feet above MSL)**
Lake Tahoe to Boca Reservoir	0.0 - 23.25	6229 - 5500
Boca to State Line	23.25 - 36	5500 - 5000
State Line to Vista	36.0 - 59.3	5000 - 4400
Vista to Derby Dam	59.3 - 76.3	4400 - 4200
Derby Dam to Wadsworth	76.3 - 87.5	4200 - 4100
Wadsworth to Dead Ox Canyon	87.5 - 97.0	4100 - 3500
Dead Ox Canyon to Numana Dam	97.0 - 101.5	3500 - 3920
Numana Dam to Marble Bluff Dam	101.5 - 108.3	3920 - 3860

Although flow records and statistics from nearby gages do not precisely reflect the hydrology of the field sites, correlations between frequency and inundation of topographic features (i.e., channel and floodplain) hold consistently throughout the project reach. In general, **rain-flood** events, those generated by intense winter rainfall atop snow pack, occur once every ten years on average (generally 10,000 cfs and above). These flows inundate floodplain areas, mobilize and transport sediments, and cause shifts in channel pattern. Unregulated spring and early summer **snowmelt** floods are of longer duration and lower discharges (generally 2,000 to 7,000+ cfs), which are well contained within the active channel. Snowmelt floods do not move significant sediment loads nor cause significant channel changes. A possible exception is for some areas below Wadsworth where channel bank materials are fine grained and easily mobilized. Snowmelt discharges do not occur regularly due to diversion at Derby Dam and storage in upstream reservoirs. Statistical correlations between inundation frequency, geomorphically significant flood events (those which shape the channel and create physical conditions for riparian vegetation) and the distribution of riparian vegetation is discussed in **Development of a Fluvial Hydrology-Vegetation Model** below. The following reach-by-reach description of hydrologic and geomorphic conditions given below includes a description of the impact of human activity and land uses which affect riparian vegetation growth.

Lake Tahoe Dam to Boca Dam

The Truckee River between Lake Tahoe and the confluence of the Little Truckee River near Boca Dam flows through an incised channel with limited areas of floodplain. Channel gradients vary between those that create white water rapids to low energy areas that are bounded by marshes (**Figure 2**).

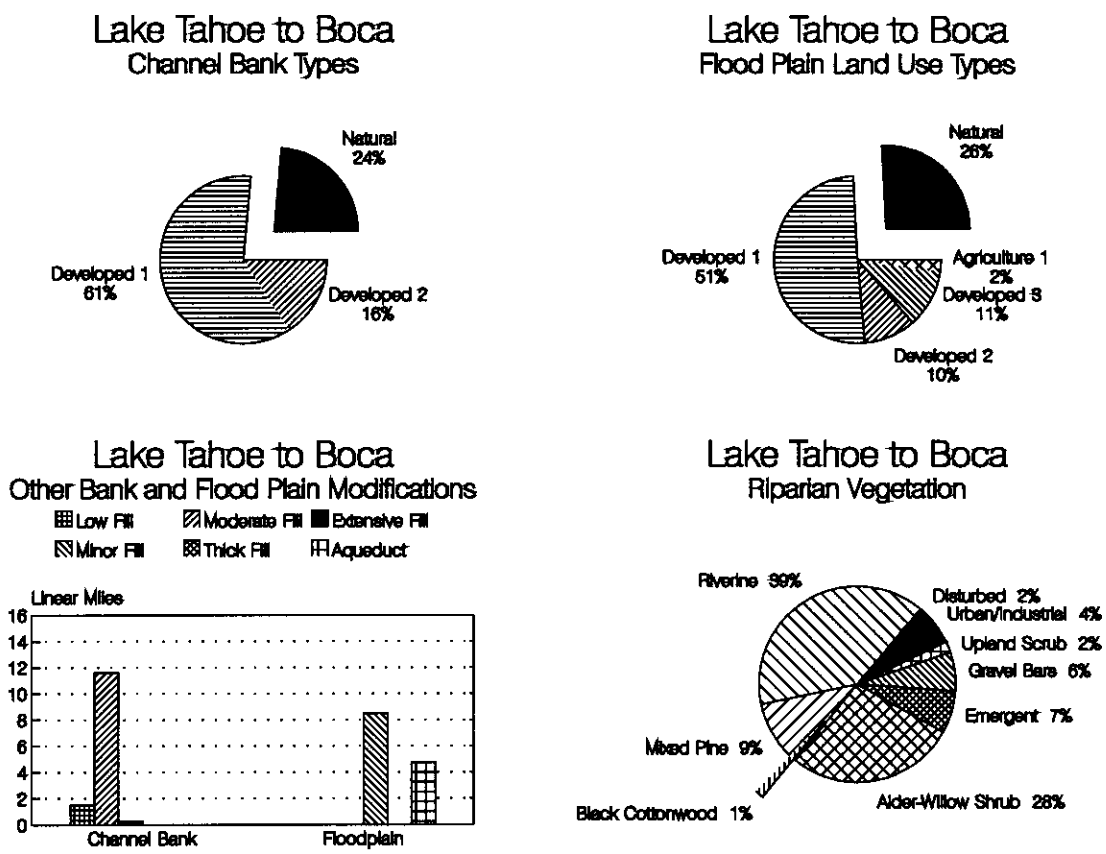

Figure 3. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Lake Tahoe to Boca Reach.

The river flows within a narrow canyon between western Tahoe City and the confluence with Squaw Valley Creek, 7 miles north; stream flows are well contained between the highway road fill and hillslopes on the opposite bank. The river changes abruptly from a low-gradient, marshy channel (characterized by the **American Gas** field site) to a steep whitewater river at Alpine Meadows (typified by field site **Walsh Bridge**). Below Squaw Valley Creek, the canyon broadens to a narrow valley with lodgepole pine and mountain alder-dominated floodplain areas and lodgepole pine/sagebrush scrub covered alluvial terraces which are elevated above the floodplain. The river gradually flattens downstream, but cascading shallow whitewater is common. Most flows are well contained within the channel and offer little area for riparian vegetation; many areas are predominately lodgepole and Jeffrey pine with limited patches of alder-willow shrub.

At Granite Campground (field site **Granite**), the channel gradient decreases and the floodplain widens to more than 120 feet. The channel morphology consists of pools and riffles. The floodplain, which supports black cottonwood and alder-willow shrub, is susceptible to flooding during larger rain-flood events that occur once every 10 years on average. The channel has remained in its present position for some time and many floodplain trees are large (24-36 inch dbh).

At River Road in Truckee, the river turns easterly and enters the Truckee Valley, where the river flows in a channel incised into valley fill of glacial outwash. The channel is steep and cobble-lined with whitewater during most discharges. Large floods are well contained within the channel, although bank erosion may occur at higher discharges. Between River Road and the sewage treatment plant, there is little riparian vegetation except for willow fringe along the base of the channel bank and scattered cottonwood higher on the bank.

Between the sewage treatment plant (location of field site **Martis Creek**) and Boca Reservoir there is a distinct floodplain supporting meadows, cottonwood trees, alder-willow scrub, and pine forest. The channel has an alternating bar, or braided, morphology which provides a variety of riparian vegetation; sediments vary between dominant boulder to fine mud in backwater areas. The flood record indicates that significant scouring events occur with major rain/flood events once every 10 years on average. Snowmelt flows are generally well contained within the channel, and to some extent keep the lower portions of the channel clear of vegetation; floodplain areas are not readily inundated during snowmelt flow in this reach.

Summer water supply for riparian vegetation is provided by surface flow in the river, groundwater and underflow, spring flow, and irrigation on the floodplain in urban areas and at the sewage treatment plant. In the summer of 1992 when field work was conducted for this study, many portions of this reach were nearly dry save some small isolated ponds. There was little detectible flow. It is reported that the Tahoe City to Squaw Valley reach is a gaining stream by virtue of springflow. This flow appeared sufficient enough to support groundwater for most riparian trees present (McKenna 1990).

Boca Reservoir to State Line

From Boca Reservoir to the California-Nevada State Line, the Truckee River is confined by bedrock within a narrow canyon and steep mountain hillslopes. Opportunities for survival of riparian vegetation are limited due to frequent scour and lack of suitable substrates. There are, however, significant but discontinuous floodplain areas occurring throughout this reach supporting good stands of cottonwood forest and alder-willow shrub. The floodplain is not usually inundated by spring and early summer snowmelt runoff, but rather by the relatively infrequent 10-year rain flood events (characteristic of field site **Farad**). Some channel reaches have boulder/cobble bars which support alder-willow shrub vegetation; these sites are subject to frequent scour, including periods during spring snow melt floods (characteristic of field site **Boca**). The hydrology and geomorphology of this reach have been highly altered in many places by fill placement for roads and railroads and bridges. This practice destroys floodplain areas that may have normally supported riparian vegetation (**Figure 3**). In-channel diversion dams occur for run-of-the-river hydroelectric power generation at Floriston and at Puny Dip Canyon.

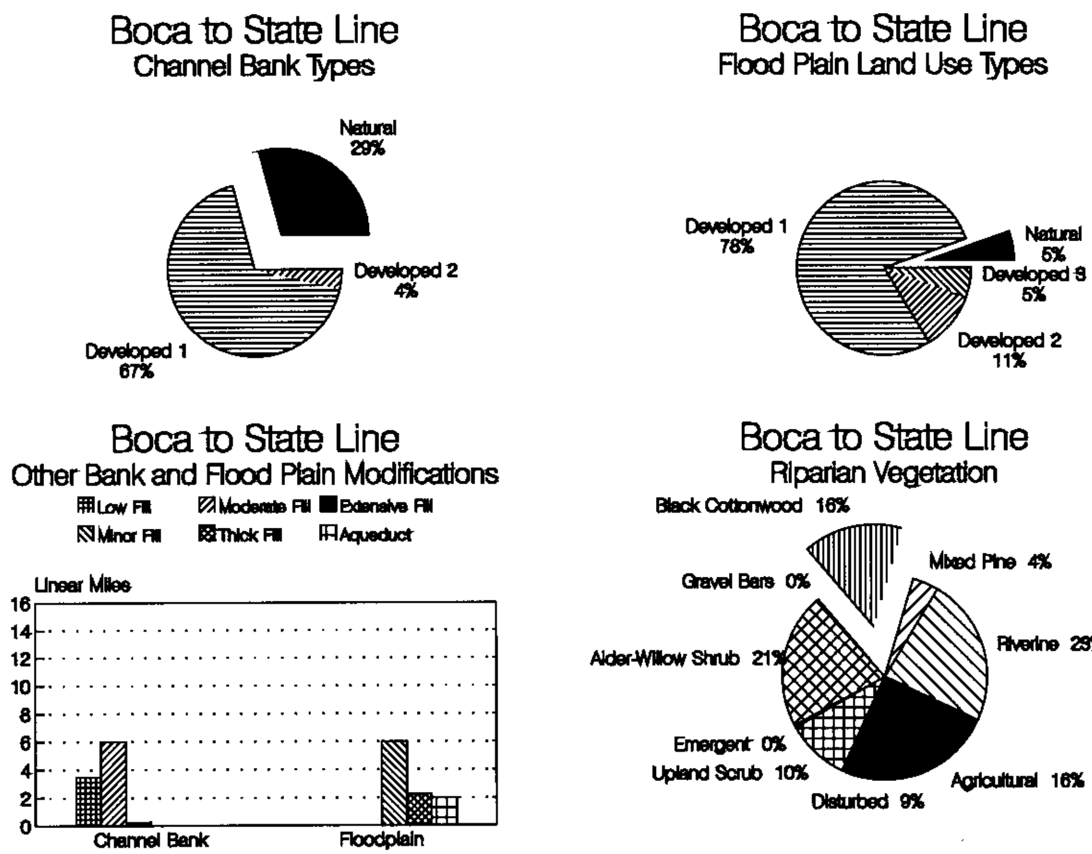

Figure 3. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Boca to State Line Reach.

Stateline to Vista

The Stateline to Vista reach contains a variety of settings including a high-gradient mountain stream with dense riparian cover, side-lined concrete channels in downtown Reno, and a riparian corridor surrounded by desert at Vista. The river in this reach has been substantially altered by earthwork and hydrologic modification and other ongoing human activity which has reduced or eliminated opportunities for riparian vegetation (**Figure 4**).

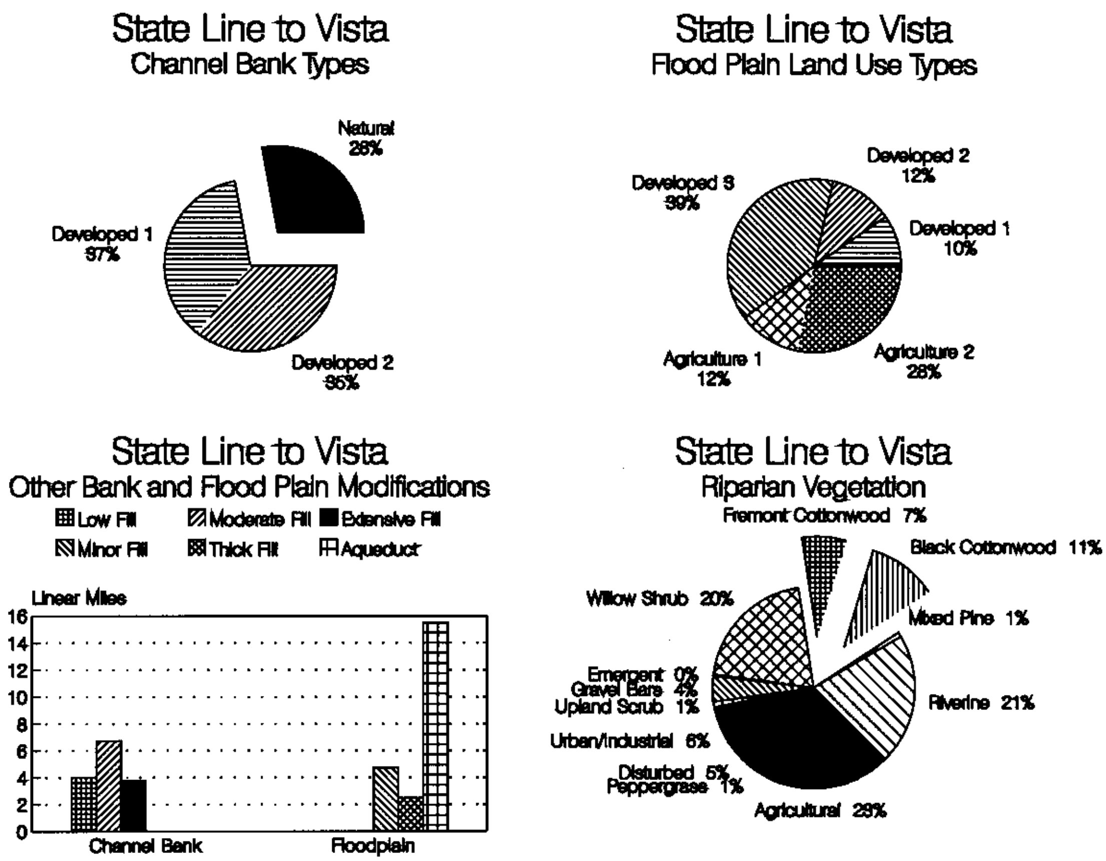

Figure 5. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the State Line to Vista Reach.

Immediately below Stateline, the valley of the Truckee River widens just upstream of Verdi. Between Verdi and West Reno, the channel is bounded by substantially wider floodplain areas, many of which were once mixed meadow and black cottonwood riparian forest and have since been converted to pasture or urban lands. The river still has a high gradient between Verdi and downtown Reno, with frequent scouring floods near the channel and far less frequent inundation of floodplain areas which support black cottonwood and pine forest (at field site **Verdi**) and Fremont's cottonwood and willow (at field site **Oxbow**).

Below downtown Reno within the town of Sparks, the river is channelized within earthen banks. Bank erosion protection works are found in many areas, consisting of everything from large rock revetments to dumped concrete rubble (characteristic of field site **Spice Island**). The active channel in the Sparks area is approximately 200 feet wide, 15 to 18 feet deep with steep to moderately sloped banks, alternating gravel/cobble bars, and a regular pool/riffle morphology in the low flow channel. The cities of Reno and Sparks have developed some public access river parks; however, there are substantial areas where urban uses occur up to the top of bank. There is limited native riparian vegetation in these areas.

Numerous water supply diversions occur between Stateline and downtown Reno. Some of these diversions are for municipal and industrial uses. Part of the water returns to the river at the Reno/Sparks sewer plant near Vista. Other diversions flow within unlined earthen ditches and, combined with irrigation return flow, do provide a supplemental water source for riparian vegetation on the channel banks.

The channel in the Stateline to Vista reach is stable. There were reports of significant channel incision at Verdi where residents report a 6-foot decline in bed elevations from the February 1986 flood; this could have lowered the hydraulic control for the summer water table under floodplain areas supporting riparian vegetation.

Vista to Derby Dam

The Truckee River between Vista and Derby Dam flows within a narrow desert valley of variable width. The wider areas are generally correlated with broad floodplain areas, although past channelization below Vista appears to have stranded former floodplain areas well above inundation and summer water levels. In broad floodplain areas, riparian vegetation has been cleared to accommodate agricultural, grazing, industrial or urban uses (**Figure 5**). Remnant stands of Fremont's cottonwood and willow are found in some areas, particularly where inadvertent buffering has occurred (such as the **Clark-Tracy** field site where placement of railroad fill isolated the floodplain area road access). Gravel mining has severely impacted sections of this reach leaving a denuded channel and large pits where the floodplain areas once occurred. The hydrology of this reach is severely affected by upstream regulation and diversion which remove flow, and by sewage effluent discharge at Vista which slightly increases flow.

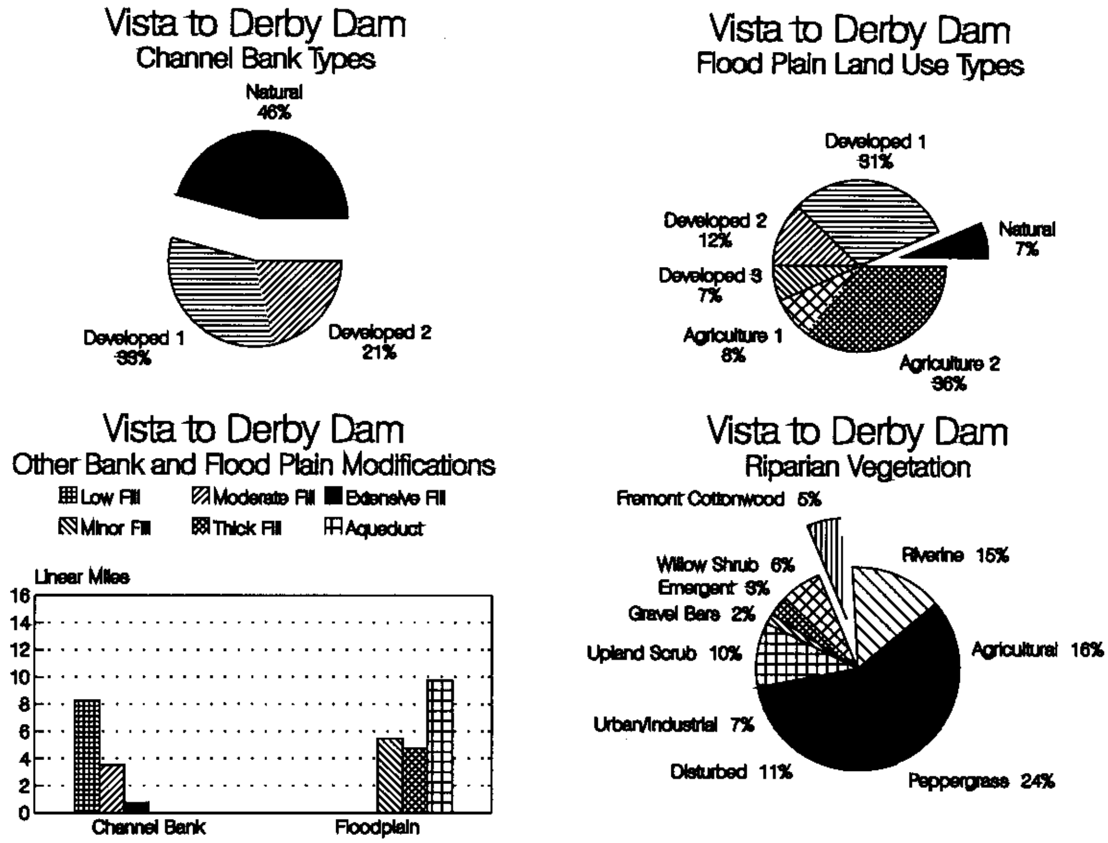

Figure 5. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Vista to Derby Dam Reach.

Derby Dam to Wadsworth

Derby Dam marks a significant hydrologic boundary in the Truckee River, where much of the stream flow is diverted south-eastward to Lahontan Reservoir. The floodplain areas below Derby Dam are highly altered by agricultural uses and road fill placement offering little opportunity for riparian vegetation growth (**Figure 6**). There are some stands of Fremont's cottonwood and willow indicating that seepage from valley side or floodplain irrigation channels, groundwater and surface water through Derby Dam are sufficient to support some riparian vegetation.

Wadsworth to Dead Ox Canyon

At Wadsworth, the Truckee River turns northward and enters a wide alluvial valley bounded by alluvial fans and desert mountains. The wider valley provides for a significantly wider floodplain and opportunities for riparian forest and shrub vegetation. Historic and ongoing land uses have severely reduced stands and successful reproduction of the riparian trees and shrubs. Channelization, hydrologic modification, clearing, agriculture and grazing have severely reduced riparian vegetation, and that which remains is in a highly degraded condition (**Figure 7**).

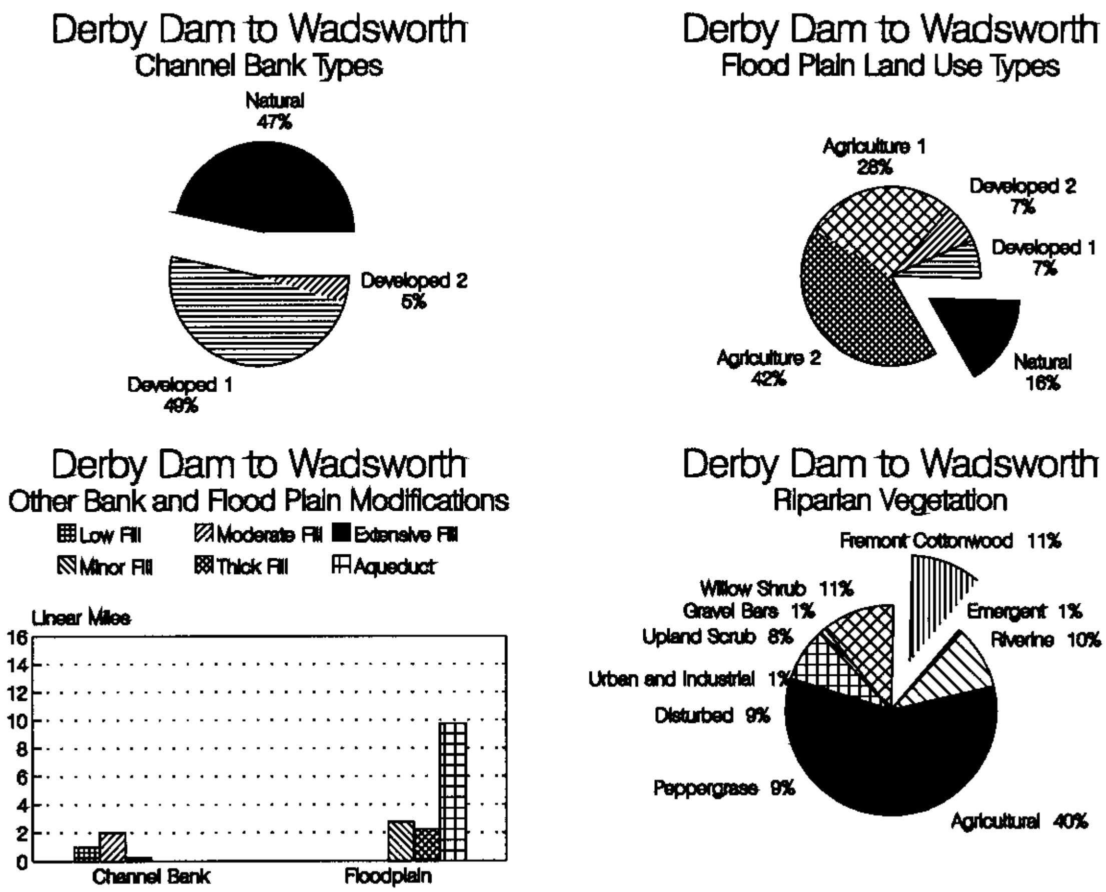

Figure 6. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Derby Dam to Wadsworth Reach.

Where once the channel freely meandered and was perhaps modified annually by spring snow melt floods creating substantial areas of willow shrub and cottonwood forest, channelization and hydrologic modification has reduced the area of successful vegetation reproduction to the active channel (characteristic of field site **Powerline**). Vegetation in the active channel is highly susceptible to flood scour unless it is given sufficient time to become established (an experiment of potential riparian survival against large flows is underway as the recent drought has actually allowed some active channel stands to reach 5-7 years in age. Grazing and trampling by domestic livestock also reduces or eliminates riparian vegetation, particularly young plants and seedlings.

The hydrology of this reach is highly regulated by storage and diversion. The hydrology has been modified to eliminate moderate-sized floods typically associated with snowmelt flows. Such flows, given the fine grained-bank material, were likely very important for channel and floodplain forming processes. These intermediate flows have been eliminated by upstream reservoir storage and diversions, particularly at Derby Dam. This has left a regime of minimal low flows and extreme high flows produced by severe rain-flood events. Thus, channel forming events are extreme and, when combined with channelization projects and a lack of stabilizing vegetation, result in a deeper, narrower and straighter channel. Summer season water supplies depend upon the characteristic of the particular water year and flow available below the upstream diversions. There are no significant perennial tributary streams below Derby Dam. Irrigation for agriculture on the floodplain may add to the moisture available in the floodplain for riparian vegetation.

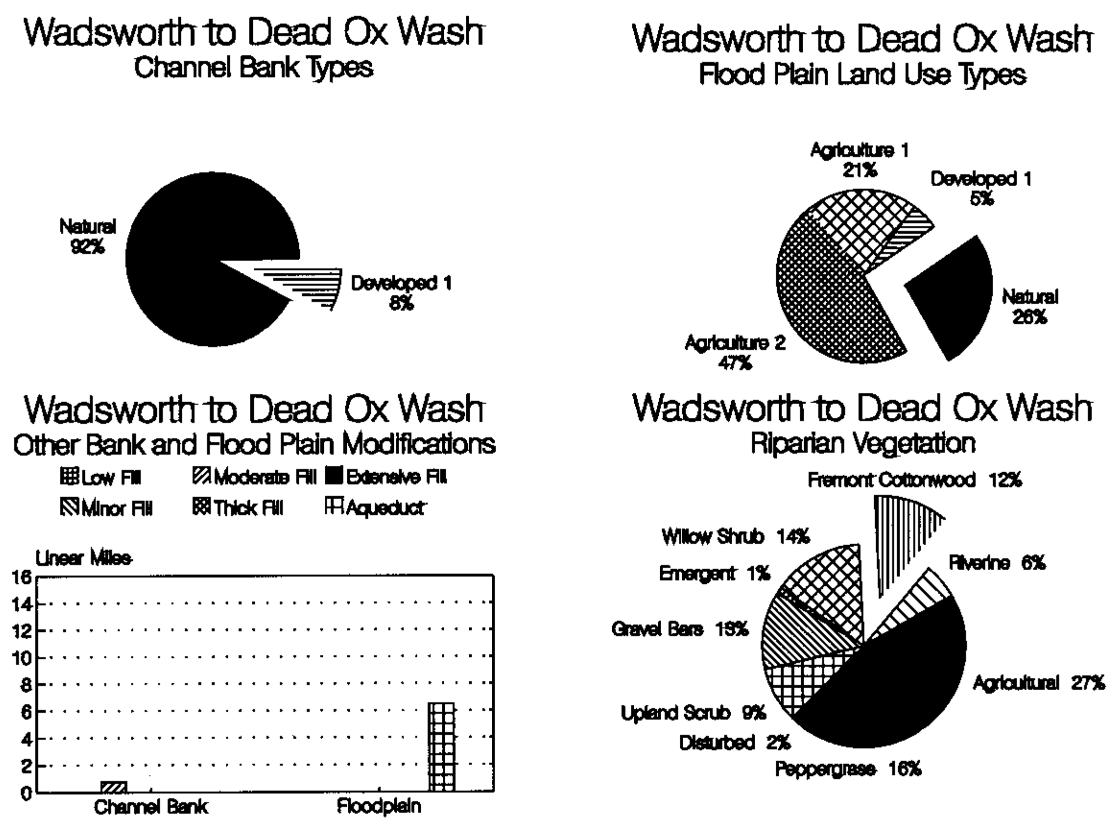

Figure 7. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Wadsworth to Dead Ox Reach.

Dead Ox Wash to Numana Dam

The Truckee River below Dead Ox Wash enters a confined reach where the river is incised within a canyon of Quaternary Lake deposits and volcanic rock. The narrow width and inaccessible nature of the canyon limits any agricultural uses except grazing, which appears to have a profound effect on vegetation cover (**Figure 8**). The channel is generally stable, but large riparian trees are absent and willow scrub growth is severely limited. The hydrology of the river here is similar to upstream reaches, but channel mobility is limited by the constricted canyon walls.

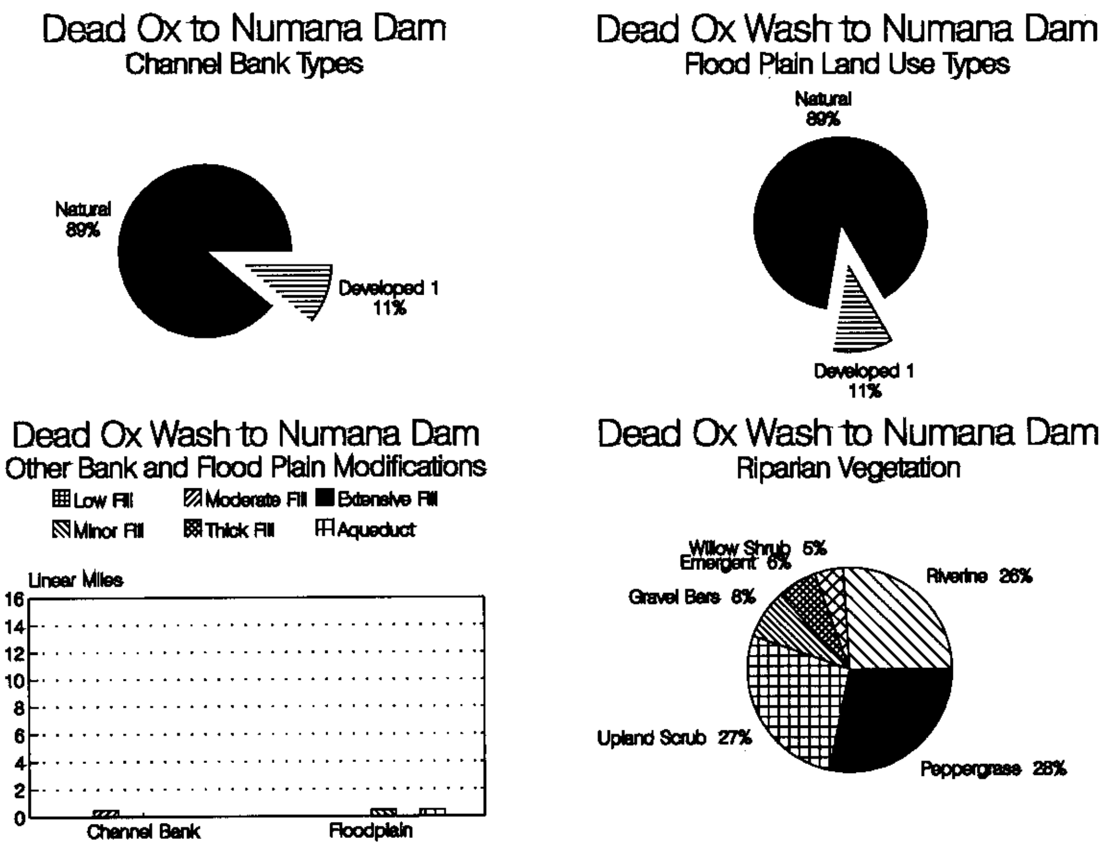

Figure 8. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Dead Ox to Numana Dam Reach.

Numana Dam to Marble Bluff

Below Numana Dam (a diversion structure for an irrigation canal) where the Truckee River emerges from the Dead Ox Wash Canyon, the valley becomes wider and areas for riparian vegetation and agricultural development increase (**Figure 9**). The channel pattern meanders through agricultural fields and pasture land that line the river and dominate the floodplain. Some stands of Fremont's cottonwood and patches of willow shrub riparian vegetation are found along the unlined irrigation canals, and the impoundment area behind Marble Bluff dam contains an extensive scrub-shrub riparian wetland. The hydrology of this reach is again highly variable, and similar to other reaches below Wadsworth and Derby Dam.

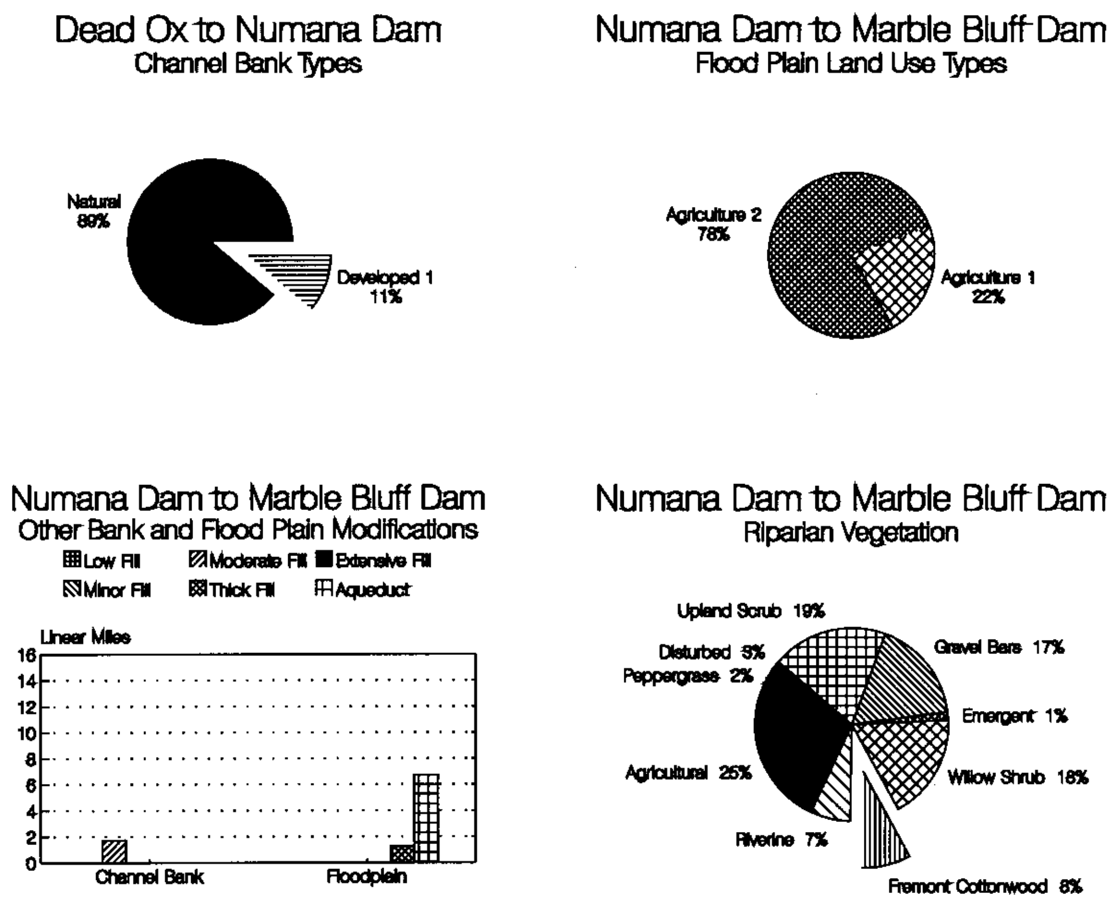

Figure 9. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Numana Dam to Marble Bluff Dam Reach.

GENERAL VEGETATION

Overview

Two approaches were used to assess the nature and condition of the existing riparian vegetation. Cover type mapping was employed for a general assessment of the areal extent of riparian vegetation along the entire 115 river miles. The primary use for this information is to serve as baseline habitat data for the Habitat Evaluation Procedures (HEP) study discussed later in this report. More detailed data on the species composition and abundance were collected at 11 field sites (**Figure 1**) for the riparian habitat/fluvial hydrology study. The criteria upon which site selection was based are presented below in the section on floodplain mapping.

The vegetation of the study area ranges from montane coniferous forests near Lake Tahoe to cold desert vegetation around Pyramid Lake. The natural community classification of the California Department of Fish and Game (Holland 1986) is a useful framework for describing the natural vegetation found between these extremes (**Table VI**). Several additional types are necessary to fully describe the land cover. Each of these types is described in detail below.

Also listed in **Table VI** is the code used to label polygons of the various cover types on the maps accompanying this report. Because of the resolution of the aerial photographs used to prepare the maps, it was necessary to lump some of the community types. The areal extent of the mapped cover types is given by reach in **Tables VII** and **VIII** (agricultural types have been lumped in these tables). Pie charts are included in **Figures 2 through 9** which provide a better visual image of these values by reach. Map codes corresponding to the names used in the figures are also given in **Table VI**.

Two techniques were used to emphasize important aspects of the pie charts. Exploded slices display the proportion of cottonwood riparian forests [Note that reach length and the total acreage of vegetation varies]. A second aspect is shown by shaded slices for degraded habitats (disturbed, urban/industrial, peppergrass, and agricultural types). One peculiarity should be noted. The State Line to Vista reach, which includes the greater Reno area, has a high proportion of cottonwood forest and a low proportion of degraded habitat. Only the existing riparian corridor was mapped, thereby excluding much of the previous floodplain which is now in a degraded condition.

Table VI. Vegetation along the Truckee River based on the Natural Community Classification of the California Department of Fish and Game (Holland 1986). The map code is the symbol assigned to polygons of each cover type on the maps in **Appendix C**. Names used in **Figures 2 through 9** are also given.

Natural Community Classification	**Map Code**	**Figures 2-9**
Riparian and Bottomland Forest and Scrub Habitats		
Montane Black Cottonwood Riparian Forest	**BC**	**Black Cottonwood**
Modoc-Great Basin Cottonwood Riparian Forest	**FC**	**Fremont Cottonwood**
Montane Riparian Scrub	**W**	**Alder-Willow Shrub**
Modoc-Great Basin Riparian Scrub	**W**	**Willow Shrub**
Emergent Vegetation and Gravel Bars		
Transmontane Freshwater Marsh	**E**	**Emergent**
Gravel Bars[1]	**G**	**Gravel Bars**
Montane Coniferous Forests		
Jeffrey Pine Forest	**PI**	**Mixed Pine**
Eastside Ponderosa Pine Forests	**PI**	**Mixed Pine**
Lodgepole Pine Forest	**PI**	**Mixed Pine**
Upland Scrub Habitats		
Sagebrush Steppe	**S**	**Upland Shrub**
Desert Saltbush Scrub	**S**	**Upland Shrub**
Desert Greasewood Scrub	**S**	**Upland Shrub**
Other[1]		
Riverine	**R**	**Riverine**
Ponds	**P**	--------
Urban and Industrial	**UI**	**Urban and Industrial**
Disturbed	**D**	**Disturbed**
Peppergrass	**WT**	**Peppergrass**
Agricultural	**A**	**Agricultural**
Irrigated	**IA**	**Agricultural**
Facilities	**AF**	**Agricultural**
Abandoned	**AA**	**Agricultural**

[1] not included in Natural Community Classification.

Riparian and Bottomland Forest and Scrub Habitats

Montane Black Cottonwood Riparian Forest

Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) is the dominant tree in riparian forests from the vicinity of Verdi to upstream of Truckee. It is best developed on broad alluvial terraces near Verdi. Scattered Jeffrey pines (*Pinus jeffreyi*) may be present, but are never dominant.

Canopy closure ranges from nearly complete in young, dense stands to about 65% in mature stands. Dense patches of willow, commonly yellow willow (*Salix lutea*) or shining willow (*S. lucida* spp. *lasiandra*), may be present locally. Interior rose (*Rosa woodsii*) is also a common shrub. The understory is highly variable with Kentucky bluegrass (*Poa pratensis*) or rusty sedge (*Carex subfusca*) often forming dense stands on drier sites, while horsetail (*Equisetum arvense*) dominates moister areas. A variety of herbaceous species may also be present.

Table VII. Areal extent of cover types for the four upper study reaches of the Truckee River. The length and the number of acres of riparian corridor per river mile are also given for each reach.

	Lake Tahoe to Boca	Boca to State Line	State Line to Vista	Vista to Derby Dam
Reach Length	23 mi (14.3 km)	13 mi (8.1 km)	23 mi (14.3 km)	17 mi (10.6 km)
COVER TYPE	**ac (ha) %**	**ac (ha) %**	**ac (ha) %**	**ac (ha) %**
OPEN WATER			0.00	
Riverine	39.95 (98.72) 39.4	29.15 (72.03) 23.4	0.00	49.07 (121.25) 14.9
Ponds	----- ------ ----	----- ------ ----	0.13 (0.32) <0.1	0.12 (0.30) <0.1
FOREST				
Mixed Pine	9.57 (23.65) 9.4	5.13 (12.68) 4.1	2.01 (4.97) 0.7	----- ------ ----
Black Cottonwood	1.43 (3.53) 1.4	19.66 (48.58) 15.8	29.71 (73.41) 11.1	----- ------ ----
Fremont Cottonwood	----- ------ ----	----- ------ ----	18.88 (46.65) 7.1	17.95 (44.35) 5.4
SCRUB-SHRUB				
Alder-Willow	28.15 (69.56) 27.7	26.38 (65.18) 21.1	----- ----- ----	----- ------ ----
Mixed Willow	----- ------ ----	----- ------ ----	54.58 (134.87) 20.4	21.14 (52.24) 6.4
EMERGENT	7.06 (17.44) 7.0	0.46 (1.14) 0.4	0.79 (1.95) 0.3	11.08 (27.38) 3.3
GRAVEL BARS	6.48 (16.01) 6.4	0.50 (1.23) 0.4	10.75 (26.56) 4.0	5.43 (13.42) 1.6
UPLAND SHRUB	1.93 (4.77) 1.9	12.36 (30.54) 9.9	2.27 (5.61) 0.8	34.00 (84.01) 10.2
OTHER				
Urban and Industrial	4.38 (10.82) 4.3	----- ------ ----	15.76 (38.94) 5.9	22.92 (56.63) 6.9
Disturbed	2.51 (6.20) 2.5	11.24 (27.77) 9.0	12.73 (31.46) 4.8	35.10 (86.73) 10.6
Peppergrass	----- ------ ----	----- ------ ----	2.22 (5.49) 0.8	80.32 (198.47) 24.2
Agricultural	----- ------ ----	19.85 (49.05) 15.9	61.17 (151.15) 22.9	54.55 (134.79) 16.4
Reach Totals	**101.46 (250.71)**	**124.73 (308.21)**	**266.97 (659.68)**	**331.68 (819.58)**
Acres/Mile	4.4	9.6	11.6	19.5

Table VIII. Areal extent of cover types for the four lower study reaches of the Truckee River. The length and the number of acres of riparian corridor per river mile are also given for each reach.

	Derby Dam to Wadsworth	Wadsworth to Dead Ox Wash	Dead Ox Wash to Numana Dam	Numana Dam to Marble Bluff Dam
Reach Length	11 mi (6.8 km)	10 mi (6.2 km)	4 mi (2.5 km)	7 mi (4.3 km)
COVER TYPE	**ac (ha) %**	**ac (ha) %**	**ac (ha) %**	**ac (ha) %**
OPEN WATER			0.00	
Riverine	23.58 (58.27) 9.65	17.92 (44.28) 5.6	0.00	15.83 (39.12) 6.6
Ponds	0.79 (1.58) 0.32	0.18 (0.44) <0.1	0.04 (0.10) <0.1	0.38 (0.94) 0.2
FOREST				
Mixed Pine	----- ------ -----	----- ------ ----	----- ----- ----	----- ------ ----
Black Cottonwood	----- ------ -----	----- ------ ----	----- ----- ----	----- ------ ----
Fremont Cottonwood	26.17 (64.67) 10.71	37.90 (93.65) 11.8	----- ----- ----	19.70 (48.68) 8.2
SCRUB-SHRUB				
Alder-Willow	----- ------ -----	----- ------ ----	----- ----- ----	----- ------ ----
Mixed Willow	27.37 (67.63) 11.20	46.10 (113.67) 14.4	2.02 (4.99) 4.5	42.41 (104.79) 17.7
EMERGENT	1.45 (3.28) 0.59	3.42 (8.45) 1.1	2.82 (6.97) 6.3	3.40 (8.40) 1.4
GRAVEL BARS	2.56 (6.33) 1.05	40.09 (99.06) 12.5	3.49 (8.62) 7.8	41.30 (102.05) 17.3
UPLAND SHRUB	20.01 (49.44) 8.19	28.36 (70.08) 8.8	12.15 (30.02) 27.1	46.11 (113.94) 19.3
OTHER				
Urban and Industrial	2.45 (6.05) 1.00	----- ------ ----	----- ----- ----	----- ------ ----
Disturbed	22.26 (55.00) 9.10	6.97 (17.22) 2.2	----- ----- ----	6.80 (16.80) 2.8
Peppergrass	21.02 (51.94) 8.60	51.74 (127.85) 16.1	12.63 (31.21) 28.2	3.68 (9.09) 1.5
Agricultural	96.78 (239.14) 39.59	87.83 (217.03) 27.4	----- ----- ----	59.64 (147.37) 25.0
Reach Totals	**244.44 (604.01)**	**320.51 (791.73)**	**44.77 (110.63)**	**239.25 (591.19)**
Acres/Mile	22.2	32.0	11.2	34.2

Modoc-Great Basin Cottonwood-Willow Riparian Forest

Fremont's cottonwood (*Populus fremontii*) is the sole dominant tree in this riparian forest which occurs downstream of Verdi along the Truckee River. It is best developed in Oxbow Nature Park in Reno and between the towns of Wadsworth and Dead Ox Wash. Canopy closure ranges from 100% in young, dense stands to about 70% in mature stands. In pre-settlement condition, the understory was probably a grassy sward of slender wheatgrass (*Elymus* *trachycaulus*) but this species now commonly occurs only as relict patches. Oxbow Nature Park is probably the best remaining example of the pre-settlement condition. Most other stands have little,if any, understory, although patches of broadleaved peppergrass (*Lepidium latifolium*) are common in swales. Shrubs are presently uncommon except for big sagebrush (*Artemisia tridentata*). Both the absence of typical riparian willows and the presence of big sagebrush may also reflect the effects of a lowered groundwater table.

Montane Riparian Scrub
This community commonly occurs as a narrow thicket along the banks of the river and on a few gravel bars upstream of Reno. Numerous shrub species occur, but the most common is mountain alder (*Alnus incana* ssp. *tenuifolia*). Coyote willow (*Salix exigua*) is common upstream to about the state line, but becomes increasingly less important in California. Other associated shrubs include yellow willow, shining willow, dusky willow (*S. melanopsis*), and red-osier dogwood (*Cornus sericea*). A dense canopy is common, and often precludes the development of a significant herbaceous layer. Fowl mannagrass (*Glyceria striata*) is a common understory species.

Modoc-Great Basin Riparian Scrub
This riparian community occurs as a narrow thicket along the river banks and lining irrigation ditches downstream of Verdi. It also occurs on more stable gravel bars. Large patches are uncommon with notable examples at Oxbow Nature Park and in the backwaters of the higher diversion dams. Coyote willow is the most common species, although both yellow and shining willow are also abundant. Less common are Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix* spp.). The freshly scoured surfaces produced by the 1986 flood and the subsequent six-years of drought has resulted in an expansion of the total area of this type. In many areas along the river channel, stands (up to 6 feet in height in 1992) of these willows and Fremont's cottonwood dating from the 1986 growing season are common. Older, denser stands seldom have a significant herbaceous understory, but under the younger stands numerous species are present. The most common are white sweet-clover (*Melilotus alba*), white clover (*Trifolium repens*), broad-leaved peppergrass, and slender-beak sedge (*Carex athrostachya*). All but the sedge are exotic species.

Emergent Vegetation and Gravel Bars

Montane Freshwater Marsh
This community is uncommon and is generally restricted to a few islands between the town of Truckee and Tahoe City, although stringers also may be found locally along the river banks. Common species include slender-beak sedge, water sedge (*Carex aquatilis*), and beaked sedge (*Carex utriculata*). Numerous other herbaceous species may be present.

Transmontane Freshwater Marsh

This community is restricted to local areas and narrow stringers along the river downstream of Verdi. Most occurrences are small, but larger examples can be found at Oxbow Nature Park, near Derby Dam, and in association with oxbow lakes in cut-off meanders downstream of Wadsworth. Common species include cat-tails (*Typha latifolia*), hardstem bulrush (*Scirpus acutus*), Olney's bulrush (*Scirpus americanus*), and common reed (*Phragmites australis*). Broadleaved peppergrass may also be common locally. Associated species include slender-beak sedge, soft rush (*Juncus effusus*) and least spikerush (*Eleocharis acicularis*).

Gravel Bars

Exposed gravel bars are one of the most diverse habitats within the study area in vascular plant species, but the overall cover of plants is generally low (less than 30%). Numerous species may occur, among the most constant of which are slender-beak sedge, common monkey-flower (*Mimulus guttatus*), and hairy willow-herb (*Epilobium ciliatum*). Short-awn foxtail (*Alopecurus aequalis*) is common upstream of Boca. Because of the preceding six years of drought, more gravel bars have been exposed and their surfaces colonized by species adapted to this habitat. The total area of this habitat has increased since 1986.

Montane Coniferous Forests

Jeffrey Pine Forest

Eastside Ponderosa Pine Forest

Lodgepole Pine Forest

These types were indistinguishable in the aerial photography used in this study and were lumped. Jeffrey pine and ponderosa pine (*Pinus ponderosa*) are common as scattered trees or in mixed stands along the river upstream of Verdi. Above Boca, lodgepole pine (*Pinus contorta*) becomes increasing common and is often found growing in dense monotypic stands. The understory of the Jeffrey and ponderosa pine stands is typically occupied by upland shrubs such as serviceberry (*Amelanchier alnifolia* var. *pumila*), antelope bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpos rotundifolius*), and sulfur flower (*Eriogonum umbellatum*). Scattered grasses including Idaho fescue (*Festuca idahoensis*), western needlegrass (*Achnatherum occidentalis*), rusty sedge, and pinegrass (*Calamagrostis rubescens*) may also be present.

Upland Scrub Habitats

Sagebrush Steppe

Desert Saltbush Scrub

Desert Greasewood Scrub

These types were also lumped because they were indistinguishable in the aerial photography. Most upland scrub adjacent to the riparian corridor upstream of Wadsworth is dominated by big sagebrush. The scrub downstream of Wadsworth, especially on the Pleistocene lake sediments, may have abundant shadscale

(*Atriplex confertifolia*), four-wing saltbush (*A. canescens*), and black greasewood (*Sarcobatus vermiculatus*). Nevertheless, big sagebrush is seldom uncommon anywhere along the river, and both shadscale and greasewood may be found upstream of Wadsworth. The understory is commonly dominated by the exotic annual grass, cheatgrass (*Bromus tectorum*). In years with sufficient rainfall, an abundance of other annuals may be produced; these include tansy mustard (*Descurainia sophia*), Rocky Mountain bee plant (*Cleome serrulata*), and Russian thistle (*Salsola kali*).

Other

Urban and Industrial
Urban areas include cities, small towns and unincorporated residential areas along the riparian corridor. Industrial sites include gravel mining areas, power plants, and water development facilities.

Disturbed
Areas mapped as disturbed included highways, road and bridge crossings of the river, road embankments and railroad beds constraining the river channel, and sites where the ground surface has been significantly modified. The latter sites are generally characterized by a lack of forest or shrub cover and the absence of any permanent structures or buildings. They are often gravel storage areas or inactive construction sites.

Peppergrass
Extensive areas lying primarily downstream of Reno are dominated by dense stands of broadleaved peppergrass. This noxious weed tends to exclude other plant species from the sites it has occupied. Another noxious weed which resembles peppergrass, white-top (*Cardaria pubescens*), also occurs along the lower river. Peppergrass is generally the taller of the two and, therefore, dominates whenever the two occur together; peppergrass is more common. The two species were lumped together for our analysis. Because of the special management problems posed by these species, they were mapped as a separate cover type.

Agricultural
This cover type category includes both irrigated and non-irrigated crop and pasture lands (native and seeded), abandoned agricultural land, and agricultural support facilities such as barns, equipment storage areas and sheds, corrals, and rural residences. During the initial mapping, irrigated land, non-irrigated land, abandoned land, and support facilities were coded separately. Irrigated land and non-irrigated land proved difficult to distinguish, however, in some areas. In addition, the irrigation status of an individual tract of land may vary even during a given growing season. For this reason, these categories were lumped in the final tabulation. Abandoned land and support facilities were only a small proportion of the total agricultural

land and for this reason were also lumped in the single agricultural category in the final tabulation.

Vegetation Analysis

Methodology

Cover Type Mapping

Cover type maps were prepared for the riparian corridor of the Truckee River between Lake Tahoe and Marble Bluff Dam. Vegetation and land use types were mapped on acetate overlays of black-and-white aerial photography at a scale of 1 inch to 100 feet (1:1,200). Source photos for these enlargements were flown on 11-04-91; the scale of the original photos was 1:12,000. Cover type polygons were manually delineated according to the classification shown in **Table VI**. Natural community classifications have been developed by the California Department of Fish and Game (Holland 1986). These descriptions pertain to natural communities and, because most of the study area has a long history of disturbance, can only be used as a general guide to the existing vegetation. Additional cover types are cultural types resulting from human activities. Montane coniferous forests were mapped only as pine forest because of the difficulty of identification of species from the aerial photography. Upland scrub types were lumped for the same reason.

The minimum mapping criterion for forested types was at least six trees in an area of 0.5 acre. Riparian scrub was generally identifiable as such, but it was not possible to delineate subclasses based on canopy height, an important aspect of biological values. An emergent strand is present along much of the river, but is too narrow to map at the working scale. Where it was identifiable from the photography, it was mapped, but not distinguished taxonomically from freshwater marsh. Because of the dynamic nature of the Pyramid Lake Delta (below Marble Bluff Dam), it was excluded from the scope of work for the project and cover type mapping was not done in this area. Most of this area is densely vegetated by tamarisk scrub. Cover type mapping was restricted to the floodplain and contiguous upland areas. The description, distribution, and relative proportions of these cover types are discussed by reach in the **Project Reaches and Field Sites** section above.

Data Collection

To test the correlation between riparian vegetation with fluvial hydrology, canopy coverage data were collected along the cross-sections used to calculate channel hydraulics. These data were collected by structural layer according to the following definitions and procedures:

> **Tree layer:** single- or multiple-stemmed woody plants in excess of 20-ft in height and 10-cm diameter-at-breast height(dbh). Data were collected on tree size (dbh) and density within 100-ft of the transect. Canopy coverage was estimated at random locations along the transect using a spherical densiometer. Canopy height was estimated using a clinometer.

Shrub layer(s): all woody plant species less than 20-ft in height. Canopy coverage was estimated along each cross-section using the line-intercept method (Mueller-Dombois and Ellenberg 1974). To provide detailed information on stand structure, these data were collected in three height classes: shrubs > 10-ft, shrubs > 3-ft and ≤ 10-ft, and shrubs ≤ 3-ft.

Herbaceous layer: all non-woody species including herbs, grasses, and graminoids. Canopy coverage visually estimated by species using the line-intercept method.

Ground surface: Ground surface data on brushpiles, litter, and bare ground was also tallied using the line-intercept method. Bare ground was further recorded as clay, silt, sand, gravel, cobbles, and boulders.

Other information collected included site elevation (taken from topographic maps), transect orientation (measured from aerial photos), current land use, and evidence of recent disturbance (e.g., grazing, beaver activity). A list of vascular plant species encountered along the transects is attached (**Appendix D**). The taxonomic reference for all plant scientific names used in this report is the new edition of the Jepson Manual (Hickman 1992). Common names used in this report are also included in **Appendix D**.

Data Analysis

Classification techniques. All vegetation samples were subjected to Two-way Indicator Species Analysis (TWINSPAN), a hierarchical classification procedure (Hill 1979; Gauch and Whittaker 1981). The basic process which TWINSPAN uses is to divide the initial group of samples on the basis of species composition and abundance into two groups, each of which is then subdivided into two more groups. This process can be repeated until a pre-selected minimum class size is reached. Because of the size of the data set, samples were stratified by physiognomy (forest, shrub, emergent) prior to analysis.

Ordination techniques. Ordination is a collective term for multivariate statistical techniques which arrange samples or species along ordinate axes on the basis of the abundance of the species. The resulting diagram is a graphical summary of the community data (**Figure 10**). In a sample ordination, points which lie close together are more similar to each other in species composition and abundance than are those which lie farther apart. The ecological explanation for these spatial distances is often informally made on the basis of professional judgement; this is referred to a indirect gradient analysis. If environmental data have been collected, they also may be incorporated into the analysis. This procedure is called direct gradient analysis (Gauch 1982; Jongman *et al.* 1987).

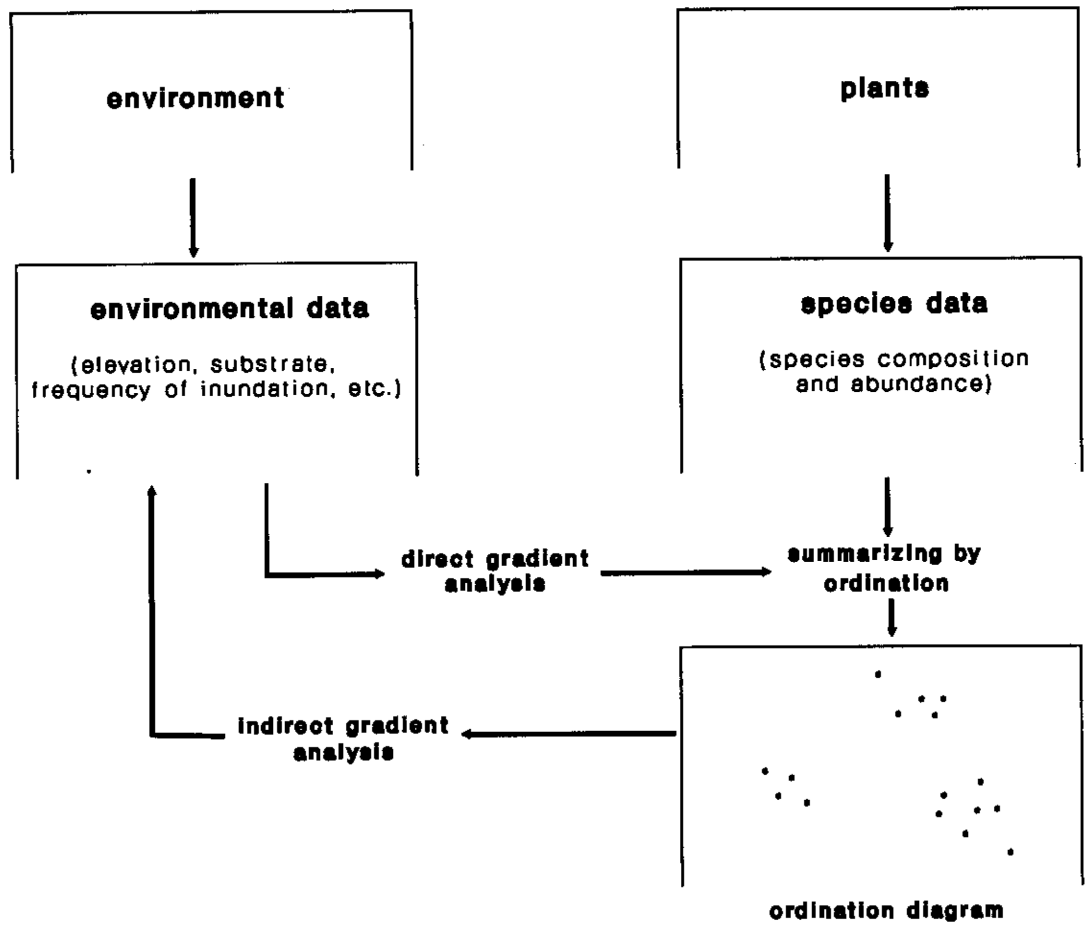

Figure 10. The role of ordination in depicting differences among biological and environmental data as spatial distance. (modified from Jongman <u>et al</u>. 1987, p. 92).

A wide variety of ordination procedures are available The best method for a given application often depends upon the nature of the data set being analyzed. It is common for the ecologist to employ a variety of approaches to examine the data set and choose the one(s) which, in his or her professional judgement, yields the best results. For the analyses in this study, detrended correspondence analysis (DCA) was chosen from among the various techniques applied. Because we also had collected formal environmental data, we used a recent direct gradient analysis variant of the procedure, referred to as detrended canonical correspondence analysis (DCCA). Both of these procedures are among those available in the program CANOCO (Jongman *et al.* 1987)

RIPARIAN VEGETATION

Overview

Riparian vegetation occupies one of the most dynamic areas of the landscape, the zone of direct interaction between terrestrial and aquatic ecosystems within the context of fluvial landforms and the geomorphic processes that create them. Riparian zones extend outward to the limits of flooding and upward into the canopy of streamside vegetation. They can be viewed in terms of hydrologic and geomorphic processes, terrestrial plant succession, and aquatic ecosystems. These processes vary in both space and time (Gregory *et al.* 1991).

Because most rivers span a broad ecological gradient in a drainage basin, riparian ecosystems can be viewed as hierarchies of drainage segments, reach types, channel units, and channel subunits based on functional relationships between valley landforms and the processes that create them (Frissell *et al.* 1986). Segments of a drainage network are defined by regional landform patterns and range in scale from 10 km to more than 100 km. They are often marked by major topographic discontinuities, such as high-gradient montane rivers or lower-gradient rivers on valley floors in mountainous topography (Gregory *et al.* 1991).

Such a demarcation applies on the Truckee River along the California/Nevada state line. Reaches in the upper (CA) segment tend to be constrained by bedrock and have relatively straight, single channels. The stream channel during flood flows is relatively fixed within narrow floodplains; stream depth and velocity increase rapidly with increasing discharge. In contrast, (unchannelized) reaches in the lower (NV) segment tend to have less lateral constraint and may have complex channels with more extensive floodplains. At high flows, water may spread across the floodplain dissipating much of the energy of the current.

The delineation of the Truckee River drainage basin within the study area into a montane segment and a valley floor segment is paralleled by an ecological distinction between cooler montane environments of the eastern slope of the Sierra Nevada and the hotter climate of the Great Basin. This ecological gradient is reflected in a marked difference in flora between the two segments. Perhaps because of the influence of cold-air drainage, however, the typical montane species assemblage extends downstream to the vicinity of Reno.

Other important factors also determine the direction and trend of plant succession within the study area. These include local groundwater influence, as well as the more widespread effects of human influence such as the clearing and agricultural conversion of floodplain habitats, livestock grazing, the spread of noxious weeds, the post-World War II introduction of beaver (*Castor canadensis*) to the drainage basin (Hall 1960; Ingles 1965), stream channelization, and water impoundment and diversion. While the emphasis of our study is on the latter three of these impacts, a plan for the management of the riparian resources of the Truckee River must be addressed from a ecosystem perspective.

The damming of rivers for hydropower production, flood control, or water supply has resulted in reductions in annual flow volumes, shifts in seasonal flow peaks from spring to summer, and greater fluctuations in annual flow volumes (Chien 1985). The consequent downstream effects on riparian vegetation range from extreme to subtle (Williams and Wolman 1984; Risser and Harris 1989). Extreme effects have included the widespread loss of low elevation riparian ecosystems (Stromberg and Patten 1990). More subtle effects may include a reduction in the biological integrity of downstream riparian ecosystems through changes in total area, density, species composition, and species diversity (Kondolf *et al.* 1987).

Downstream effects of water impoundment and diversion on the Truckee River have ranged from extreme to subtle. A good example of an extreme effect is the stranding of floodplain terraces in the vicinity of Nixon as a result of stream incision due to the lowering of the level of Pyramid Lake after the construction of the diversion dam at Derby. More subtle changes have occurred in the reduction in total area and fragmentation of the riparian forest and scrub-shrub cover and changes in the stand structure of forest trees.

Other changes in the river have resulted from the construction of railroads, roads, highways, bridges, and channelization projects. The effects of such projects range from subtle localized impacts to significant changes in channel morphology and the removal of riparian vegetation.

Three broad classes of riparian vegetation occur within the study area along the Truckee River: forests, scrub-shrub, and emergent. The classification and ecological relationships of various subclasses within these three broad classes is discussed in the following sections. Because of its greater structural complexity and ecological importance, the riparian forests are considered in greater detail. Nevertheless, riparian forests, scrub-shrub, and emergent vegetation comprise a integrated mosaic which provides ecosystem functions beyond those produced by the individual vegetation types. Thus, although it is convenient to discuss the individual structural types separately, the importance of landscape level factors such as patch size, shape, configuration, and juxtaposition in ecosystem functions should be recognized.

Riparian Forests

Overview. Because of the biological importance of riparian forests, a special effort was made to collect data on the species composition, structure, and ecological condition of these forests within the study area. Two species of cottonwood, Fremont's and black, are predominant in the riparian forests of the Truckee River. There is a somewhat distinct geographical separation between the species with Fremont's cottonwood being the sole dominant downstream of Reno and black cottonwood having this distinction upstream of Verdi. Between Reno and Verdi the two species may be found growing together. The geographical separation represents the ecological difference between the hotter conditions of the sagebrush steppe/salt desert shrub ecosystems adjacent to the river downstream of Reno and the cooler canyons of the foothills and montane forests of the eastern slope of the Sierra Nevada. This ecological distinction is also expressed in a gradual increase in evergreen coniferous trees in the montane riparian forests. The conifers, which include lodgepole and Jeffrey pine and, to a lesser extent, white fir (*Abies concolor*) comprise a significant percentage of the forest canopy only upstream of Truckee.

Cottonwood Community Classification. A total of 39 vegetation samples were taken within various structural conditions of cottonwood dominated communities. These samples included a total of 60 vascular plant species. The results of the TWINSPAN analysis are shown schematically in **Figure 6**. As one would expect, the initial dichotomy is generaly separates those communities in which black cottonwood is predominant from those in which Fremont's cottonwood predominates. As noted earlier this is a geographical separation which expresses an ecological distinction between these two congeneric tree species.

Further distinctions are made within the black cottonwood group on the basis of size class and associated species composition. The first division of the black cottonwood group separates those communities in which occur on higher terraces from those which are located more approximate to the river. The first group comprises black cottonwood tree and shrub communities with grassy understories. Scattered patches of shrubs other than cottonwood may occur in either community. Swards of Kentucky bluegrass or slender wheatgrass predominate in the understory. The shrub dominated communities are seral stages of the forests, and are commonly found where there has been recent beaver activity. The higher terraces on which these communities are found are only infrequently inundated by flood waters. Our hydrologic data suggests a recurrence interval of about 10 to 25 years. Side channels cut into the terraces may carry water more frequently, as suggested by the more common occurrence of willows or horsetails in these swales.

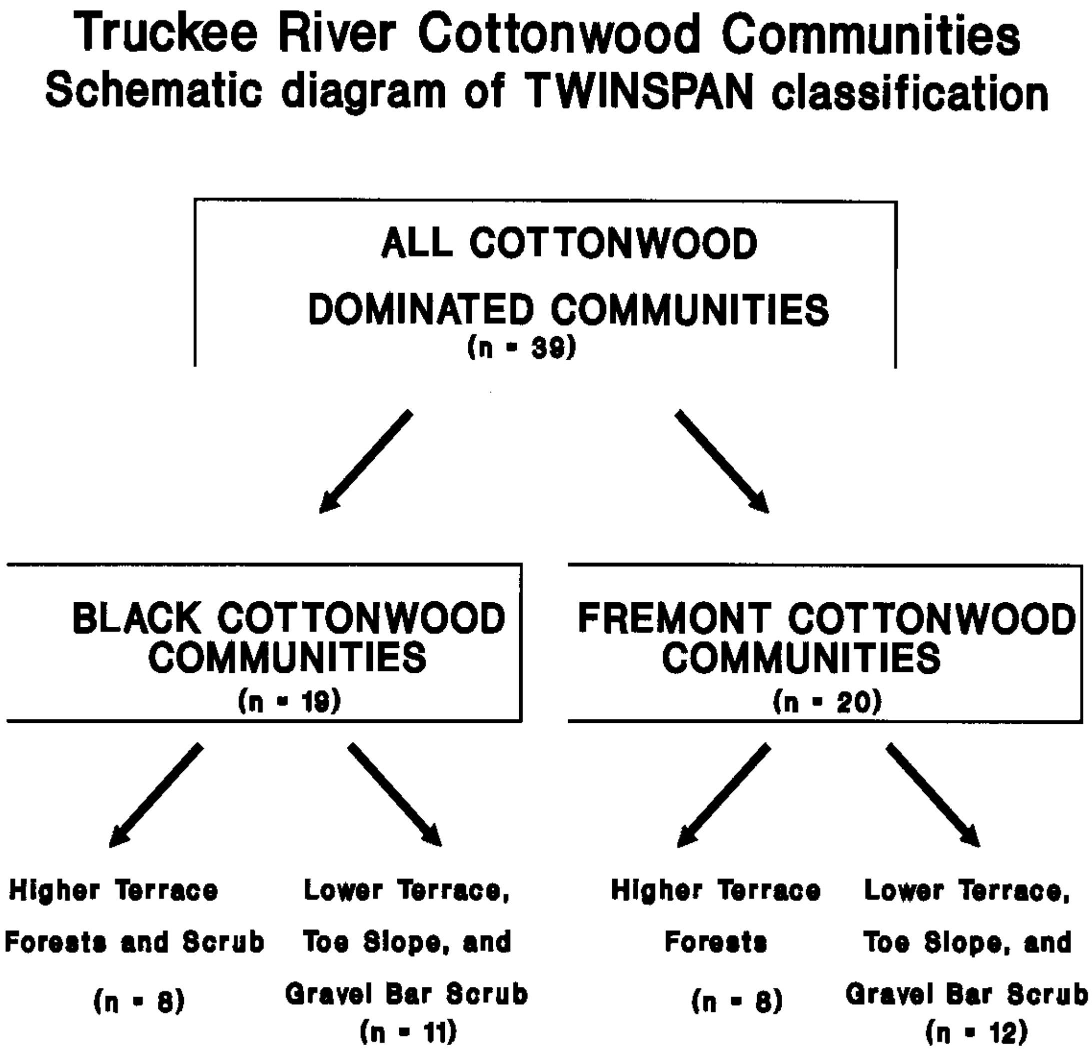

Figure 11. Schematic diagram of Two-way Indicator Species Analysis (TWINSPAN) of cottonwood dominated communities along the Truckee River in California and Nevada.

The second group of black cottonwood communities are those with a higher frequency of inundation (**Figure 11**). These are generally located on lower terraces and toe slopes adjacent to the river channel or, in some cases, on gravel bars within the channel itself. Shrubs of black cottonwood, mountain alder, and yellow or coyote willow predominate. These shrubs, as well as the associated species, are indicative of a more hydric environment. Most of these communities are probably inundated by river water on an annual basis.

The initial division of the Fremont's cottonwood dominated communities separates those dominated by cottonwood trees from the shrub communities (**Figure 6**). As in black cottonwood, the forest communities commonly occur on higher terraces subject to a lower frequency of inundation. Understories in these communties are generally depaupaurate, comprise of scattered sagebrush or dense patches of broadleaved peppergrass. The latter species probably reflects the long history of intensive livestock grazing on the lower river, while the presence of sagebrush is probably indicative of a general lowering of groundwater levels below the terraces due to water diversion.

Fremont's cottonwood dominated shrub communities are located on lower terraces, toe slopes adjacent to the river channel, and on gravel bars with the river channel. Other shrub species are uncommon in most samples, although several samples with yellow and coyote willow were (mis)classified with the black cottonwood samples on the basis of the willow species. Most associated herbaceous species indicate a more hydric environment. Based on shrub cuttings taken at numerous sites and a review of aerial photographs, it appears that most of these communities have become established since the major flood event of 1986.

Cottonwood Community Samples and Species Ordinations. A DCA ordination of the 39 samples from cottonwood communities shows a structure similar to the classification produced by TWINSPAN (**Figure 7**). Communities dominated by Fremont's cottonwood and black cottonwood show good separation along Axis 1 of the ordination diagram. Fremont's cottonwood forests and shrub communities also show displacement along Axis 2, although little separation occurs along Axis 2 between forests and shrub communities dominated by black cottonwood. In ecological terms, there is more difference between the Fremont's cottonwood forest and shrub samples than there is between the black cottonwood forest and shrub samples with respect to the gradient expressed along Axis 2. The environmental differences underlying this ecological separation will be addressed later in this report.

The samples ordination in **Figure 7** is based on the identity and abundance of the species in the 39 samples. A species ordination (**Figure 8**) shows the species which exert major influence on the distribution of the samples in the ordination diagram. Note that "species" is used in a broader than usual sense here with respect to the riparian trees and shrubs. The trees and shrubs were treated as different "species" based on their size class. For example, Fremont's cottonwood is shown on the diagram as a tree (bold italics), a tall shrub (underlined italics), and low- to medium-size shrubs (unbolded italics). The latter two size classes were lumped and hereafter will be referred to only as low shrubs.

From the species ordination diagram it can be seen that Fremont's cottonwood trees and sagebrush are the primary species determining the placement of the Fremont's cottonwood forest samples, and low shrubs of Fremont's cottonwood exert a major influence on the location of the Fremont's cottonwood shrub samples (**Figure 8**). Other species influential in determining the placement of the samples are Fremont's cottonwood tall shrubs and coyote willow in the forest samples, and annual beard grass (*Polypogon monspielensis*), soft rush, and Olney's rush in the low shrub samples. A similar association is shown between black cottonwood trees and yellow willow tall shrubs, and between black cottonwood tall shrubs, mountain alder tall shrubs, slender-beak sedge, and (less strongly) black cottonwood low shrubs. Shrubs of yellow willow occupy an intermediate position in the diagram, indicating their wide distribution.

Forest stand structure. To further examine the structure of riparian forests along the Truckee River, detailed information on the size-class distribution, canopy coverage, and canopy height was collected along the transects at the Powerline,

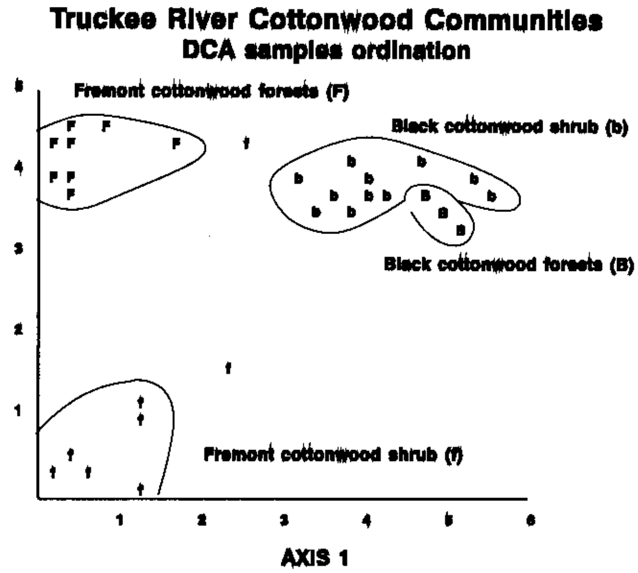

Figure 12. Detrended **C**orrespondence **A**nalysis (DCA) ordination diagram of cottonwood samples from Truckee River sites. See text for discussion.

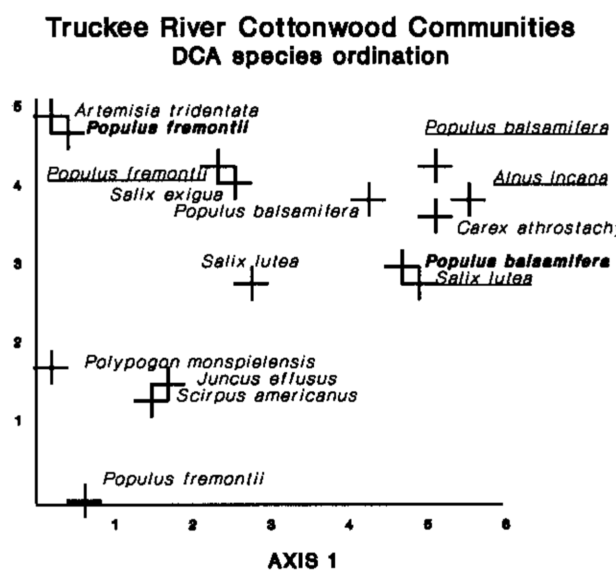

Figure 13. Species ordination diagram showing species exerting major influence on the distribution of samples shown in Figure 4. See text. Size-classes as follows: low shrubs (italics), tall shrubs (underline), trees (bold).

Clark, Oxbow, Verdi, Farad, Granite, and Bridge field sites. Size-class distribution data are summarized in **Table X** and in frequency histograms (**Figures 11, 12**). **Table X** is divided into an upper (Powerline, Clark, and Oxbow samples) and lower portion (Verdi, Farad, Granite, and Bridge samples). The upper division contains all of the Fremont's cottonwood forest samples, while the lower division includes black cottonwood and conifer samples.

Table X. Tree densities, mean diameter-at-breast height (dbh), and basal area for forest samples along the Truckee River. The Powerline, Clark, and Oxbow samples are from Fremont's cottonwood forests. Black cottonwood (bc), Jeffrey pine (jp), and lodgepole pine (lp) are dominant at the other sites.

Forest Stand	Number of trees measured	Number of trees/ha	Mean dbh (cm)	Std. Dev.	Std. Error	Basal Area (m^2/ha)
Powerline 1	4	19.1	76.7	2.8	1.4	53.9
Powerline 2	5	20.3	69.6	3.0	1.3	47.2
Powerline 3	8	19.2	63.0	1.7	0.6	36.6
Powerline 4	4	10.8	81.0	2.0	1.0	33.9
Powerline 5	5	23.2	59.7	0.4	0.7	39.7
Powerline 6	7	32.9	59.7	1.4	0.5	56.3
Clark 1	30	185.5	23.1	1.3	0.2	47.6
Clark 2	n/a	n/a	n/a	n/a	n/a	n/a
Clark 3	n/a	n/a	n/a	n/a	n/a	n/a
Clark 4	35	251.8	27.9	1.3	0.2	94.5
Oxbow 1	54	18.6	47.2	4.3	0.6	19.9
Verdi 1 (bc)	103	92.9	22.9	2.4	0.2	23.3
Verdi 2 (bc)	60	95.7	24.7	1.8	0.2	27.9
Farad 1 (bc)	n/a	n/a	n/a	n/a	n/a	n/a
Granite 1 (bc)	16	176.3	42.7	3.0	0.7	154.2
Granite 2 (jp)	n/a	n/a	n/a	n/a	n/a	n/a
Granite 3 (jp)	9	105.8	51.8	1.6	0.5	136.5
Bridge 1 (lp)	26	70.0	29.7	2.0	0.4	29.7
Bridge 2 (lp)	6	38.4	21.1	0.8	0.3	8.2

Among the Fremont's cottonwood samples, clear differences can be seen in tree densities and mean diameters between the Powerline and Clark samples (**Table X**). In general, the Powerline samples show densities of about 20 trees/hectare with a mean diameter between about 60 to 70 cm. An ANOVA test of the mean dbh values among the six Powerline samples shows no significant difference at α = .08. Although this is an acceptable significance level for ecological data, it should be noted that Powerline 4 is significantly different from both Powerline 5 and Powerline 6 at α = .05. Basal areas range between about 35 and 55 m^2/ha. In contrast, the Clark samples have tree densities about ten time higher than those at the Powerline site, and mean dbh values more than 50% smaller. Basal areas at the Clark site range from comparable to more than twice that of the Powerline samples. The Oxbow sample shows a tree density similar to those at the Powerline site, although the mean dbh is somewhat smaller.

There are similar differences among the Fremont's cottonwood samples in mean canopy coverage (**Table XI**). Powerline samples have lower canopy coverage values, ranging between about 50 to 65%, while those at the Clark site range between 70 to 85%. There do not appear to be any differences among the canopy heights measurements taken at the two sites. The canopy coverage at the Oxbow site is comparable to those at the Clark site, while the canopy height represents an extreme value among all the sites.

The size class histograms are of interest for what they reveal about the ecological condition of the riparian forests at the various sites. The histogram from the Oxbow field site approximates the pre-settlement condition of the Fremont's cottonwood riparian forest (**Figure 9**). The site has not recently been grazed and most of the trees are protected from beaver activity by chicken-wire. Slightly more than 50% of the cottonwood present in the sample are in the smallest size class, i.e., less than 15 cm diameter-at-breast height (dbh). There is a general trend toward fewer individuals in each of the successively larger size classes. No attempt was made to age larger trees. Larger trees at the Oxbow site have been cored by the Nevada Department of Wildlife and commonly exceed 140 years in age, but the centers of the trees are often rotted making this a minimum estimate (Toulouse, personal communication, 1992). Cottonwoods have relatively short life-spans, less than 200 years in most cases (Stromberg *et al.* 1991). If trees 75 cm or greater dbh are classified as old-growth, 11.7% of the population can be characterized as such.

The Verdi (black cottonwood) and Clark (Fremont's cottonwood) field sites have histograms with similar shapes (**Figure 9**). As at the Oxbow site previously described, the largest percentage of trees is in smallest size class, and there is a decrease in the number of individuals in successive larger size classes. There are no trees at either site, however, that exceed 60 cm dbh. These stands presumably represent younger forests. The abundant smaller trees suggest that there may be adequate reproduction to insure long-term maintenance of riparian forest at these sites.

Table XI. Mean canopy coverage and canopy height (single measurement) for forest samples along the Truckee River. The Powerline, Clark, and Oxbow samples are from Fremont's cottonwood forests. Black cottonwood (bc), Jeffrey pine (jp), and lodgepole pine (lp) are dominant at the other sites.

Forest Stand	Number of readings	Mean Canopy Coverage (%)	Std. Dev.	Std. Error	Canopy Height (m)
Powerline 1	16	56.7	27.1	6.8	20.6
Powerline 2	16	52.7	26.0	6.5	18.4
Powerline 3	16	62.4	18.4	4.6	16.5
Powerline 4	16	67.9	20.8	5.2	17.1
Powerline 5	12	49.2	26.6	7.7	17.1
Powerline 6	16	54.9	25.4	6.4	17.7
Clark 1	48	92.6	3.6	0.5	17.4
Clark 2	12	77.7	12.3	3.5	18.0
Clark 3	8	74.2	26.7	9.4	19.5
Clark 4	64	85.1	10.7	1.3	17.4
Oxbow 1	60	73.1	20.7	2.7	21.9
Verdi 1 (bc)	24	75.6	16.2	3.3	13.1
Verdi 2 (bc)	24	76.8	12.4	2.5	15.2
Farad 1 (bc)	16	88.3	9.4	2.3	8.2
Granite 1 (bc)	12	79.9	13.4	3.9	24.7
Granite 2 (jp)	4	60.2	13.3	6.6	18.9
Granite 3 (jp)	12	26.0	19.2	5.5	27.4
Bridge 1 (lp)	20	61.1	28.3	6.3	19.3
Bridge 2 (lp)	12	20.7	23.8	6.9	13.3

In contrast to the previous sites, the stand structure at the Powerline field site (Fremont's cottonwood) resembles a bell-shaped curve (**Figure 9**). Nearly 50% of the individuals are in the 45-60 cm dbh size class, and there is a notable lack of individuals in the smaller size classes. As at the Oxbow site roughly 10% of the trees can be classified as old-growth. The ecological conditions at the Powerline site are typical of the forests fragments which remain downstream of Wadsworth. There is no reproduction occurring which would ensure the maintenance of riparian forest in the area over the long-term.

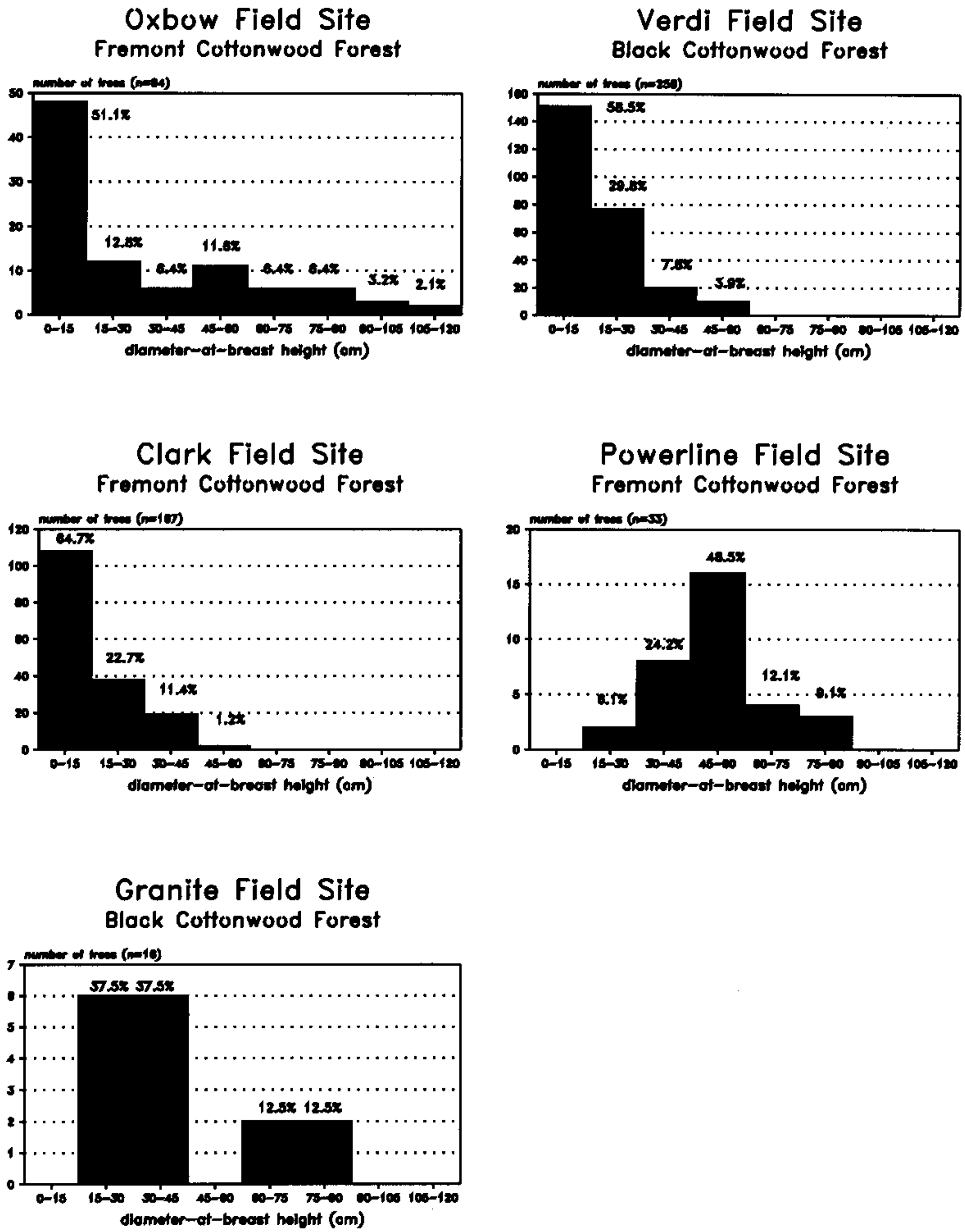

Figure 14. Size-class histograms for Fremont's cottonwood and black cottonwood forests at five field sites along the Truckee River. See text for further details.

The final histogram of cottonwood forests comes from the Granite field site (black cottonwood) several miles upstream of Truckee (**Figure 9**). The population here has a bipartite distribution with 25% of the individuals between 60-90 cm dbh and the remaining 75% between 15-45 cm dbh. There are no trees in thesmallest size class, nor are there any between 45-60 cm dbh. This site receives heavy recreational use, and is the location of U.S. Geological Survey stream gaging station. The results are skewed by the small sample size (n=16).

Also of interest at the Granite field site are samples which represent mixed populations of black cottowood, lodgepole pine, and Jeffrey pine (**Figure 10**). In these stands, the larger size classes are comprised entirely of Jeffrey pine. while the smaller size classes include both lodgepole pine and cottonwood. There are no trees present less than 30 cm dbh. The historic conditions leading to the present situation are obscure. One final histogram is presented to show a more typical size class distribution on the upper portion of the river within the study area. The Bridge site (**Figure 10**) has over 70% of the individuals in the lowest size class with fewer individuals in successive larger size classes. Of particular interest here is the presence of Jeffrey pine and white fir in only the smallest size classes. This may reflect the effects of drier conditions during the recent years of drought on the establishment success of these species.

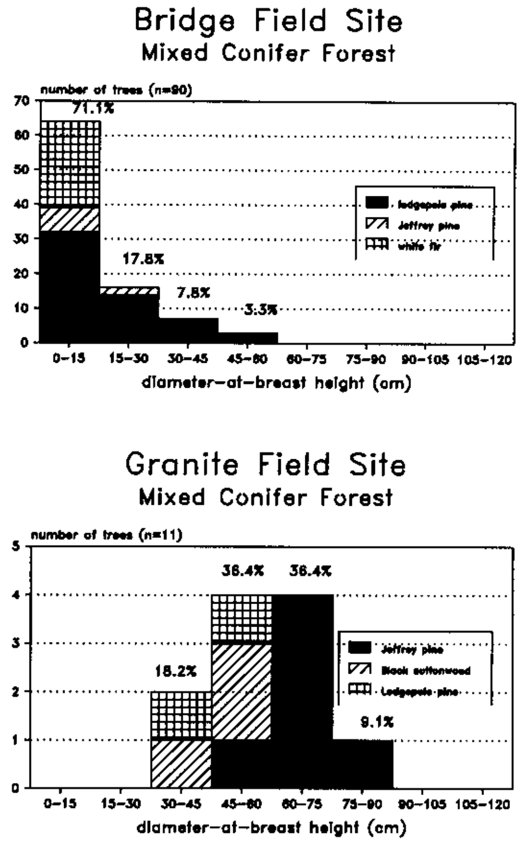

Figure 15. Size-class frequency histograms for mixed conifer forests at Bridge and Granite field sites. See text for further details.

Riparian Scrub-shrub

Overview. Scrub-shrub riparian communities occur throughout the entire length of the Truckee River within the study area, although their distribution is discontinuous. Common shrubs include coyote willow, yellow willow, shining willow, dusky willow, and mountain alder. Less common shrubs include silver buffaloberry (*Sheperdia argentea*), and red-osier dogwood. Also commonly occurring are shrub size Fremont's and black cottonwood. The geographical separation between the montane riparian zone of the eastern Sierra Nevada and the lowland riparian zone of the intermountain west is also reflected in the ecological differentiation of the shrub assemblage. Fremont's cottonwood and coyote willow are characteristic of lower elevations, while black cottonwood, mountain alder, and dusky willow distinguish the montane riparian assemblage.

Although data was collected according to three size-classes of shrubs, this introduced a complexity into the data set which complicated the classification and ordination analyses. For this reason, all shrub size-classes were lumped prior to the computer analyses. The elimination of this [successional] "noise" from the data set resulted in more easily interpretable results.

Scrub-shrub Community Classification. A total of 49 riparian shrub samples with 60 species were include in the TWINSPAN hierarchical classification. The initial dichotomy made a general separation between the Fremont's cottonwood-dominated scrub-shrub communities common at the Powerline and Clark sites along the lower reaches of the river and the alder and willow communities which predominate at the sites upstream of Clark (**Figure 16**).

The second division of the Fremont's cottonwood communities separates the Clark samples from the Powerline samples. The primary reason for this distinction is the absence of species other than cottonwood in the Clark samples. This is probably related to substrate differences between the two sites. The second division of the alder and willow communities upstream of the Clark site separates the montane riparian samples dominated by mountain alder from the montane and Great Basin willow communities. A few samples with an abundance of shining willow are included with the alder group because of the abundance of alder in them, but otherwise the alder-dominated samples lack other shrub species. Important herbaceous species in the alder group include fowl mannagrass, slender-beak sedge, and Kentucky bluegrass.

The willow group of shrub samples is characterized primarily by the abundance of coyote and yellow willows, although lesser amounts of shining willow, red-osier dogwood, mountain alder, and black or Fremont's cottonwood shrubs occur in some samples. A variety of herbaceous species occur among these samples. Important species include slender-beak sedge, Kentucky bluegrass, common horsetail, water-hemlock (*Cicuta douglasii*), and slender wheatgrass.

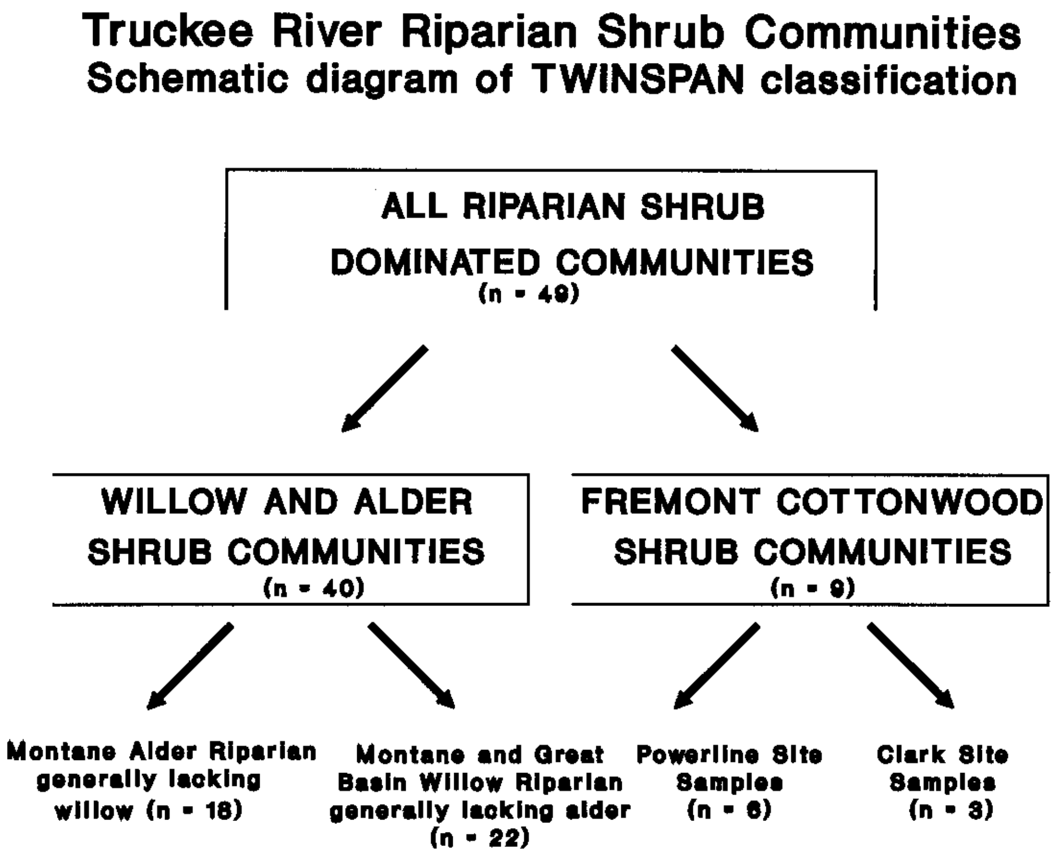

Figure 16. Schematic diagram of **T**wo-way **In**dicator **Sp**ecies **An**alysis (TWINSPAN) of riparian shrub communities along the Truckee River in California and Nevada. See text for further details.

Scrub-shrub Samples and Species Ordinations. The DCA ordination of the scrub-shrub samples illustrates a data structure generally similar to that shown in the classification produced by TWINSPAN (**Figure 16**). The first axis of the ordination shows good separation between the Powerline and Clark shrub samples and the montane riparian samples dominated by mountain alder. The second axis also shows good clustering with coyote and shining willow communities located adjacent to the center of Axis 1, black cottonwood shrub communities at the center of the ordination diagram, and yellow and dusky willow shrub communities lying in a loose cluster in the upper portion of the diagram.

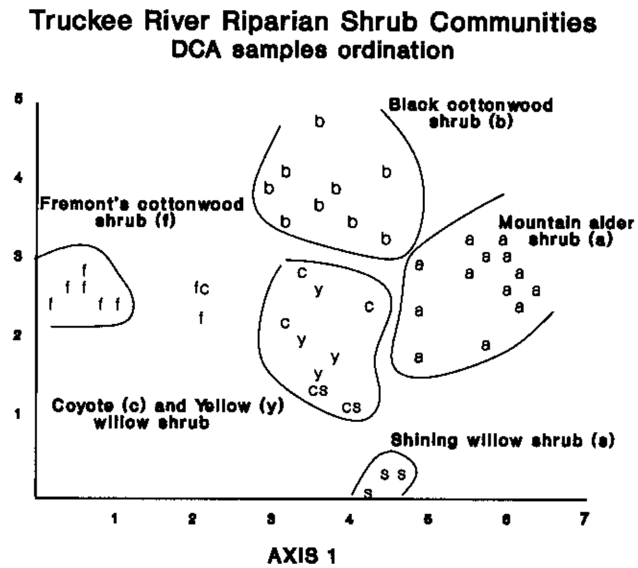

Figure 17. Detrended Correspondence Analysis (**DCA**) ordination diagram of riparian shrub samples from Truckee River field sites. See text for discussion.

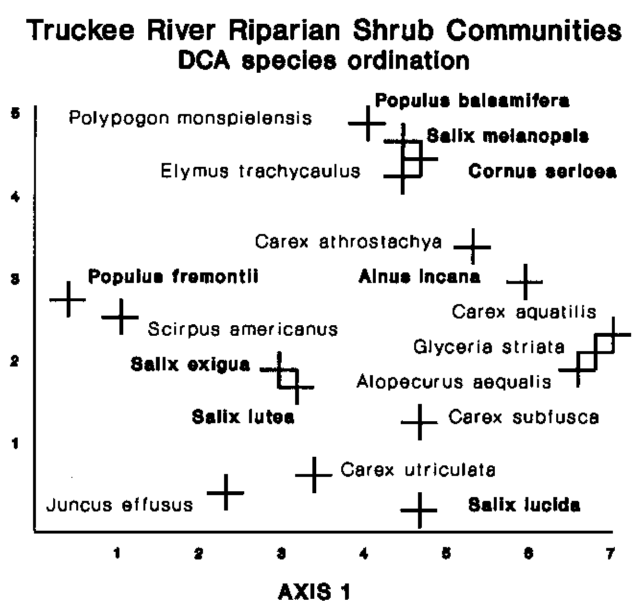

Figure 18. Species ordination diagram showing species exerting major influence on the distribution of samples shown in Figure 17.

The samples ordination in **Figure 17** is based on the identity and abundance of the species in the shrub samples included in the analysis. A species ordination (**Figure 18**) shows the species which exert major influence on the distribution of the samples in the ordination diagram. From the species ordination diagram it can be seen that Fremont's cottonwood is the only shrub determining the placement of the samples along the left margin of the diagram. Mountain alder plays a similar role along the right margin of the diagram. Herbaceous species important in the Fremont's cottonwood shrub communities include annual beard grass, broadleaved peppergrass, and Olney's rush. Important herbaceous species in the alder shrub communities include fowl mannagrass, water sedge, and short-awn foxtail.

Shrub species important in the distribution of samples along Axis 2 include coyote and shining willow (bottom), black cottonwood (central), and yellow willow, dusky willow, and red-osier dogwood (upper). Important herbaceous species include small-fruited bulrush (*Scirpus microcarpus*), water-hemlock, soft rush, and beaked sedge (lower samples); hairy willow-herb and common monkey-flower (central samples); and, silver wormwood (*Artemisia ludoviciana*), slender wheatgrass, common horsetail, and slender-beak sedge (upper samples).

Emergent Vegetation and Gravel Bars

Overview. Dense patches of emergent herbaceous vegetation and sparsely-vegetated gravel bars occur adjacent to and within the active river channel and in backwater areas throughout the study area. The structure of the emergent vegetation ranges from simple monotypic stands of spike-rush, cat-tails, or common reed to more diverse assemblages of herbaceous species. Gravel bars, although they most commonly have only sparse vegetation cover, often provide habitat for a diverse assemblage of herbaceous species. The total areal extent of herbaceous emergent vegetation is probably relatively stable, but the vegetation of instream gravel bars is subject to removal and abrasion by scour during high flow periods. Because our study was conducted at the end of an extended period of drought, gravel bars which may be less vegetated under wetter conditions had well-established stands of vegetation.

Emergent Vegetation/Gravel Bar Classification. The classification of 46 emergent and gravel bar samples produced by TWINSPAN generally shows a pattern similar to that already described above for forest and shrub vegetation (**Figure 19**). The primary distinction is between montane terrace and gravel bar communities (n=32) and emergent and gravel bar communities of the lower river (n=14). The third level of the montane classification further distinguishes between more densely vegetated sedge communities on montane terraces (n=22) and the willow-herb dominated communities more typical of montane gravel bars (n=10). Lower river samples are characterized on the basis of the dominant species. Nine samples reflect the least spikerush community which typically occurs adjacent to the active stream channel. The remaining five samples were taken from herbaceous stands in which broadleaved peppergrass was dominant.

Emergent Vegetation/Gravel Bar Sample and Species Ordinations. When the 46 samples of emergent herbaceous vegetation and gravel bar communities are subjected to DCA ordination, a familiar pattern emerges (**Figure 20**). The primary axis reflects the environmental gradient between upper montane and montane terraces and gravel bars, and the channel-edge communities of least spikerush and broadleaved peppergrass typical of the lower river.

The species ordination (**Figure 21**) shows the primary species underlying the ecological separation displayed in the samples ordination. Montane terrace communities are dominated by either water sedge, beaked sedge, slender-beak sedge, or rusty sedge. The latter species is indicative of somewhat drier sites than the other two sedge species. Montane gravel bars are dominated either by fowl mannagrass or short-awn foxtail, although numerous other species may be present. Hairy willow-herb is the dominant species on gravel bars along the lower river. A discontinuous band of least spikerush is common along the active river channel along the lower river.

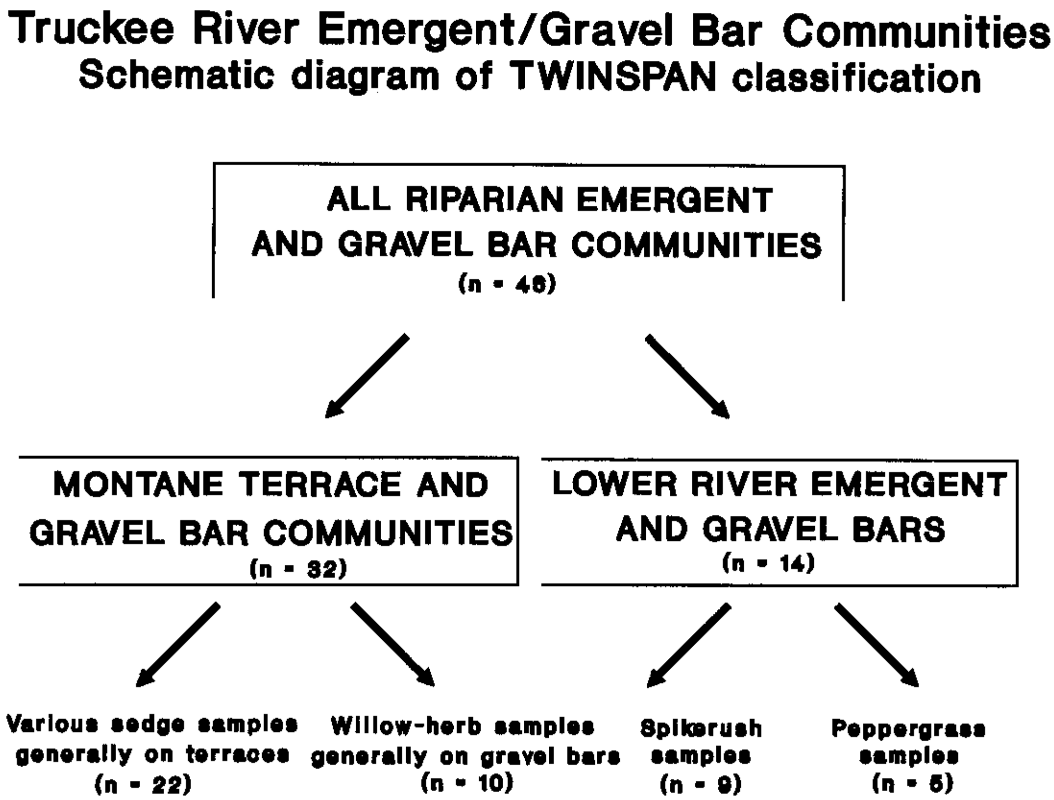

Figure 19. Schematic diagram of **T**wo-way **In**dicator **Sp**ecies **An**alysis (**TWINSPAN**) of emergent riparian communities and gravel bars at field sites along the Truckee River.

It may be monotypic or occur with small amounts of annual beard grass or Olney's bulrush. In many places, this band is contiguous to a more dense herbaceous assemblage dominated by peppergrass to the upland side. Velvetgrass (*Holcus lanatus*), rough cocklebur (*Xanthium strumarium*), and soft rush are common in this community. In the latter community, peppergrass may be the most abundant herbaceous plant species, although it is far less abundant on these sites than in either shrub or forest communities. Low stature shrubs of coyote or shining willow may also be present and comprise up to about 8% of the relative cover within the community.

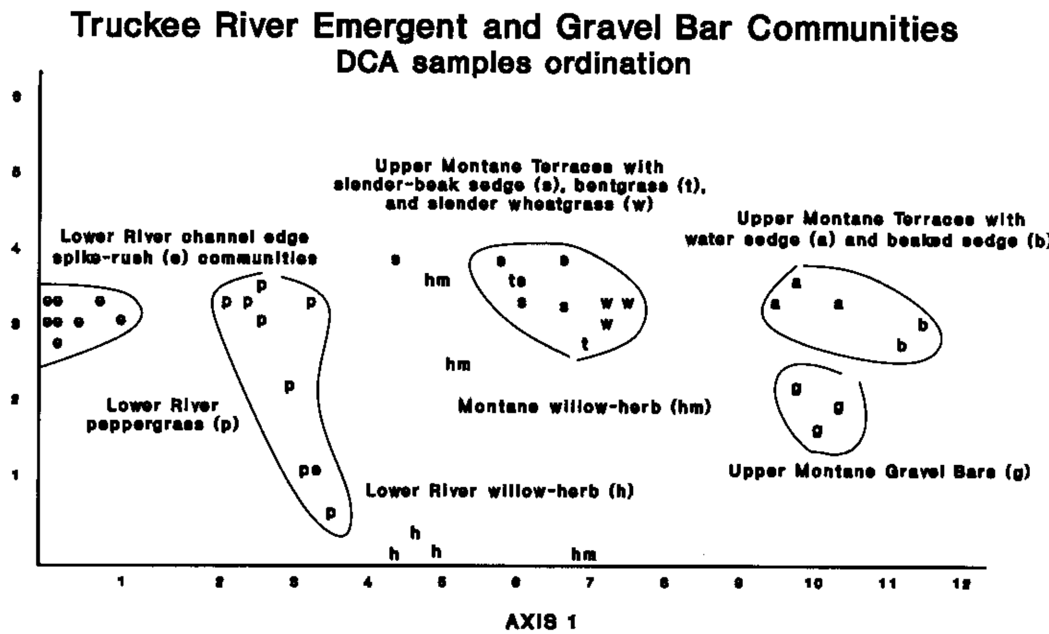

Figure 20. Detrended Correspondence Analysis (**DECORANA**) ordination diagram of emergent riparian and gravel bar communities from Truckee River sites. See text for discussion.

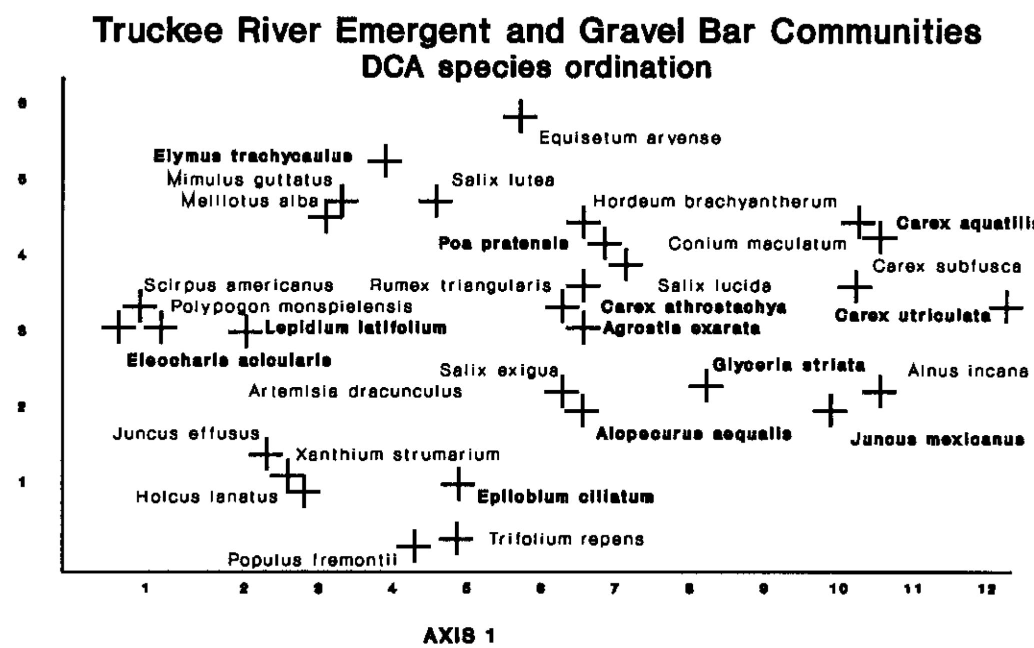

Figure 21. Species ordination diagram showing species exerting major influence on the distribution of samples shown in Figure 20.

DEVELOPMENT OF FLUVIAL HYDROLOGY-VEGETATION MODELS

Introduction

A deterministic model capable of predicting the relationship between fluvial hydrology and riparian vegetation is possible only in a limited sense. There are many factors besides surface water flow which influence the distribution of plant species. The Truckee River has had a long history of modification by human activities such as the conversion of its floodplain terraces to urban and agricultural uses, irrigation, reservoir impoundment and water diversion, roadbed construction, and overgrazing by domestic livestock with the consequent replacement of most native herbaceous species by exotic plants. Grazing also affects the reproduction and population behavior of many species of plants, including shrubs and trees. The riparian forests of the Truckee River have also been impacted by the introduction of beaver after World War II (Hall 1946, 1960; Ingles 1965).

It is important to realize that while there is a close association between riparian vegetation and the river channel, this relationship does not depend entirely upon fluvial hydrology of the river *per se*. Groundwater sources, independent of surface flow, also may play a significant role in the maintenance of riparian vegetation. A recent study of a portion of the Truckee River has shown that, during the current drought, water in some reaches during the later growing season is almost completely derived from groundwater (McKenna 1990). In urban and agricultural areas, stormwater runoff and irrigation return flow may be a major source of flow accretion in reaches of the river. Even in more natural settings, however, such as the reaches of the Truckee River between Tahoe City and Truckee, 99% of the total late season discharge is attributable to accreted groundwater during drought periods. In most reaches, the major portion of the accreted groundwater is accounted for by bank storage. The water in bank storage in this area is recharged both by Lake Tahoe water and by snowmelt. The degree to which the loss of Lake Tahoe water (because of the low lake level) in recent years affects bank storage recharge is unknown.

Our preliminary data analysis suggests that a general model of the relationship between fluvial hydrology and riparian vegetation is feasible for reaches of the Truckee River where groundwater discharge does not play a significant role. These include reaches where the river has incised a narrow canyon in bedrock, such as between Boca and Verdi, and Vista to Wadsworth (exclusive of areas within the latter reach where agricultural runoff is a major source of accreted water).

Groundwater accretion occurs in the Dodge Flat area between Wadsworth and Dead Ox Wash (Bratberg 1980). Some of the water diverted into the Truckee Canal at Derby Dam is used for irrigation on lands around Wadsworth and Fernley. The runoff returns to the Truckee River via groundwater, but the return flow is of lower quality than the river water (Sinclair and Loeltz 1963). A general map of groundwater flow northwest from the Fernley area is provided by Bratberg (1980, Fig. 11). This map shows a shallow water table to lie at an elevation of about 4,040 feet near Wadsworth and falling to about 4,000 feet over the next three miles downstream. The river channel surface elevation along this same reach ranges from about 4,028 to 3,995 feet. Thus, the average distance from the ground surface to the shallow aquifer is about five to twelve feet. In practice, the shallow groundwater surface has been found to lie at the approximate level of the open water in the river channel (P. Wagner 1993). Our field observations suggest that in general this is too great a depth to support wetland shrubs on the upper river terraces, but close enough to the ground surface to maintain older cottonwood trees established under more favorable conditions than currently exist.

Other sources of groundwater within the area include an upstream aquifer which parallels the gradient of the Truckee River, and snowmelt recharge from the Pah Rah and Truckee Ranges which border the eastern and western sides of the river valley below Wadsworth. The contribution of these aquifers is substantially less than the aquifer which flows from the Fernley area. Direct precipitation in the area is lower than the estimated evapotranspiration and is unlikely to contribute significantly to aquifer recharge. Leaching of evaporite deposits within the Lahontan lake sediments contribute to high concentrations of calcium, sulfate, sodium, and chloride in the local groundwater (Bratberg 1983). Linear ponds on the east side of the river, between the confluences of Gardella Canyon and Fort Defiance Creek, are roughly aligned with the lineation of the Walker Lake Fault Zone. The quality of the water appears to differ from the general water quality in the area. In addition, the water level in the ponds is higher in elevation than the surrounding unconfined aquifer (but lower than the piezometric surface of the underlying confined aquifer).

Because instream flows below Wadsworth are usually lowest (often less than 50 cfs) during the peak irrigation months, the river water cannot dilute the lower quality groundwater inflow. Groundwater inflow during the winter, when evapotranspiration is minimal and there is no irrigation water has been shown to be rather constant at 11.8 cfs. During periods of high flow (greater than 1000 cfs), the river appears to lose water between the Wadsworth and Nixon gages (U.S. Geological Survey 1978). Possible reasons include storage in meander scars, oxbow lakes, and banks (Bratberg 1980); the loss may also be attributable to errors in gage calibration at higher flows.

This information is provided as a cautionary note against too strict an interpretation of the models discussed below under **Impacts Analysis** and presented in **Appendix E**. While these are general models with utility for predicting the gross effects of instream flows on riparian vegetation, precise estimates of the impacts of stream flow on riparian ecosystems must be based on detailed investigations of both surface and subsurface water supplies.

Overview of the General Models

The general models presented in **Appendix E** are preliminary Habitat Suitability Index (HSI) models. There are three models, one each for emergent riparian, scrub-shrub riparian, and forested riparian. The models incorporate three variables which are measures of aspects of biotic integrity: 1) the percentage of obligate, facultative wet, and facultative plant species; 2) the percentage of native plant species; and, 3) the relative percent canopy coverage of native plant species. In addition, a fourth variable representing hydrologic regime is included in each model. The three measures of biotic integrity are the same among the three models, while the hydrologic regime variable is specific to each of the three riparian community types.

The hydrologic regime variable incorporates five major parameters of fluvial hydrology which influence riparian vegetation: 1) frequency of inundation; 2) magnitude of flows; 3) timing of flows; 4) duration of flows; and, 5) pattern of flows. All of these may affect the major life history stages of plants, i.e., seed dispersal, germination, seedling establishment, and growth and maintenance. The relationships among the hydrologic factors and plant life histories are complex, and our understanding of them is hampered by a lack of data on the biological requirements of most plant species. Fremont's and black cottonwood are two of the better studied riparian trees of western North America, and the following discussion will emphasize them. Where possible, inferences will be drawn to other shrub and herbaceous species associated with cottonwood on the Truckee River.

Cottonwood is a copious seed producer. Our observations on the Truckee River indicate that seeds ripen and are released between early May and early July with the peak occurring during the month of June. The extremely small seeds are initially dispersed by wind, and may be carried long distances before reaching the ground. Seeds of Fremont's cottonwood lose viability after approximately three weeks (Fenner *et al.* 1985). If the seeds are deposited on a moist mineral surface, they germinate rapidly. Under an unimpaired flow regime, seed release in many years coincides with large magnitude, snowmelt floods. The receding floodwaters leave a fresh deposit of moist alluvial sediments which afford the newly released seeds a favorable site for germination. If vegetation is dense, seedling establishment may depend on scouring flows during the previous winter or the prior year. The moist surface may, in some years, supplied by spring or early summer rains (Stromberg and Patten 1991). Most of the above probably applies to willow species as well.

The newly germinated seedlings are dependent on moisture in the soil matrix if they are to successfully establish in areas where groundwater lies at a distance from the ground surface, or in areas away from the active stream channel. Recent studies in the southwestern United States have shown

Fremont's cottonwood to be a phreatophyte, i.e., it avoids drought by tapping into local groundwater (Busch *et al.* 1992). For this to occur, the rate of root penetration must keep pace with the loss of moisture in the soil matrix through evaporation. If adequate soil moisture is available, root growth may be rapid; in the Central Valley of California, where the growing season is long, roots of Fremont's cottonwood may extend to depths of 15 feet in two years (T. Griggs 1993). Willows are also obligate wetland species, but they appear to have a more shallow maximum rooting depth than cottonwood. Terraces which currently support large, older cottonwood along the lower Truckee River probably lie at elevations of 20 to 30 feet above the local groundwater table, and lack willows. Willows appear to be restricted to areas within 10 feet of groundwater. Alder appears to be more restricted, being uncommon more than 6 feet above groundwater.

Growth and maintenance requirements of cottonwood trees are more difficult to quantify, and require in-depth, site specific studies. Such studies are available for Bishop Creek in Inyo County, and for Lee Vining and Rush Creeks in the Mono Lake Basin (Stromberg and Patten 1991, 1992). Relationships were developed between seasonal flow volumes and tree ring widths, between annual ring width and canopy vigor, and between ring width and population mortality. At Bishop Creek, healthy cottonwoods were found to have annual ring widths between 3-4 mm depending on elevation. In the Mono Lake Basin, radial growth rates below 2 mm/year correlated with low canopy vigor; very low growth values (less than 1 mm/year) were associated with tree mortality. Based on these results, instream flow recommendations were possible for three categories of flow: 1) **subsistence flows** (flows associated with growth rates of 1.75 mm/year and some decline in canopy vigor); 2) **maintenance flows** (those producing growth rates of 2.00 mm/year and relatively vigorous canopies); and, 3) **attainment flows** (those producing growth rates of 2.5 mm/year and vigorous canopies, i.e., those allowing attainment of biotic potential). Similar information is not available for shrubs occurring within the study area.

Because the seasonal flow volumes which correlate with these categories are specific to the streams studied, the flow recommendations in these studies are not translatable to the Truckee River. It is worthwhile noting, however, that substantially higher flows are necessary to maintain floodplain trees than are required for channel-side trees. In addition, the data suggest that the flow needs of floodplain trees are higher under existing conditions than they were historically. This may be because stream incision has reduced the water available to floodplain trees from a given flow volume.

Of the five hydrologic parameters, we have adequate monthly information on the frequency of inundation, magnitude of flows, and, to a lesser extent, the timing of flows. The influence of timing of flows is also important, however, on a weekly basis. The duration of inundation is primarily of importance at a daily,or perhaps weekly, scale, but duration must be estimated because of the lack of data of this precision. Pattern of flows is also generally expressed on a daily basis.

The frequency of inundation can be estimated from the flood frequency graphs included in **Appendix A**. This value, expressed in years, can be included as an environmental variable in a modified version of the **detrended correspondence analysis** program described earlier in the community discussion. Other environmental variables can be included as well. In addition to the frequency of inundation, we included site elevation, ground surface litter cover, and proportion of ground surface covered by silt or clay, sand, gravel, cobbles, or boulders. When environmental data is included, the process is termed **direct gradient analysis** and the analytical procedure is known as **detrended canonical correspondence analysis** (**DCCA**). Despite this seemingly complex name, the procedure is the same as the ordination procedure described earlier. Both samples and species are arranged in an ordination diagram with the spatial distances between samples or species representing ecological separation. The environmental data is included in a parallel data set and an axis is shown which corresponds to the best fit of each environmental variable to the samples and species data.

Upper Truckee River

The results of the DCCA ordination for the upper Truckee River samples are shown in **Figure 22**. The diagram shows that the upland forest and shrub samples lie at the far left of Axis 1 and the emergent wetland and gravel bar communities to the far right. The other community types lie between these extremes. The environmental axes are also shown. Note that the environmental axes associated with frequency of inundation, substrate, and litter cover lie nearly parallel to Axis 1 of the ordination diagram, while elevation displays a similar relationship to Axis 2.

Because we are most interested with the frequency of inundation (for the reason discussed above), this environmental axis is more closely examined in **Figure 23**. Here the frequency of inundation axis is extended and labeled with values, which can be extrapolated to the various samples by the construction of perpendicular lines. Emergent and gravel bar communities, lying at the far right, can be seen to be inundated annually, while the upland forest and scrub types occurring to the far left are inundated by flood events occurring only every 15 or more years. Cottonwood riparian forest inundation events occur at 5 to 15 year intervals, and alder-willow shrub communities every 1 to 5 years (**Tables XI** and **XII**). The interpretation of these data for each of the vegetation types is discussed separately below.

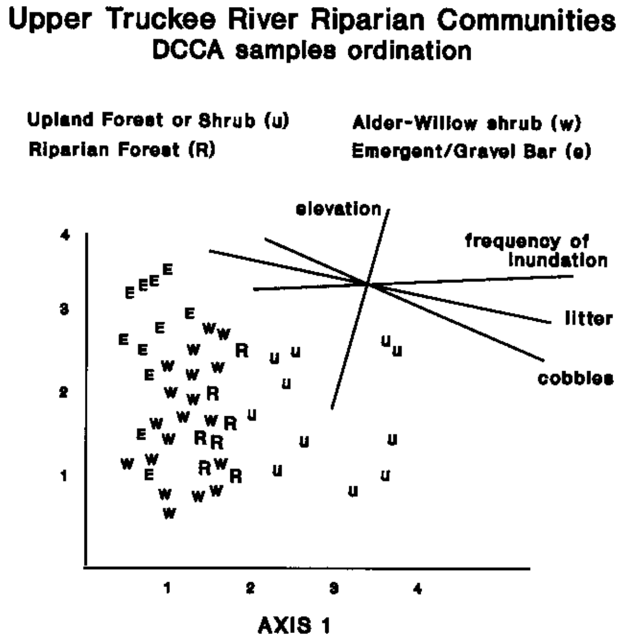

Figure 22. Detrended Canonical Correspondence Analysis ordination of upper river riparian vegetation. Major environmental vectors are also shown.

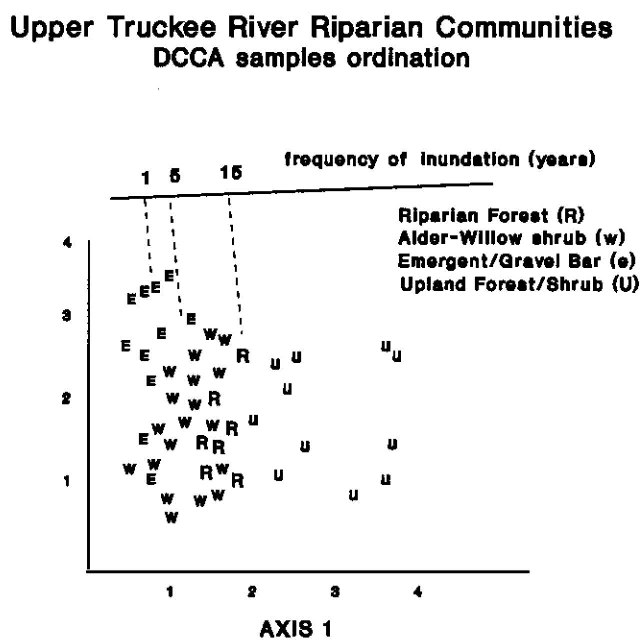

Figure 23. Same as Figure 22, but with frequency of inundation vector isolated. See text for discussion.

Emergent and Gravel Bar Communities

Emergent wetland and gravel bar communities occur in bands adjacent to and within the active river channel. Beaked sedge is the most abundant species, although fowl mannagrass, slender-beak sedge, and several other species of grasses and herbs are present with higher constancy. Shrubs of alder or willow also occur infrequently in low abundance (**Table XII**). Introduced weeds, although present, are neither frequent nor abundant. The substrate is typically of cobbles. These communities are inundated on an annual basis. The narrow distribution of these types and the prevalence of obligate and facultative wet species suggest that the communities cannot tolerate extended periods of drought. Our data suggest that flows of about 100 cfs are sufficient to inundate the topographic surfaces on which these communities are found (**Table XI**).

Because of the generally steep channel profile, most of the species are probably restricted in their ability to migrate in response to flow fluctuations. Flows significantly greater than those characteristic of the past several years could reduce the total areas of these types by restricting them to a narrow band along the channel bank. Extreme flows would also increase the substrate instability, thereby making it more difficult for plant species to colonize the exposed surfaces. There is no evidence of loss of suitable substrate or emergent vegetation as a result of the increased runoff during the spring of 1993.

Table XI. Flow ranges required for inundation of topographic surfaces supporting various riparian plant communities along the upper Truckee River. Frequency of inundation ranges are given in parentheses. Flow values are in cubic feet per second (cfs). Bracketed numbers give the percent of time that the flows are exceeded [flows of 3000 cfs are exceeded only about 5% of the time].

Gaging Station	Emergent/Gravel Bar (annual)	Alder-Willow Shrub (1-5 years)	Riparian Forest (5-15 years)	Upland Forest or Shrub (> 15 years)
@ Tahoe City	70-100 [99-20%]	100-1100	1100-1600	>1600
@ Farad	<100 [95%]	100-5500	5500-9000	>9000
@ Reno	400-600 [46-28%]	600-6000	6000-10200	>10200

Table XII. Plant species composition and abundance of riparian vegetation along the upper Truckee River, CA/NV. Communities are grouped into four frequency of inundation categories. Abundance values are given in **percentage canopy coverage** followed by the **constancy** of the species (% of samples in which the species occurs) in parentheses. Also given is the **Indicator Category** for each species (Reed, 1988b). Introduced species are marked with an **asterisk**. **Common Names** are provided in **Appendix D.**

			Frequency	of Inundation	
	Indicator	**1 year**	**1 to 5 yrs**	**5 to 15 yrs**	**>15 years**
Scientific Name/Substrate Type	Category	(n = 21)	(n = 39)	(n = 18)	(n = 14)
Trees					
Populus balsamifera	FACW	---------	2.0 (3)	6.5 (22)	----------
Populus fremontii	FACW	---------	1.9 (3)	---------	8.3 (7)
Pinus contorta	FAC	---------	1.0 (5)	4.1 (22)	6.6 (14)
Pinus jeffreyi	UPL	---------	---------	2.6 (5)	8.5 (29)
Abies concolor	UPL	---------	---------	---------	14.3 (14)
Tall Riparian Shrubs					
Alnus incana tenuifolia	FACW	12.8 (14)	14.2 (15)	1.0 (5)	----------
Populus fremontii	FACW	---------	1.9 (5)	---------	----------
Elaeagnus angustifolia*	FAC	---------	1.4 (8)	---------	----------
Salix lutea	OBL	---------	---------	6.6 (22)	----------
Populus balsamifera	FACW	---------	---------	1.9 (17)	5.2 (7)
Salix melanopsis	OBL	---------	---------	0.5 (5)	----------
Medium Riparian Shrubs					
Alnus incana tenuifolia	FACW	2.0 (14)	23.1 (33)	0.8 (5)	----------
Salix lucida lasiandra	OBL	0.5 (5)	7.2 (20)	---------	----------
Salix lutea	OBL	0.3 (5)	4.1 (15)	3.4 (17)	----------
Salix exigua	OBL	---------	2.3 (18)	5.9 (17)	----------
Populus balsamifera	FACW	---------	1.3 (8)	0.6 (22)	1.6 (7)
Eleagnus angustifolia*	FAC	---------	0.6 (8)	---------	----------
Salix melanopsis	OBL	---------	0.5 (5)	---------	----------
Cornus sericea	FACW	---------	<0.1 (3)	0.5 (5)	----------
Low Riparian Shrubs					
Salix lutea	OBL	2.4 (9)	<0.1 (3)	---------	----------
Salix lucida lasiandra	OBL	0.8 (14)	0.1 (5)	---------	----------
Populus balsamifera	FACW	0.7 (5)	1.4 (18)	1.3 (28)	2.1 (7)
Alnus incana tenuifolia	FACW	0.4 (5)	0.3 (5)	---------	----------
Salix exigua	OBL	<0.1 (5)	1.3 (13)	0.1 (5)	1.0 (7)
Salix melanopsis	OBL	---------	0.1 (3)	---------	----------
Cornus sericea	FACW	---------	0.3 (3)	---------	----------

Scientific Name/Substrate Type	Indicator Category	Frequency of Inundation 1 year (n = 21)	1 to 5 yrs (n = 39)	5 to 15 yrs (n = 18)	>15 years (n = 14)
Upland Shrubs					
Ribes viscosissimum	NI	0.8 (5)	---------	---------	2.9 (14)
Rosa woodsii	FAC-	---------	1.4 (10)	5.6 (33)	3.6 (29)
Chrysothamnus nauseosus	UPL	---------	0.2 (3)	0.5 (5)	0.6 (14)
Chrysothamnus viscidiflorus	UPL	---------	0.2 (3)	1.2 (17)	----------
Populus tremuloides	FAC+	---------	<0.1 (3)	---------	6.3 (14)
Artemisia tridentata	UPL	---------	---------	0.2 (17)	5.5 (29)
Amelanchier alnifolia pumila	FACU	---------	---------	---------	5.6 (14)
Symphoricarpos rotundifolius	UPL	---------	---------	---------	2.7 (21)
Purshia tridentata	UPL	---------	---------	---------	2.6 (21)
Prunus emarginata	UPL	---------	---------	---------	2.1 (14)
Grasses and Graminoids					
Carex utriculata	OBL	8.8 (14)	1.1 (10)	---------	----------
Glyceria striata	OBL	4.0 (38)	3.5 (13)	---------	----------
Carex athrostachya	FACW	3.5 (33)	0.6 (10)	---------	1.0 (7)
Carex aquatilis	OBL	2.4 (5)	2.1 (10)	---------	----------
Alopecurus aequalis	OBL	2.3 (24)	0.6 (3)	---------	0.2 (4)
Hordeum brachyantherum*	FACW-	1.9 (29)	0.7 (8)	---------	----------
Poa pratensis*	FACU	1.6 (19)	6.9 (33)	9.0 (50)	6.5 (36)
Agrostis exarata	FACW	1.2 (19)	0.6 (3)	---------	----------
Juncus mexicanus	FACW	1.0 (9)	0.4 (5)	0.3 (5)	----------
Carex subfusca	FAC-	0.7 (9)	4.9 (31)	0.6 (11)	8.5 (29)
Carex lanuginosa	OBL	0.4 (9)	0.2 (3)	---------	----------
Dactylis glomerata*	FACU	0.4 (5)	---------	---------	----------
Juncus balticus	OBL	0.1 (5)	---------	<0.1 (5)	----------
Phalaris arundinacea*	OBL	---------	1.4 (5)	---------	----------
Bromus tectorum*	UPL	---------	0.2 (3)	1.3 (17)	2.5 (14)
Elymus trachycaulus	FACU	---------	6.7 (36)	15.1 (72)	7.4 (57)
Scirpus microcarpus	OBL	0.3 (5)	0.5 (5)	---------	----------
Calamagrostis rubescens	UPL	---------	1.0 (3)	---------	----------
Juncus effusus	OBL	---------	0.4 (3)	---------	----------
Achnatherum occidentalis	UPL	---------	0.1 (3)	---------	2.5 (14)

Scientific Name/Substrate Type	Indicator Category	Frequency of Inundation 1 year (n = 21)	1 to 5 yrs (n = 39)	5 to 15 yrs (n = 18)	>15 years (n = 14)
Poa cusickii	UPL	---------	---------	<0.1 (5)	----------
Festuca idahoensis	UPL	---------	---------	---------	1.9 (14)
Hesperostipa comata	UPL	---------	---------	---------	0.1 (7)
Elymus elymoides	UPL	---------	---------	---------	<0.1 (7)
Herbs					
Mimulus guttatus	OBL	2.9 (24)	---------	---------	----------
Melilotus alba*	FACU	2.6 (19)	0.3 (8)	---------	1.6 (7)
Equisetum arvense	FAC	2.6 (14)	6.3 (23)	2.1 (22)	0.6 (14)
Epilobium ciliatum	FACW	2.3 (38)	<0.1 (5)	---------	----------
Verbascum thapsus*	UPL	1.3 (24)	---------	<0.1 (5)	----------
Arnica amplexicaulis	FACW	0.9 (5)	---------	---------	----------
Trifolium repens*	FACU	0.6 (9)	0.3 (5)	---------	----------
Rumex triangulivalvis	FACW	0.5 (14)	---------	---------	----------
Plantago lanceolata*	FACU	0.2 (14)	---------	---------	----------
Solidago canadensis	FACU	0.2 (5)	0.7 (5)	0.4 (5)	0.3 (7)
Sphenosciadium capitellatum	OBL	0.1 (5)	---------	---------	----------
Tragopogon dubius*	UPL	0.1 (5)	---------	<0.1 (11)	----------
Fragaria virginiana	FAC	<0.1 (5)	---------	---------	----------
Artemisia dracunculus	UPL	---------	<0.1 (3)	1.4 (11)	2.0 (7)
Artemisia ludoviciana	FACU	---------	0.5 (8)	0.6 (22)	----------
Conium maculatum	FACW	---------	4.4 (18)	2.1 (22)	0.6 (7)
Urtica dioica	FAC	---------	0.5 (3)	0.6 (5)	----------
Cicuta douglasii	OBL	---------	0.3 (5)	5.8 (11)	----------
Heracleum lanatum	FAC	---------	<0.1 (3)	---------	1.4 (7)
Potentilla glandulosa	FACU	---------	<0.1 (3)	---------	<0.1 (7)
Hypericum anagalloides	OBL	---------	<0.1 (3)	---------	----------
Phacelia heterophylla	FACU	---------	<0.1 (3)	---------	----------
Cirsium arvense	FAC-	---------	---------	2.3 (22)	----------
Smilicina stellata	FAC	---------	---------	1.3 (5)	----------
Lupinus polyphyllus	FACW	---------	---------	0.4 (5)	----------
Galium triflorum	FACU	---------	---------	<0.1 (5)	----------
Vicia americana	NI	---------	---------	<0.1 (11)	----------

Scientific Name/Substrate Type	Indicator Category	Frequency of Inundation 1 year (n = 21)	1 to 5 yrs (n = 39)	5 to 15 yrs (n = 18)	>15 years (n = 14)
Wyethia amplexicaulis	UPL	---------	---------	---------	0.7 (14)
Sidalcea glaucescens	UPL	---------	---------	---------	0.2 (7)
Polygonum douglasii	UPL	---------	---------	---------	0.2 (7)
Eriogonum umbellatum	UPL	---------	---------	---------	0.1 (7)
Penstemon sp.	UPL	---------	---------	---------	<0.1 (7)
Substrate					
litter	n/a	37.9 (52)	80.6 (97)	83.2 (94)	94.2 (100)
brush piles	n/a	---------	6.8 (15)	4.5 (22)	----------
clay	n/a	2.5 (5)	0.2 (3)	---------	1.0 (7)
sand	n/a	---------	1.2 (8)	6.4 (22)	----------
gravel	n/a	7.2 (14)	---------	---------	2.6 (21)
cobbles	n/a	43.6 (71)	6.2 (18)	0.3 (5)	0.2 (7)
boulders	n/a	8.8 (19)	5.0 (20)	5.6 (5)	2.0 (36)

Alder-Willow Shrub Communities

These scrub-shrub wetlands commonly occur along the channel bank, but they can also occasionally be found on stabilized gravel bars within the active stream channel. Tall and medium tall shrubs of mountain alder are most abundant and constant, but several species of willow are also common. These communities have the highest number of native plant species with a rich assortment of graminoids and herbs present in relatively low abundance (**Table XIII**). The substrate is typically comprised of a mixture of boulders, cobbles, and clay. Most of the ground surface is covered by litter. Inundation frequencies range from 1 to 5 years, with corresponding flow rates of 100-6,000 cfs.

Introduced plant species are unimportant although Kentucky bluegrass has a relatively high abundance. Its indicator status (FACU) suggests that its success in invading this community is enhanced by low flows. Most of the shrubs are able to avoid drought by tapping into subsurface water when channel flows are low. Mountain alder, however, appears to be more adversely affected by drought than other shrubs. With higher flows the shrubs would establish at higher levels above the channel.

Riparian Forest Communities

These forested wetlands are dominated by black cottonwood although lodgepole pine is also often present in low abundance. The understory is a variety of willow and cottonwood shrubs. Both the tree canopy and the shrub layers are discontinuous, thereby creating an open forest with a variety of grasses, graminoids, and herbs growing on the ground surface (**Table XII**). Slender wheatgrass is the most abundant and constant of these, although the introduced species, Kentucky bluegrass, is common as well. The substrate is comprised of sand. Most of the ground surface is covered with litter, and there are frequent brushpiles. Many of these originate from material deposited by high flows in previous years. The inundation range for these terraces is between 5 and 15 years, with corresponding flow rates between 1,000 and 10,000 cfs.

These surfaces, in general, tend to be in relatively good ecological condition. Cottonwood regeneration is good and there is little or no grazing by domestic livestock. Downstream of the State line, most of the terraces on which these riparian forests occurred have been converted to agricultural or residential use, although numerous patches remain. Between the State Line and Boca, these forests are restricted to narrow bands between the highway and railroad embankments. Upstream of Boca, these cottonwood riparian forests are limited to a few small patches. The minimum flow requirements under which this portion of the Truckee River is currently managed appear to be sufficient to maintain the existing riparian forests, although loss is still occurring through clearing, development, and beaver activity.

Upland Forest and Shrub Communities

Upland forest and shrub communities are never inundated by high water and are not likely to be affected by changes in flow regimes. Our data suggest that during the prolonged drought leading up to this study, some upland species were able to establish in riparian areas. Higher flows, whether due to increased precipitation or additional releases from reservoirs will probably lead to mortality to individuals on unfavorable sites. Continued low flows, by contrast, are likely to facilitate the establishment of upland plant species in riparian areas. Over the long term, this could lead to a loss of riparian adapted species in favor of facultative taxa (Smith *et al.* 1991).

Restoration Considerations

Most of the losses of riparian vegetation along the upper Truckee River are related to highway and railroad construction in the narrow river canyon. In addition, local loss has occurred due to urban and agricultural development of the riparian corridor. Restoration possibilities are limited due to the nature of the impacts along the upper river. A limited survey of the cottonwood stands in the canyon in the vicinity of Floriston suggests that beaver comprise a significant threat to the long-term maintenance of forested riparian communities in this area. Most of the trees in the riparian forests, which are already reduced to a narrow strip by the highway and/or the railroad bed, show evidence of beaver predation. Numerous beaver cut trees have been already fallen. As noted earlier, beaver are not thought to be native to the Truckee River. In the narrow canyon reaches, where the wetland construction and enhancement benefits of beaver populations are nil, their presence is a detriment to the ecosystem. Unless steps are taken to remove the beaver, or protect the remaining trees with chicken wire, the long-term persistence of a riparian cottonwood forest along the upper Truckee River is doubtful.

Lower Truckee River

The results of the DCCA ordination for the lower Truckee River samples are shown in **Figure 24**. The diagram shows that the upland scrub samples lie at the far left of Axis 1 and spikerush communities to the far right. The other community types lie between these extremes. The environmental axes are shown in the upper right corner. Note that the environmental axes associated with frequency of inundation lies nearly parallel to Axis 1 of the ordination diagram, while the vertical axis lies parallel to the vector for cobbles.

Because we are most interested with frequency of inundation (for reasons discussed above), this environmental axis is more closely examined in **Figure 25**. Here the frequency of inundation axis is extended and labeled with values, which can be extrapolated to the various samples by the construction of perpendicular lines. Least spikerush communities, lying at the far right, can be seen to be inundated annually, while the upland scrub (i.e., sagebrush or greasewood) communities to the far left are inundated only by flood events occurring every 15 or more years. Cottonwood forests inundation events occur at 5 to 15 year intervals, and cottonwood shrub communities every 1 to 5 years (**Tables XIII, XIV**). The interpretation of these data for each of the vegetation types is discussed separately below.

Spikerush Communities

This emergent wetland type occurs as a band adjacent to the active river channel. The width of the band varies with local topography, but seldom exceeds 10 feet. Least spikerush is the most abundant and most constant species, but a variety of other grasses, graminoids, and herbs infrequently occur (**Table XIV**). Low shrubs of Fremont's cottonwood, willow, or alder may be present but are always sparse. Introduced weeds are neither frequent nor abundant. The substrate is comprised of a mixture of clay and sand with good water holding capacity. This community is inundated on an annual basis. The narrow distribution of this community and the prevalence of obligate wetland plant species suggests that it cannot tolerate extended periods of drought. Our data suggest that flows in the range of several hundred cfs are generally sufficient to inundate the topographic surfaces on which this community occurs (**Table XIII**). If the channel profile is not too steep, most of the species of this community probably have the ability to migrate in response to short-term flow fluctuations. Flows significantly greater than those characteristic of the past several years would probably reduce the total area of this community type by restricting it to a narrow band along the channel bank. Flows during 1993, which reached 2,000 cfs, did not appear to impact these communities.

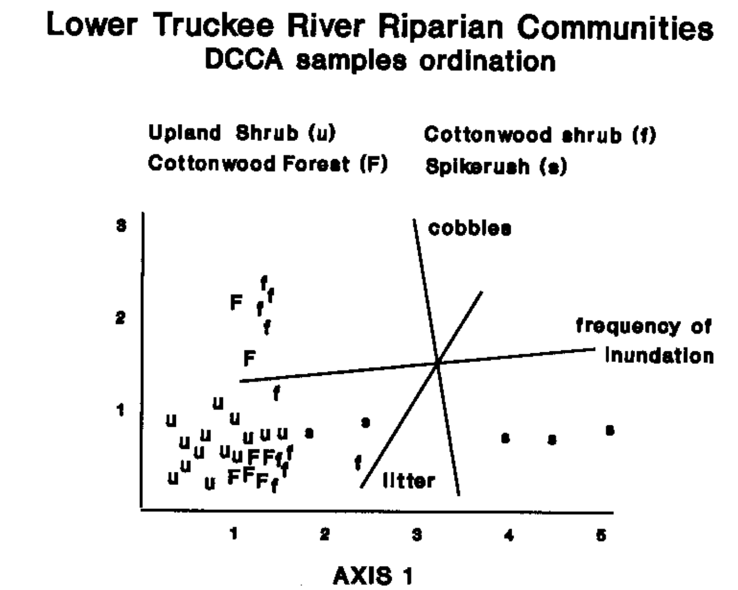

Figure 24. Detrended Canonical Correspondence Analysis ordination of lower river riparian vegetation. Major environmental vectors are also shown.

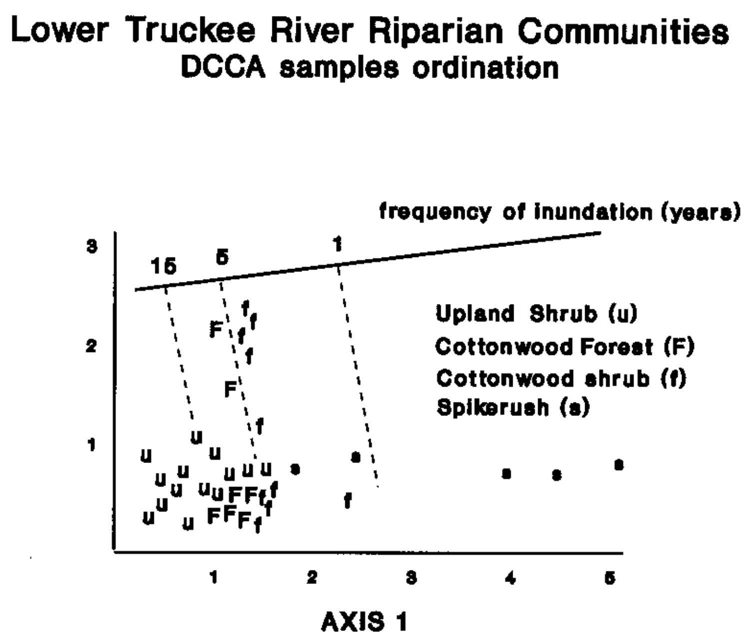

Figure 25. Same as Figure 24 with frequency of inundation vector emphasized. See text for discussion.

Table XIII. Flow ranges required for inundation of topographic surfaces supporting various riparian plant communities along the lower Truckee River. Frequency of inundation ranges are given in parentheses. Flow values are in cubic feet per second. Bracketed numbers give the percent of time that the flows are exceeded [flows of 3000 cfs are exceeded only about 5% of the time].

Gaging Station	Spikerush (annual)	Riparian Shrub (1-5 years)	Forest (5-15 years)	Upland Shrub (> 15 years)
@ Reno	400-600 [46-28%]	600-6000	6000-10200	>10200
@ Sparks	100-200 [92-50%]	100-6900	6900-10500	>10500
Near Vista	<100 [91%]	100-5800	5800-10000	>10000
Below Tracy	400-600 [65-38%]	600-6000	6000-11200	>11200
Below Derby Dam	100-200 [37-32%]	200-5000	5000-9000	>9000
@ Wadsworth	<100 [63%]	100-6800	6800-12000	>12000
Near Nixon	80-125 [45-50%]	100-5500	5500-10000	>10000

Cottonwood Shrub Communities

This scrub-shrub wetland commonly occurs along the channel bank but occasionally extends onto bars within the active stream channel. Medium tall and low shrubs of Fremont's cottonwood are most abundant and most constant. The total shrub cover is generally low (about 25%). This community has the highest number of native plant species with a rich assortment of graminoids and herbs present in relatively low abundance (**Table XIV**). The substrate is typically a mixture of sand and cobbles. About 1/3 of the ground surface is covered with litter. Inundation frequencies range from about 1 to 5 years, with corresponding flow rates between several hundred and 5,000 to 7,000 cfs. This shrub community has a large number of introduced grasses and herbs, including peppergrass and sweet-clover both of which are abundant and frequent. Several of the introduced weeds in this community are Facultative Upland species (FACU) suggesting that their success in invading this community is enhanced by low flows. The shrubs are generally able to avoid drought conditions by tapping into subsurface water when channel flows are low. With an increase in flow rates, these shrubs would be able to establish at higher levels above the channel. The relative cover and constancy of willows is relatively low, especially when compared to those of cottonwood. The clonal root structure of willows is better adapted to the dynamic conditions on the

Table XIV. Plant species composition and abundance of riparian vegetation along lower Truckee River, Nevada. Communities are grouped into four frequency of inundation categories. Abundance values are given in **percentage canopy coverage** followed by the **constancy** of the species (% of samples in which the species occurs) in parentheses. Also given is the **Indicator Category** for each species (Reed, 1988b). Introduced species are marked by an **asterisk**.

		Frequency of Inundation			
Scientific Name/Substrate Type	Indicator Category	**1 year** (n = 12)	**1 to 5 yrs** (n = 18)	**5 to 15 yrs** (n = 26)	**>15 years** (n = 27)
Trees					
Populus fremontii	FACW	---------	---------	25.3 (38)	8.3 (7)
Tall Riparian Shrubs					
Populus fremontii	FACW	---------	---------	5.8 (4)	---------
Medium Riparian Shrubs					
Populus fremontii	FACW	---------	10.4 (22)	4.9 (8)	0.6 (4)
Salix exigua	OBL	---------	1.0 (17)	---------	---------
Salix lutea	OBL	---------	0.7 (6)	---------	---------
Salix lucida lasiandra	OBL	---------	0.9 (6)	---------	---------
Alnus incana tenuifolia	FACW	---------	0.8 (6)	---------	---------
Low Riparian Shrubs					
Salix lucida lasiandra	OBL	4.1 (17)	---------	---------	---------
Salix exigua	OBL	2.6 (25)	0.4 (6)	---------	---------
Alnus incana tenuifolia	FACW	0.6 (8)	---------	---------	---------
Populus fremontii	FACW	0.3 (8)	12.0 (44)	8.2 (4)	---------
Ulmus parvifolia*	NI	<0.1 (8)	---------	---------	---------
Salix lutea	OBL	---------	0.3 (6)	---------	---------
Upland Shrubs					
Artemisia tridentata	UPL	---------	0.2 (6)	1.7 (38)	21.8 (56)
Chrysothamnus nauseosus	UPL	---------	1.5 (6)	0.5 (4)	---------
Chrysothamnus viscidiflorus	UPL	---------	---------	0.2 (4)	4.7 (11)
Gutierrezia sarothrae	UPL	---------	---------	<0.1 (4)	<0.1 (4)
Sheperdia argentea	NI	---------	---------	---------	5.0 (11)
Sarcobatus vermiculatus	FACU	---------	---------	---------	0.4 (7)
Prunus andersonii	UPL	---------	---------	---------	0.1 (4)

Scientific Name/Substrate Type	Indicator Category	Frequency 1 year (n = 12)	of Inundation 1 to 5 yrs (n = 18)	5 to 15 yrs (n = 26)	>15 years (n = 27)
Grasses and Graminoids					
Eleocharis acicularis	OBL	52.6 (67)	6.5 (28)	---------	---------
Scirpus americanus	OBL	8.9 (25)	1.1 (11)	---------	---------
Polypogon monspielensis*	FACW+	5.2 (17)	2.2 (17)	---------	---------
Poa pratensis*	FACU	1.1 (8)	1.3 (17)	---------	---------
Juncus balticus	OBL	0.7 (8)	1.1 (6)	---------	---------
Carex utriculata	OBL	0.7 (8)	0.4 (6)	---------	---------
Phalaris arundinacea*	OBL	0.9 (8)	0.2 (6)	---------	---------
Carex douglasii	FACU	0.1 (8)	0.3 (6)	---------	---------
Carex lenticularis	OBL	0.1 (8)	---------	---------	---------
Juncus effusus	OBL	---------	2.0 (17)	---------	---------
Holcus lanatus*	FAC	---------	3.0 (17)	---------	---------
Hordeum brachyantherum*	FACW-	---------	<0.1 (6)	---------	---------
Bromus tectorum*	UPL	---------	0.5 (6)	0.2 (8)	---------
Distichlis spicata	FAC+	---------	---------	<0.1 (4)	0.2 (4)
Elymus trachycaulus	FACU	---------	---------	1.4 (8)	---------
Leymus cinereus	NI	---------	---------	0.2 (8)	3.3 (18)
Herbs					
Lepidium latifolium*	FAC	1.6 (8)	20.7 (56)	16.3 (65)	20.8 (44)
Melilotus alba*	FACU	1.5 (8)	14.3 (39)	0.2 (4)	0.2 (4)
Artemisia dracunculus	UPL	0.2 (8)	1.2 (17)	<0.1 (4)	0.5 (11)
Mimulus guttatus	OBL	0.4 (8)	0.2 (6)	---------	---------
Epilobium ciliatum	FACW	0.3 (17)	2.6 (17)	---------	---------
Trifolium repens*	FACU	0.2 (8)	1.5 (17)	0.2 (8)	---------
Xanthium strumarium	FAC	---------	3.9 (22)	---------	---------
Conringia orientalis*	NI	---------	2.6 (6)	---------	---------
Castilleja minor	OBL	---------	0.2 (6)	---------	---------
Plantago lanceolata*	FACU	---------	0.2 (6)	---------	---------
Urtica dioica	FAC	---------	0.2 (6)	---------	---------
Artemisia ludoviciana	FACU	---------	<0.1 (6)	---------	---------

Scientific Name/Substrate Type	Indicator Category	Frequency of Inundation 1 year (n = 12)	1 to 5 yrs (n = 18)	5 to 15 yrs (n = 26)	>15 years (n = 27)
Substrate					
litter	n/a	15.8 (33)	33.6 (50)	56.7 (88)	49.0 (96)
brush piles	n/a	---------	1.7 (6)	---------	1.3 (11)
clay	n/a	57.2 (67)	5.6 (6)	---------	---------
sand	n/a	19.2 (25)	36.2 (50)	33.0 (77)	34.4 (89)
gravel	n/a	---------	---------	1.7 (15)	3.5 (15)
cobbles	n/a	6.9 (25)	22.9 (28)	8.4 (15)	10.3 (33)
boulders	n/a	0.9 (8)	---------	0.3 (4)	---------

edge of the active river channel. Hence, the community would be more stable if willow growth were to be encouraged in this community. Once established, willows can be expected to thrive up to about eight feet above the water table as indicated by the level of instream water during low flow conditions.

Cottonwood Forest Communities

This forested wetland is dominated by a single species of tree, Fremont's cottonwood. Understory shrubs are commonly upland species. Native grasses are present infrequently in low amounts. The herb layer is comprised primarily of introduced species with peppergrass being the most abundant and most frequent (**Table XV**). The substrate is usually sand. A litter layer is common, and comprised of either cottonwood leaves or dense patches of dried peppergrass stalks from the previous year. Inundation ranges for this topographic surface range between 5 and 15 years with corresponding flow rates of between 5,000 and 12,000 cfs.

As noted earlier, reproduction on this topographic surface is very low and, in most cases, is not taking place at all. Successful reproduction in Fremont's cottonwood depends on an exposed, moist mineral surface when viable seeds are present. Seeds are viable for only about three weeks (Fenner *et al.* 1985). The period of seed release along the lower Truckee River is from May to July with the peak occurring during the month of June. Under unimpaired flows, these conditions occurred infrequently and natural generation of cottonwood was episodic. The most recent year in which these conditions occurred was 1983 when flows at the Nixon gage ranged between 5,000 and 6,400 cfs between late-May and late-June (Water Engineering and Technology 1991). Any reproduction resulting from this period has largely been removed, however, by the extreme flood event of 1986 during which flows rose to nearly 15,000 cfs and abruptly receded. These flows occurred during the winter, however, precluding the availability of viable seed.

Nevertheless, historical reproduction did occur with sufficient frequency to provide for long-term maintenance of cottonwood gallery forests, particularly in the area downstream of Wadsworth. The observations of Ridgeway (1877) are of particular note here. Referring to their camp at the "Big-Bend of the Truckee", i.e., the vicinity of Wadsworth, he noted: "... along the bank of the river, and surrounding the sloughs connected with the stream were exceedingly dense willow-jungles, the sloughs themselves being filled with rushes, flags, and other aquatic plants; but most of the valley consisted of meadow-land, interspersed with velvety swards of "salt-grass" ... **and studded with fine large cotton-wood trees ... which were here and there grouped into delightful groves, sometimes unencumbered, but generally with a shrubby undergrowth, amongst which the "buffalo-berry"** (sic) **was conspicuous.**" Later, in a description of the "Truckee Reservation, near Pyramid Lake," he further noted, "there was no material difference from the surroundings of our former camp at Big-Bend, twenty-five miles above, **except that the valley was considerably broader and the cotton-wood** (sic) **groves proportionately more extensive.**"

Also of interest in the above quotation is the description of buffalo-berry as "conspicuous." This shrub was seen at only one field site, Clark-Tracy, where it occurred on the highest portion of the topographic profile. The species (*Sheperdia argentea*) is not in the list of wetland indicator plants for either California or the Intermountain Region (Reed 1988a, 1988b). Nevertheless, it is frequently described in floras as occurring along streams and is seldom found growing in the sagebrush steppe. Our observations suggest that the appropriate indicator category is FAC. Its rarity in the study area in comparison to pre-settlement times is evidence of the profound effects that hydrologic alteration (and perhaps grazing by domestic livestock as well) have had on the riparian ecosystem. It is also worth noting that sagebrush, an upland species, is the only common shrub in the understory of the remaining cottonwood forests, thereby corroborating the shift to more xeric conditions than were prevalent in pre-settlement times.

Our observations and an earlier study by Jones and Stokes (1990) suggest that there has been no significant reproduction of cottonwood trees on the higher terraces along the lower Truckee River since 1938. All documented reproduction is occurring at the base of the channel bank along the active river channel where it is highly susceptible to being removed by the next major flood event. Jones and Stokes also estimated that 108 acres of mature cottonwood forest was lost due to bank failure, washout, and lowering of the water table during the period 1976-1987. Our cover type mapping indicates that about 85 acres of cottonwood forest remain below Derby Dam, all of which is in degraded condition and persists only as small patches of trees. These data suggest that unless steps are taken immediately to preserve the few remaining patches, mature riparian forest along the lower Truckee River will be lost before plantings could mature sufficiently to replace them.

Preservation of the remaining riparian forest fragments and restoration plantings to insure the long-term replacement of the mature forest canopy are necessary steps, but they alone are not sufficient to restore the biological integrity of the riparian forest ecosystem of the lower Truckee River. While flood flows and appropriate seasonal distribution of water are critical to the natural regeneration of the riparian forest, the instream flow necessary to maintain riparian vegetation is also an important component. The indicator category assigned to Fremont's cottonwood in the Intermountain Region and California is FAC (Reed 1988a, 1988b), but recent studies in Arizona have shown that the species is consistently a phreatophyte, i.e., it persists in arid environments by tapping into local groundwater (Busch *et al.* 1992). In other words, it is an obligate wetland species in the sense that it does not tolerate drought but avoids it. Despite the aridity of the surface of the terrace which currently supports it (arid enough for sagebrush to thrive), the cottonwood trees depend upon a direct connection to subsurface water. The same was found to be true for willow. In contrast, some evidence was found that tamarisk was capable of extracting soil moisture which, if true, could partially account for the competitive exclusion of cottonwood and willow by tamarisk in riparian forests (Busch *et al.* 1992).

Some preliminary work has been conducted using tree ring analysis on the instream needs for the maintenance of riparian trees and shrubs. These studies have shown that diversion of significant amounts of water has resulted in low growth rates, low canopy vigor, and high mortality (Stromberg and Patten 1990, 1991). These studies, however, were done on streams substantially smaller than the Truckee River, and the flow recommendations within them are not directly translatable to our study. Similar studies were beyond the scope of our investigations.

A functional approach to riparian tree growth and maintenance, however, can shed some light on the needs of these species along the lower Truckee River. Whether flood flows of sufficient magnitude and time result in regeneration of cottonwood on the higher flood terraces, or restoration plantings of cottonwood poles are made, these plants will need to be irrigated until their root systems reach the local groundwater table. It is not our intention to provide a detailed restoration plan here. Our topographic profiles and hydraulic cross-sections provide useful information, however, on the probable depth to the water table (**Appendix B**). The elevation difference between the higher flood terraces and the 100 cfs inundation level is on the order of 10 to 12 feet at the Clark-Tracy field site and 8 to 10 feet at the Powerline field site. In late summer, flow level may fall as low as 50 cfs in these reaches, and a minimum estimate of the depth to the water table on most of the highest terraces is probably on the order of 15 feet.

It should be pointed out that while the long-term maintenance of the riparian forest canopy is a worthy goal, it should not be confused with the restoration of the biological integrity of the riparian ecosystem. As the historical quotation provided above shows, grassy meadows and dense willow and buffalo-berry patches were also part of the pre-settlement condition of the riparian corridor. Our profile data show that riparian shrubs do not establish more than 6 to 8 feet above the 100 cfs inundation level, or roughly half the distance to the higher terrace surface on which they were originally found. Although this is just an estimate, it appears that flows on the order of 1,000 or more cfs well into the growing season (late June) could be effective in restoring the local groundwater table to an elevation sufficient to provide for the long-term maintenance of riparian shrubs on the higher terraces. This assumes that grazing by domestic livestock is eliminated also.

Upland Shrub Communities

Upland shrub communities generally are comprised of big sagebrush, black greasewood, shadscale, and a variety of other alkali tolerant shrubs. These communities are seldom inundated by floodwaters, and do not require it [although black greasewood has been shown to be phreatophytic in some areas]. The lowering of the groundwater table cause by water diversion and stream incision has lead to an increase in big sagebrush in the areas which currently support old-growth cottonwood trees. This has also been documented along Bishop Creek in Inyo County (Smith *et al.* 1991). Restoring the groundwater table to within the rooting depth of big sagebrush for sufficient duration would lead to increased mortality.

Restoration Considerations

Although numerous considerations were discussed above for the long-term maintenance of riparian forests on the lower Truckee River, the most serious short-term threat is the removal of mature trees for firewood. At the Powerline field site, there were an estimated maximum number of 100 mature trees on the terrace along the western side of the river. During a revisit to this site in June of 1993, it was discovered that at least 12 of these mature trees had been cut for firewood during the previous winter and spring. These were, in every case, living trees. Unless steps are taken to educate local people of the value of these resources, restoration efforts are doomed to failure. Strict enforcement of existing regulations may be necessary if losses due to woodcutting are to be controlled.

The impacts of beaver to the cottonwood forests of the lower Truckee River are minor in comparison to those of woodcutters. Beaver can play a positive role in the ecology of riparian ecosystems by creating pools of standing water which facilitate the establishment of wetland vegetation. In this respect, beaver can provide an inexpensive and low maintenance substitute for the check dams proposed by both Jones and Stokes (1990) and the Sverdrup Corporation (1993). Information is available on management techniques which can enhance or degrade beaver habitat. Steps which can be taken to minimize the negative effects of beaver herbivory include the grading of streambanks and the planting of a buffer strip of dense willows parallel to the shoreline; in addition, trees should not be planted along the riverbank, but placed as far back as practical (Willis 1978). Because beavers can be important creators and enhancers of wetland habitat they should not be removed from the riparian ecosystem. Instead, steps should be taken to protect existing trees and restoration plantings. The high densities of natural cottonwood regeneration should provide both sufficient reproduction and forage for beaver.

Invasive noxious weeds along the lower river include peppergrass, white-top, tamarisk, and Russian thistle. The last of these, while a copious seed producer with high dispersal capabilities, is an annual and perhaps the most easily controlled. Whitetop and, in particular, peppergrass are extremely invasive and capable of outcompeting most native herbaceous species. The latter species presents the greatest challenge on the lower river. Tamarisk is present, but abundant only in the Pyramid Lake Delta where it is dominant. Scattered individuals are located in the cottonwood shrub along the active stream channel, but do not appear to be outcompeting the native shrubs. It is also locally abundant along irrigation ditches in the vicinity of Wadsworth.

Finally, the considerations of geomorphic stability outlined by Brian Richter (1993), provide an essential framework for restoration on the lower Truckee River. Restoration efforts should focus on those areas which have the highest potential for success, i.e., those sections of the river which appear to have reached a significant degree of dynamic stability.

Impacts Analysis

Subject to the limitations described in detail in the **Introduction** to this section, the preliminary model in **Appendix E** can be used for calculating Habitat Suitability Indices by reach (or a combination of reaches). With- and without-project alternatives can be evaluated on the basis of expected changes in the hydrologic regime. The word models for the hydrologic regime variable can be refined for each reach by substituting numerical values into the variable components. For example, the growing season can be described in terms of a specific period of days during the water year, or the magnitude of flows can be specified as a range of values expressed in second-feet. The process is one of tailoring the components of the variable to meet the specific conditions of a given reach. These refinements will be made during continuing work during FY94. In addition, we will better define the integration of the hydrologic simulations with the habitat suitability models. If the cover type maps accompanying this report can be transferred from AUTOCAD into ARCINFO, and combined with digital elevation information from along the river corridor, further refinements in the application of the models may be possible.

HABITAT EVALUATION PROCEDURES

Purpose and Overview

The purpose of the wildlife habitat suitability study is to determine the existing conditions along the Truckee River for selected wildlife species. To accomplish this, the Service's Habitat Evaluation Procedures (HEP) was used. HEP data establish baseline ecological conditions against which the size and direction of habitat change due to various flow schedules can be measured.

HEP is a habitat-based evaluation methodology used to quantify (1) baseline wildlife habitat values; (2) impacts from proposed actions; and, (3) gains in habitat values on mitigation areas with management. The method is based on the assumption that habitat quality and quantity can be numerically described in terms of habitat units.

Habitat quantity is easily measurable. Habitat types, such as "riverine" or "sagebrush uplands" are delineated for the study area. Habitat quality, however, differs from one species to another. HEP employs carefully chosen evaluation species in a species-habitat approach. Habitat quality for a given evaluation species is assigned through use of a Habitat Suitability Index (HSI) model. HSI values quantify the value of the habitat types to each evaluation species. The HSI value multiplied by acres of a habitat type equals Habitat Units (HU), and HU's are the numerical basis of the HEP analysis.

Once project alternatives are established, impact assessment is performed by quantifying HSI values at several points in time over the life of a proposed project or management action. These points in time are known as "Target Years," and they are selected for years in which changes in habitat conditions can be reasonably defined. In every HEP analysis, there must be a Target Year 0 (TY0), which represents the baseline conditions, Target Year 1 (TY1), which is the first year habitat conditions are expected to deviated from baseline conditions, and ending Target Year.

Evaluation species' HSI's and habitat acreage are required for all Target Years. Acreage at TY0 are termed "baseline". Impact assessment is conducted by annualizing habitat conditions and impacts over the life of a project by comparing HU's from two scenarios. These scenarios are (1) Future-With-Project and (2) Future-Without-Project. For each scenario, HU's are determined for each and every Target Year, and the HU's are integrated over the life of the project in an annualization process. Impact assessments are calculated using the annualized average HU's, known as Average Annual Habitat Units (AAHU). The net impact of a proposed project is calculated by subtracting the Future-Without-Project AAHU's from Future-With-Project AAHU's ($AAHU_{with}$ - $AAHU_{without}$). This process is performed for impact assessment on project lands and management actions on mitigation lands because both are in essence a "project". The ratio of the net change in AAHU's for the project area versus the management times the size of the candidate management area defines the number of acres necessary to offset project losses, given the proposed management plan.

Assumptions

Several general assumptions are necessary for the proper use of HSI models.

1. HEP is a suitable methodology for quantifying direct impacts to wildlife habitats.

2. Quality and quantity of wildlife habitat can be numerically described using indices derived from HSI models and the associated Habitat Units.

3. The HEP assessment is directly applicable only to the selected evaluation species.

4. HSI models are hypotheses based on available data.

5. HSI models are conceptual models and may not measure all ecological factors that affect the quality of a given habitat type for the evaluation species.

6. The HSI value for the evaluation species is a measure of habitat quality that is assumed to be linearly related to carrying capacity of some other response measure for the evaluation species.

Resource Objectives

A general resource objective for the Truckee River Riparian Study is the conservation of riparian habitat and associated wildlife species. Several specific objectives are derived from this general objective. These are:

1) to identify, conserve, and enhance stands of mature cottonwood forest, and to ensure their natural regeneration;
2) to identify and conserve riparian scrub-shrub and emergent riparian vegetation;
3) to conserve the habitat of rare and declining wildlife species;
4) to control the spread and, where possible, eradicate non-native plant species and, in particular, noxious and invasive weeds such as peppergrass and tamarisk.

Evaluation Species Selection

To further the above objectives, evaluation species were chosen to represent one or more of the existing riparian and upland cover types. A preliminary list was compiled from regional wildlife species lists (Tuttle and Whitehill 1991; URS Corporation 1986), various field guides, and suggestions from biologists from the Reno Field Office of the USFWS. Based on Service policy, species listed as Threatened or Endangered by either the Federal government or the States of California or Nevada were excluded.

A total of eight species were selected. The criteria used to select the evaluation species for this study were:

1. The species must have a relatively high probability of occurring in the study area.
2. The species will likely be impacted by the project, particularly changes in flow regime.
3. Sufficient data must be available to assign with some degree of confidence a relationship between the HSI model, habitat quality and some measure of a species response (i.e. biomass, density, reproductive success, etc.). Species with established models are preferred but not required.
4. The baseline habitat conditions at the study site are indicative of the habitat conditions for the evaluation species.
5. Each evaluation species utilizes the habitat type(s) they were selected to represent.
6. The species occupies an ecological niche that represents significant environmental values in the study area.
7. The species has the potential to respond to management activities in the potential mitigation areas.
8. The species must be native to the area.

Existing HSI models were used without modification. No HSI models were available that were designed for specific application to the Truckee River. However, models for mink, sage thrasher, and yellow warbler are applicable throughout the range of the species. Western wood-pewee and Wilson's warbler models used in this study were developed for the western slope of the Sierra Nevada. Those for the northern oriole and American kestrel were designed for the Central Valley of California. Nevertheless, all of the species selected are known to reside in the study area and discussions with local biologists and the model developers indicated that the existing models were applicable and modifications were deemed unnecessary. The habitat(s) each species was chosen to represent and the habitat variables upon which each model is based are given in **Table XV**.

Table XV. Evaluation species, habitat types, model variables and cover types used in the Habitat Evaluation Procedures (HEP) analysis.

Evaluation Species	Habitat Type	HEP Model Variables	Cover Type
1. Wilson's Warbler	Cottonwood-Pine	% shrub cover	Mixed Pine
		% overstory canopy cover	Black Cottonwood
		% herb cover (>6")	
2. Western Wood-Pewee	Cottonwood-Pine	Habitat stage	Mixed Pine
		Distance from edge	Black Cottonwood
3. Yellow Warbler	Cottonwood/Willow	% deciduous shrub canopy cover	Fremont's Cottonwood
		Average height deciduous shrub canopy	Alder Willow
		Deciduous shrub canopy, hydrophytic	Mixed Willow
4. Northern Oriole	Cottonwood/Willow	Average height deciduous tree canopy	Fremont's Cottonwood
		% deciduous tree canopy cover	Alder Willow
		Stand width	Mixed Willow
5. American Kestrel	Cottonwood-Pine	% bare ground	
	Cottonwood/Willow	% herbaceous cover <= 12" tall	Black Cottonwood
		% shrub cover <= 16.5'	Fremont's Cottonwood
		Number perch sites	
		Vegetative structure	
		Number of nest sites/acre	
		Distance to nest	
		Distance to food	
6. Mink	Riverine	% year with surface water	Riverine
		% tree/shrub canopy cover within 100m (328 feet) of water or wetland edge	Emergent
7. Muskrat	Riverine	% stream gradient	Riverine
		% riverine channel with surface water present during typical minimum flow	Emergent
		% channel dominated by emergent herbaceous vegetation	
		% herbaceous cover within 10m (32.8 feet) water's edge	
8. Sage Thrasher	Sagebrush Uplands	% canopy cover (shrub)	Upland Shrub
		Average shrub height	
		Evergreen shrub type	

Field Methodology

Most habitat variables were measured along transects chosen for the riparian vegetation/fluvial hydrology study. The criteria used to select site and transect locations for this study are discussed in the section on **Floodplain and Channel Bank Mapping**. Descriptions of the project reaches and field sites are provided in **Project Reaches and Field Sites** above (see also **Table V**). Adjustments were made in the HEP analysis to accommodate choices made for the vegetation study. HSI values for reaches with no transects were extrapolated from the HSI values for the most similar reach. HSI values for each species at the Clark study site (Reach 4) were used for Reach 5, and Powerline study site HSI's (Reach 6) were used for Reaches 7 and 8. Reach 8 is representative in vegetation to Reach 6, but Reach 7's values are more speculative. HSI values from reaches with more than one study site were averaged to obtain an overall HSI value for each reach. Vegetation transects crossed cover types, but the HEP were adjusted to reflect each cover type.

Vegetation data collected during the riparian vegetation/ fluvial hydrology study, such as "percent shrub cover" or "percent bare ground", were collected on various dates between April and October 1992. Additional field data such as the "number of kestrel nest sites per acre" or "average height of deciduous shrubs" were measured by three separate field crews of two members each on July 30 and 31, August 4, 19, and 20, 1992. Belt transects two meters wide were established at the field sites. Crew members measured ten to twelve variables using a meter stick, spherical densiometer, and ocular estimation.

Baseline Analysis

The areal extent of habitat types were was derived from cover type maps which were digitized using AUTOCAD software. **Table XV** shows the correlation between habitat types and cover types. Most habitat types contain multiple cover types. Mixed habitat types, such as Cottonwood-Pine, were calculated by adding the acres of component cover types. For example, "black cottonwood" and "mixed pine" cover types constitute the Cottonwood-Pine habitat type.

Variables measured in the field at each transect for each evaluation species were tabulated, and each variable's Suitability Index (SI) determined from the species' HSI model. Numerical calculations were executed manually and with Lotus 1-2-3 software. The HSI models used in the study are included in **Appendix F.** SI values are based on an optimum value of an evaluation species' habitat needs for reproduction, cover, food or water. For example, if open vegetation facilitates kestrel foraging, with less than 30% shrub cover considered optimal, any value up to 30% is given an SI rating of 1.0. Suitability Indices for "percent shrub cover" over 30% decreases to 0 at 80% shrub cover. Once SI's for each variable were derived, an overall HSI was calculated from an equation, specific to each species, where all SI's are weighted in their importance in determining habitat value.

Table XVI presents baseline conditions by evaluation species/habitat type for each reach. It is followed by **Table XVII**, which presents the same data organized by reach for each evaluation species/habitat type. HEP accounting software can be used later to quantify Future-Without-Project and Future-With-Project scenario impacts once project alternatives are developed. Note that the values given under "Total Acres" in the following tables are the acres of habitat type available to a given evaluation species; they are not additive. For example, in Reach 1, both Wilson's warbler and the western wood-pewee evaluate the same 11 acres of Cottonwood-Pine habitat. Likewise, yellow warbler and northern oriole evaluate the same 28.15 acres of Cottonwood/Willow habitat. Recall that Cottonwood-Pine habitat includes black cottonwood riparian forest only, while Cottonwood/Willow refers only to Fremont's cottonwood forest.

The remainder of this section on HEP is devoted to a discussion of the four habitat types (Cottonwood-Pine, Cottonwood/willow, Riverine, and Sagebrush Uplands) and the species which were chosen to evaluate them.

Cottonwood-Pine: Wilson's warbler and Western wood-pewee

Western wood-pewee and Wilson's warbler were chosen to represent only the higher elevation Cottonwood-Pine forests, dominated by black cottonwood. These two species are reported to occur in Fremont's cottonwood forests also. The Cottonwood-Pine habitat type occurs upstream of Reno (Reach 3 and above), but this habitat was not measured along study transects in Reach 3 (State Line to Vista). Cottonwood-Pine HSI values for both species from the upstream Reach 2 (Boca to State Line) were used for Reach 3 values.

Western wood-pewee's zero to moderate HSI values along the river are due solely to low habitat stage values (shrub, seedlings, and saplings) in most sites except for Martis and Granite, both in Reach 1 (**Table XVIII**). Habitats of large, open areas (canopy closure 0-39%) with trees taller than 50 feet are considered optimum for this species. Tree cover from 40-69% comes close with an SI value of 0.9. The "Distance from the edge" variable was deemed optimum at all sites and was not influential in the calculation of the HSI.

Wilson's warbler HSI values are higher than those for the western wood-pewee due to the influence of a HSI value of about 0.9 at the lush Verdi site, where "percent overstory canopy cover" and "percent shrub cover" were at or near optimum (**Table XVIX**). Most Wilson warbler's HSI values from study sites ranged between 0.5 to 0.6. Herbaceous vegetation cover (>6") over 60% is considered optimum for Wilson's Warbler. No black cottonwood site had optimum vegetation; Verdi came closest at SI=.645. Percent shrub cover is optimum between 25 and 50% and is given more weight than the herb or tree cover in the calculations. Again, Verdi hit the highest value at SI=1.0 where shrub cover is 25.4% and canopy cover at 44.4% reaches an SI=.934.

Table XVI. Baseline Habitat Suitability Indices (HSI), total acres and total habitat units (HU) by evaluation species and by reach. Derived from Habitat Evaluation Procedures (HEP) analysis of the Lower Truckee River.

	Wilson's Warbler Cottonwood-Pine	Avg HSI	Total Acres	Total HU's
REACH 1	Lake Tahoe to Boca	0.468	11.00	5.15
REACH 2	Boca to Stateline	0.738	24.79	18.30
REACH 3	Stateline to Vista gauge	0.738	31.72	23.41
REACH 4	Vista to Derby Dam	0.174	0.00	0.00
REACH 5	Derby Dam to Wadsworth	0.174	0.00	0.00
REACH 6	Wadsworth to Dead Ox Wash	0.000	0.00	0.00
REACH 7	Dead Ox Wash to Numana	0.000	0.00	0.00
REACH 8	Numana to Marble Bluff	0.000	0.00	0.00
	Western Wood-pewee Cottonwood-Pine	**Avg HSI**	**Total Acres**	**Total HU's**
REACH 1	Lake Tahoe to Boca	0.492	11.00	5.41
REACH 2	Boca to Stateline	0.357	24.79	8.85
REACH 3	Stateline to Vista gauge	0.357	31.72	11.32
REACH 4	Vista to Derby Dam	0.000	0.00	0.00
REACH 5	Derby Dam to Wadsworth	0.000	0.00	0.00
REACH 6	Wadsworth to Dead Ox Wash	0.000	0.00	0.00
REACH 7	Dead Ox Wash to Numana	0.000	0.00	0.00
REACH 8	Numana to Marble Bluff	0.000	0.00	0.00
	Yellow Warbler Cottonwood/Willow	**Avg HSI**	**Total Acres**	**Total HU's**
REACH 1	Lake Tahoe to Boca	0.421	28.15	11.85
REACH 2	Boca to Stateline	0.403	26.38	10.63
REACH 3	Stateline to Vista gauge	0.529	73.46	38.86
REACH 4	Vista to Derby Dam	0.455	39.09	17.79
REACH 5	Derby Dam to Wadsworth	0.455	53.54	24.36
REACH 6	Wadsworth to Dead Ox Wash	0.573	84.00	48.13
REACH 7	Dead Ox Wash to Numana	0.573	2.02	1.16
REACH 8	Numana to Marble Bluff	0.573	62.11	35.59
	Northern Oriole Cottonwood/Willow	**Avg HSI**	**Total Acres**	**Total HU's**
REACH 1	Lake Tahoe to Boca	0.085	28.15	2.39
REACH 2	Boca to Stateline	0.678	26.38	17.89
REACH 3	Stateline to Vista gauge	0.363	73.46	26.67
REACH 4	Vista to Derby Dam	0.601	39.09	23.49
REACH 5	Derby Dam to Wadsworth	0.601	53.54	32.18
REACH 6	Wadsworth to Dead Ox Wash	0.645	84.00	54.18
REACH 7	Dead Ox Wash to Numana	0.645	2.02	1.30
REACH 8	Numana to Marble Bluff	0.645	62.11	40.06

	American Kestrel Cottonwood-Pine, Cottonwood/Willow	Avg HSI	Total Acres	Total HU's
REACH 1	Lake Tahoe to Boca	0.140	1.43	0.20
REACH 2	Boca to Stateline	0.468	19.66	9.20
REACH 3	Stateline to Vista gauge	0.198	48.59	9.62
REACH 4	Vista to Derby Dam	0.000	17.95	0.00
REACH 5	Derby Dam to Wadsworth	0.000	26.17	0.00
REACH 6	Wadsworth to Dead Ox Wash	0.000	37.90	0.00
REACH 7	Dead Ox Wash to Numana	0.000	0.00	0.00
REACH 8	Numana to Marble Bluff	0.000	19.70	0.00

	Mink Riverine	Avg HSI	Total Acres	Total HU's
REACH 1	Lake Tahoe to Boca	0.780	47.01	36.67
REACH 2	Boca to Stateline	0.926	29.61	27.42
REACH 3	Stateline to Vista gauge	0.840	56.76	47.68
REACH 4	Vista to Derby Dam	0.748	60.15	44.99
REACH 5	Derby Dam to Wadsworth	0.748	25.03	18.72
REACH 6	Wadsworth to Dead Ox Wash	0.733	21.34	15.64
REACH 7	Dead Ox Wash to Numana	0.733	14.44	10.58
REACH 8	Numana to Marble Bluff	0.733	19.23	14.10

	Muskrat Riverine	Avg HSI	Total Acres	Total HU's
REACH 1	Lake Tahoe to Boca	0.40	47.01	18.69
REACH 2	Boca to Stateline	0.33	29.61	9.78
REACH 3	Stateline to Vista gauge	0.42	56.76	23.85
REACH 4	Vista to Derby Dam	0.45	60.15	27.31
REACH 5	Derby Dam to Wadsworth	0.45	25.03	11.36
REACH 6	Wadsworth to Dead Ox Wash	0.50	21.34	10.60
REACH 7	Dead Ox Wash to Numana	0.50	14.44	7.17
REACH 8	Numana to Marble Bluff	0.50	19.23	9.55

	Sage Thrasher Sagebrush Uplands	Avg HSI	Total Acres	Total HU's
REACH 1	Lake Tahoe to Boca	0.535	1.93	1.03
REACH 2	Boca to Stateline	0.519	12.36	6.41
REACH 3	Stateline to Vista gauge	0.370	2.27	0.84
REACH 4	Vista to Derby Dam	0.791	34.00	26.89
REACH 5	Derby Dam to Wadsworth	0.791	20.01	15.83
REACH 6	Wadsworth to Dead Ox Wash	0.329	28.36	9.33
REACH 7	Dead Ox Wash to Numana	0.329	12.15	4.00
REACH 8	Numana to Marble Bluff	0.329	46.11	15.17

Table XVII. Baseline Habitat Suitability Indices (HSI), total acres and total habitat units (HU) by reach and by evaluation species. Derived from Habitat Evaluation Procedures (HEP) analysis of the Lower Truckee River.

REACH 1 **Lake Tahoe to Boca**	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.468	11.00	5.15
Western Wood-pewee	0.492	11.00	5.41
Yellow Warbler	0.421	28.15	11.85
Northern Oriole	0.085	28.15	2.39
American Kestrel	0.140	1.43	0.20
Mink	0.780	47.01	36.67
Muskrat	0.400	47.01	18.69
Sage Thrasher	0.535	1.93	1.03

REACH 2 **Boca to Stateline**	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.738	24.79	18.30
Western Wood-pewee	0.357	24.79	8.85
Yellow Warbler	0.403	26.38	10.63
Northern Oriole	0.678	26.38	17.89
American Kestrel	0.468	19.66	9.20
Mink	0.926	29.61	27.42
Muskrat	0.330	29.61	9.78
Sage Thrasher	0.519	12.36	6.41

REACH 3 **Stateline to Vista**	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.738	31.72	23.41
Western Wood-pewee	0.357	31.72	11.32
Yellow Warbler	0.529	73.46	38.86
Northern Oriole	0.363	73.46	26.67
American Kestrel	0.198	48.59	9.62
Mink	0.840	56.76	47.68
Muskrat	0.420	56.76	23.85
Sage Thrasher	0.370	2.27	0.84

REACH 4 **Vista to Derby Dam**	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.174	0.00	0.00
Western Wood-pewee	0.000	0.00	0.00
Yellow Warbler	0.455	39.09	17.79
Northern Oriole	0.601	39.09	23.49
American Kestrel	0.000	17.95	0.00
Mink	0.748	60.15	44.99
Muskrat	0.450	60.15	27.31

Sage Thrasher	0.791	34.00	26.89

REACH 5

Derby Dam to Wadsworth	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.174	0.00	0.00
Western Wood-pewee	0.000	0.00	0.00
Yellow Warbler	0.455	53.54	24.36
Northern Oriole	0.601	53.54	32.18
American Kestrel	0.000	26.17	0.00
Mink	0.748	25.03	18.72
Muskrat	0.450	25.03	11.36
Sage Thrasher	0.791	20.01	15.83

REACH 6

Wadsworth to Dead Ox Wash	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.000	0.00	0.00
Western Wood-pewee	0.000	0.00	0.00
Yellow Warbler	0.573	84.00	48.13
Northern Oriole	0.645	84.00	54.18
American Kestrel	0.000	37.90	0.00
Mink	0.733	21.34	15.64
Muskrat	0.500	21.34	10.60
Sage Thrasher	0.329	28.36	9.33

REACH 7

Dead Ox Wash to Numana Dam	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.000	0.00	0.00
Western Wood-pewee	0.000	0.00	0.00
Yellow Warbler	0.573	2.02	1.16
Northern Oriole	0.645	2.02	1.30
American Kestrel	0.000	0.00	0.00
Mink	0.733	14.44	10.58
Muskrat	0.500	14.44	7.17
Sage Thrasher	0.329	12.15	4.00

REACH 8

Numana Dam to Marble Bluff	**Avg HSI**	**Total Acres**	**Total HU's**
Wilson's Warbler	0.000	0.00	0.00
Western Wood-pewee	0.000	0.00	0.00
Yellow Warbler	0.573	62.11	35.59
Northern Oriole	0.645	62.11	40.06
American Kestrel	0.000	19.70	0.00
Mink	0.733	19.23	14.10
Muskrat	0.500	19.23	9.55
Sage Thrasher	0.329	46.11	15.17

Table XVIII. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for Western wood-pewee (Cottonwood-Pine Habitat).

	value	habitat stage SI	distance to edge SI	HSI
Amergas	1-2	.07	1.0	.173
Bridge	mixed	.33	1.0	.481
Granite	4C	.45	1.0	.588
Martis	4A	.77	1.0	.840
Boca	wt avg	.228	1.0	.377
Reach 1				**.492**
Farad	2	0	1.0	0
Verdi	3B	.6	1.0	.714
Reach 2				**.357**
Oxbow	.018	0	1.0	0
Spice I.	2	0	1.0	0
Reach 3 (used value of reach 2)				**0**
Clark	2	0	1.0	0
Reach 4				**0**
Powerline	2	0	1.0	0
Reach 6				**0**

Table XVIX. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for Wilson's warbler (Cottonwood-Pine Habitat).

	% shrub cover		**% overstory**		**% herbs >6"**		
	value	**SI**	**value**	**SI**		**SI**	**HSI**
Amergas	18.8	.750	3.8	.190	43.6	.365	.590
Bridge	23.2	.928	26.7	1.0	27.9	.198	.643
Granite	21.0	.840	12.1	.605	29.4	.235	.563
Martis	0	0	4.9	.245	17.3	0	0
Boca	21.2	.848	0	0	29.0	.225	.545
Reach 1							**.468**
Farad	39.9	1.0	5.8	.290	38.3	.458	.594
Verdi	25.4	1.0	44.4	.934	45.8	.645	.881
Reach 2							**.738**
Oxbow	72.7	.660	0	0	17.7	0	0
Spice I.	17.5	.700	0	0	19.9	0	0
Reach 3 (used value of reach 2)							**0**
Clark	6.7	.268	0	0	22.9	.073	.174
Reach 4							**.174**
Powerline	3.8	.152	0	0	16.7	0	0
Reach 6							**0**

Cottonwood/Willow: Yellow warbler and northern oriole

In contrast to the Cottonwood-Pine habitat, Cottonwood/Willow habitat is minimal upstream and expands downstream as Fremont's Cottonwood becomes more prevalent. Shrub cover is influential in the yellow warbler model. Yellow warbler HSI values remain within the 0.4 to 0.6 range throughout the length of the river as willows and young cottonwoods are widely established (**Table XX**). The northern oriole model includes a deciduous trees cover vriable. Northern oriole HSI values are low in Reach 1 due to lack of deciduous trees, and at Spice Island (Reach 3), where there are no trees at all. The HSI value improves to the 0.6 range in other reaches (**Table XXI**).

Table XX. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for Yellow warbler (Cottonwood/Willow Habitat).

	% deciduous shrub canopy cover		Avg height deciduous shrub canopy cover		% deciduous shrub canopy, hydrophytic		
	value	**SI**	**value**	**SI**	**value**	**SI**	**HSI**
Amergas	90.6	.788	1.26	.629	100	1.0	.704
Bridge	32.9	.559	.91	.478	96.2	.966	.508
Granite	45.3	.770	.65	.325	99.5	.996	.499
Martis	0	0	0	0	0	.1	0
Boca	39.3	.668	.47	.235	100	1.0	.396
Reach 1							**.421**
Farad	39.0	.663	.761	.381	96.9	.972	.496
Verdi	24.7	.420	.458	.229	100	1.0	.310
Reach 2							**.404**
Oxbow	65.3	1.0	.95	.475	100	1.0	.689
Spice I.	20.9	.355	.76	.383	100	1.0	.369
Reach 3							**.529**
Clark	42.8	.728	.72	.36	76.6	.789	.455
Reach 4							**.455**
Powerline	27.6	.469	1.38	.70	100	1.0	.573
Reach 6							**.573**

Cottonwood-Pine and Cottonwood/Willow: American kestrel

According to the model outcome, habitat quality for American Kestrel, a cavity nester, appears generally poor along the stream, owing to either a lack of nesting and perching sites or heavy shrub vegetation limiting foraging ability (**Table XXII**). However, as kestrels are known to occur along much of of the stream they are probably foraging within the surrounding sagebrush areas.

Kestrel HSI values are limited by the value of the reproduction or food variables. If any of the seven variables in the kestrel model is zero the entire HSI values falls to zero. For all reproductive variables, values resulted in either an SI of 0.0 or 1.0; that is, nest sites were either there or they were not. This means that, except for where food and reproduction values were both zero, food was the lower value.

Table XXI. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for Northern oriole (Cottonwood-Pine Habitat).

	Avg Height deciduous tree canopy cover		% deciduous tree canopy cover		Stand width	
	value	SI	value	SI	SI	HSI
Amergas	0	0	0	0	0	0
Bridge	0	0	0	0	0	0
Granite	81.0	1.0	5.7	.228	.333	.424
Martis	0	0	0	0	0	0
Boca	0	0	0	0	0	0
Reach 1						**.085**
Farad	27.0	.77	5.8	.232	.400	.415
Verdi	45.5	1.0	44.4	1.0	.833	.941
Reach 2						**.678**
Oxbow	72.0	1.0	12.7	.508	.750	.725
Spice I.	0	0	0	0	.250	0
Reach 3						**.363**
Clark	59.1	1.0	15.5	.620	.350	.601
Reach 4						**.601**
Powerline	63.6	1.0	11.8	.472	.567	.645
Reach 6						**.645**

Riverine: Mink and Muskrat

Riverine habitat for mink is of generally good quality along the entire river, ranging from 0.7 in Reaches 6 through 8, to 0.9 in Reach 2. (**Table XXIII**). Since the river has water in it throughout the year at all sites (i.e., a SI of 1.0 along the entire river), mink values are determined by the variable "percent tree/shrub canopy cover within 100m of water or wetland edge."

Muskrat HSI values stem from the lower of cover and food values. Values for the variables "percent of year with surface water present", "percent stream gradient", and "percent dominated by emergent herbaceous vegetation" were consistent along the river and thus not influenctial factors (**Table XXIV**). As a permanent stream, "Percent of year with surface water present" was considered optimum on the Truckee. The stream gradient is less than one percent throughout the river which is optimum (SI = 1.0). The muskrat food variable "Percent dominated by emergent herbaceous vegetation" had the lowest (.2) possible value at all sites.

Table XXII. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for American kestrel (Cottonwood-Pine and Cottonwood/Willow Habitats).

	% herbaceous cover < 12" value	% herbaceous cover < 12" SI	% bareground value	% bareground SI	% shrub canopy cover value	% shrub canopy cover SI	HSI
Amergas	.1664	.548	.263	.526	18.8	1.0	->
Bridge	.2926	.967	.346	.692	23.2	1.0	->
Granite	.2377	.784	.176	.352	21.0	1.0	->
Martis	.2522	.832	.538	1.0	0.0	1.0	->
Boca	0	0	.197	.394	21.2	1.0	->
Farad	.0052	.017	.288	.576	39.9	.859	->
Verdi	.0744	.246	.234	.468	25.4	1.0	->
Oxbow	.16	.528	.444	.88	72.7	.390	->
Spice I.	.0412	.136	.072	.144	17.5	1.0	->
Clark	0	0	.485	.97	6.7	1.0	->
Powerline	0	0	.410	.82	3.8	1.0	->

	# perch sites SI	vegetative structure SI	# nest sites SI	distance to nest SI	distance to food SI	HSI
Amergas	1.0	.5	1.0	1.0	1.0	0
Bridge	1.0	.5	1.0	1.0	1.0	.699
Granite	1.0	0	0	1.0	1.0	0
Martis	1.0	1.0	1.0	1.0	1.0	0
Boca	1.0	.5	0	0	1.0	0
Reach 1						**.140**
Farad	0.5	.5	1.0	1.0	1.0	.291
Verdi	1.0	1.0	1.0	1.0	1.0	.645
Reach 2						**.468**
Oxbow	1.0	0	1.0	1.0	1.0	0
Spice I.	1.0	.5	1.0	1.0	1.0	.396
Reach 3						**.198**
Clark	1.0	0	1.0	1.0	1.0	0
Reach 4						**0**
Powerline	0	0	0	1.0	1.0	0
Reach 6						**0**

The value of "percent of channel with surface water during typical minimum flow" had the greatest influence on the HSI value. Upstream of Derby Dam, values were calculated from Instream Flow Incremental Methodology (IFIM) studies. However no IFIM studies were done downstream of Derby Dam. The hydrologist suggested 50% for the lower reaches as the flow is significantly reduced below the dam. Except for this 50% value at Powerline, "percent of channel with surface water during typical minimum flow" values were 75-89%.

As "Percent dominated by emergent herbaceous vegetation (EHV)" is the same for all sites, food values were determined by "percent of herbaceous canopy cover within 10m of water's edge". The Powerline site had the widest corridor. SI values for cover here were the highest (.64) and greater than the SI values for food (0.50). At all other sites food values were less than cover values and determined the final HSI. Therefore, riverine values for muskrat, were influenced mostly by herbaceous canopy cover.

Table XXIII. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI) and overall Habitat Suitability Indices (HSI) for Mink (Riverine Habitat).

	% year with surface water present		**% tree/shrub canopy cover within 328 ft**		
	value	**SI**	**value**	**SI**	**HSI**
Amergas	100	1.0	34.9	.519	.804
Bridge	100	1.0	52.4	.729	.900
Granite	100	1.0	52.4	.729	.900
Martis	100	1.0	6.2	.174	.558
Boca	100	1.0	25.0	.400	.737
Reach 1					**.780**
Farad	100	1.0	51.6	.719	.896
Verdi	100	1.0	64.2	.870	.955
Reach 2					**.926**
Oxbow	100	1.0	66.4	.897	.964
Spice I.	100	1.0	22.1	.365	.715
Reach 3					**.840**
Clark	100	1.0	26.6	.419	.748
Reach 4					**.748**
Powerline	100	1.0	24.5	.394	.733
Reach 6					.733

Sagebrush Uplands: Sage thrasher

Sage thrasher habitat occurs in the uplands and along the outer edge of the riparian corridor along most of length of the stream. Among upland plant types, sagebrush is the optimum "evergreen scrubland type" for sage thrasher habitat. No sagebrush was measured at Amergas (Reach 1, HSI=.535) or Oxbow (Reach 3 HSI=.370) study sites. No sagebrush was measured along the vegetative/hydrologic transects at Martis, but percent canopy cover data was available from its HEP transect. HSI's of 0.5 in Reach 2 and 0.3 in Reaches 6, 7 and 8, are due to low values for "percent shrub canopy cover". The high value in Reaches 4 and 5 (0.8) is due to an optimum value of "average shrub height" (**Table XXV**).

Table XXIV. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI),and overall Habitat Suitability Indices (HSI) for Muskrat (Riverine Habitat)

	%year with surface water present		% emergent herbaceous vegetation		% stream gradient		% Herbaceous canopy cover within 10m of waters edge		% channel with surface during minimum flow		
	cover		food		cover		food		cover		
	value	SI	val	SI	value	SI	value	SI	value	SI	HSI
Amergas	100	1.0	0	.2	-	1.0	46.2	.462	0.89	0.89	0.43
Bridge	100	1.0	0	.2	-	1.0	38.8	.388	0.89	0.89	0.39
Granite	100	1.0	0	.2	.528	1.0	68.3	.683	0.89	0.89	0.54
Martis	100	1.0	0	.2	-	1.0	3.1	.031	0.75	0.75	0.22
Boca	100	1.0	0	.2	-	1.0	41.2	.412	0.75	0.75	0.41
Reach 1											**0.40**
Farad	100	1.0	0	.2	.587	1.0	6.3	.063	0.86	0.86	0.23
Verdi	100	1.0	0	.2	.608	1.0	45.8	.458	0.86	0.86	0.43
Reach 2											**0.33**
Oxbow	100	1.0	0	.2	.602	1.0	16.9	.169	0.84	0.84	0.28
Spice I.	100	1.0	0	.2	-	1.0	71.2	.712	0.88	0.84	0.56
Reach 3											**0.42**
Clark	100	1.0	0	.2	.494	1.0	50.8	.508	0.88	0.88	0.45
Reach 4											**0.45**
Powerline	100	1.0	10	.28	.411	1.0	87.2	.872	0.50	0.50	0.50
Reach 6											**0.50**

Table XXV. Field Data values, Habitat Evaluation Procedure model Suitability Indices (SI), and overall Habitat Suitability Indices (HSI) for Sage thrasher (Upland Sage Habitat).

	% Canopy cover		Average height		scrub type	
	value	SI	value	SI	SI	HSI
Amergas	0	0	0	0	1.0	0
Bridge	17.5	.350	no data	1.0	1.0	.592
Granite	36.1	.722	no data	1.0	1.0	.850
Martis	21.2	.424	34.3	.549	1.0	.615
Boca	19.2	.384	>60	1.0	1.0	.620
Reach 1						**.535**
Farad	28.4	.568	47	.752	1.0	.753
Verdi	4.1	.081	47est	.752	1.0	.285
Reach 2						**.519**
Oxbow	0	0	0	0	1.0	0
Spice I.	27.3	.546	47	.752	1.0	.739
Reach 3						**.370**
Clark	31.3	.626	>60	1.0	1.0	.791
Reach 4						**.791**
Powerline	5.4	.108	73.3	1.0	1.0	.329
Reach 6						**.329**

LITERATURE CITED

Auble, G.T., J. Friedman, and M.L. Scott. 1991. Riparian vegetation of the Black Canyon of the Gunnison River, Colorado: composition and response to selected hydrologic regimes based on a direct gradient assessment model. Report to the National Park Service, Fort Collins, CO. U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, CO. 79 pp.

Bratberg, D. 1980. Hydrogeology of Dodge Flat and its relation to flow and quality changes in the Truckee River. Unpublished M.S. thesis, University of Nevada, Reno. 100 pp.

Busch, D.E., N.L. Ingraham, and S.D. Smith. 1992. Water uptake in woody riparian phreatophytes of the southwestern United States: a stable isotope study. Ecological Applications 2(4):450=459.

California Department of Water Resources. 1991. Truckee River Atlas. Sacramento. 128 pp.

Chien, N. 1985. Changes in river regime after the construction of upstream reservoirs. Earth Surface Processes and Landforms 10:143-159.

Fenner, P., W.W. Brady, and D.R. Patton. 1985. Effects of regulated water flows on regeneration of Fremont cottonwood. Journal of Range Management 38 (2):1135-138.

Frissel, C.A., W.J. Liss, C.E. Warren, and M.C. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199-214.

Gauch, H.G., Jr. 1982. Multivariate analysis in community ecology. Cambridge University Press, Cambridge. 299 pp.

Gauch, H.G., and R.H. Whittaker. 1981. Hierarchical classification of community data. Journal of Ecology 69:135-152.

Gregory, D.I. 1982. Geomorphic study of the Lower Truckee River, Washoe County Nevada. M.S. thesis, Colorado State University, Fort Collins. 125 pp.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 41(8):540-551.

Griggs, T. 1993. Personal communication, 07-19-93.

Hall, E.R. 1946. Mammals of Nevada. University of California Press, Berkeley.

Hall, E.R. 1960. Willow and aspen in the ecology of beaver on Sagehen Creek, California. Ecology 41(3):484-494.

Hickman, J.C., Jr. 1992. The Jepson Manual: higher plants of California. University of California Press, Berkeley and Los Angeles. 1,400 pp.

Hill, M.O. 1979. TWINSPAN - a FORTRAN program for arranging multivariate data in a n ordered two-way table by classification of the individuals and attributes. Cornell University, Ithaca, NY. 60 pp.

Holland, R.F. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game, Sacramento, CA. 156 pp.

Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, CA.

Jones and Stokes Associates, Inc. 1990. Channel stabilization and riparian restoration plan for the lower 23 miles of the Truckee River, Nevada. Draft Report prepared for Pyramid Lake Fisheries Restoration Project, Sutcliffe, NV. Various pagination.

Jongman, R.H.G., C.J.F. ter Braak, and O.F.R. van Tongeren (editors). 1987. Data analysis in community and landscape ecology. Pudoc Wageningen, The Netherlands. 299 pp.

Kondolf, G.M., J.W. Webb, M.J. Sale, and T. Felando. 1987. Basic hydrologic studies for assessing impacts of flow diversions on riparian vegetation: examples from streams of the eastern Sierra Nevada, California, USA. Environmental Management 11:757-769.

Ludwig, J.A., and J.F. Reynolds. 1988. Statistical Ecology. John Wiley & Sons, New York, NY. 337 pp.

McKenna, S.A. 1990. Examination of water quality and groundwater/surface water integration during drought periods on the Truckee River, California and Nevada. Unpublished Masters thesis, University of Nevada, Reno. 143 pp.

Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York, NY. 547 pp.

Reed, P.B., Jr. 1988a. National list of plant species that occur in wetlands: California (Region 0). U.S. Dept. Interior, Fish and Wildlife Service Biological Report 88 (26.10). Washington, D.C. 135 pp.

Reed, P.B., Jr. 1988b. National list of plant species that occur in wetlands: Intermountain (Region 8). U.S. Dept. Interior, Fish and Wildlife Service Biological Report 88 (26.8). Washington, D.C. 76 pp.

Richter, B. 1993. Written memorandum to Jan Nachlinger, 09-02-1993.

Ridgway, R. 1877. Ornithology. Pp. 338-339 (Pt. III) *in* C. King (Geologist-in-Charge). Geological Exploration of the Fortieth Parallel, Government Printing Office, Washington, D.C.

Risser, R.J., and R.R. Harris. 1989. Mitigation for impacts to riparian vegetation on western montane streams. Pp. 235-252 in J.A. Gore and G.E. Petts (eds.). Alternatives in regulated river management. CRC Press, Boca Raton, FL.

Sinclair, W.C., and O.J. Loeltz. 1963. Groundwater conditions in the Fernley-Wadsworth area, Churchill, Lyon, Storey, and Washoe Counties, Nevada. U.S. Geological Survey, Water Supply Paper 1619-AA.

Smith, S.D., A.B. Wellington, J.L. Nachlinger, and C.A. Fox. 1991. Functional responses of riparian vegetation to streamflow diversion in the eastern Sierra Nevada. Ecological Applications 1(1):89-97.

Stromberg, J.C., and D.T. Patten. 1990. Riparian vegetation instream flow requirements: a case study from a diverted stream in the eastern Sierra Nevada, California, U.S.A. Environmental Management 14(2):185-194.

Stromberg, J.C., and D.T. Patten. 1991. Instream flow requirements for cottonwoods at Bishop Creek, Inyo County, California. Rivers 2(1):1-11.

Stromberg, J.C., and D.T. Patten. 1992. Instream flow relations of riparian cottonwood trees in the Mono Basin. Unpublished technical report submitted to Jones and Stokes Associates, Inc., Sacramento, CA. 46 pp.

Stromberg, J.C., D.T. Patten, and B.D. Richter. 1991. Flood flows and dynamics of Sonoran riparian forests. Rivers 2:221-235.

Sverdrup Corporation. 1993. Restoration plan for the lower Truckee River between Derby Dam and Pyramid Lake near Wadsworth, Nevada. Technical report prepared for the U.S. Department of Interior, Fish and Wildlife Service, Portland, OR. 44 pp.

Tuttle, P., and B. Whitehill. 1991. Fish and wildlife habitat restoration along the Truckee River between Pyramid Lake and Reno, Nevada. U.S. Fish and Wildlife Service, Reno Field Office, Reno, NV. 54 pp.

U.S. Geological Survey. 1978. Water Resources Data for Nevada. Water Data Report NV-78-1.

URS Corporation. 1986. Newlands Project proposed operating criteria and procedures. U.S. Department of Interior, Bureau of Reclamation. Draft Environmental Impact Statement. Technical appendices.

Wagner, P. 1993. Personal Communication, 07-19-93.

Water Engineering & Technology, Inc. 1991. Reconnaissance geomorphic investigation of Truckee River from Vista to Pyramid Lake, Nevada. Draft Report prepared for the U.S. Army Corps of Engineers, Sacramento District. 88 pp.

Williams, G.P., and M.G. Wolman. 1984. Downstream effects of dams on alluvial rivers. U.S. Geol. Survey Prof. Paper 1286. Washington, D.C.

Willis, M.J. 1978. A beaver habitat classification system for the Truckee River. Unpublished M.S. thesis, University of Nevada, Reno. 60 pp.

Table RIPARIAN 1. Mean monthly flows (cfs) in the Truckee River at Donner Creek based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 75 cfs are not met.

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	1577	1552	1256	547	442	455	340	623	778	518	173	110	223	260
NA	1504	1516	1252	543	441	458	347	602	762	517	174	112	226	270
LWSA	1504	1516	1252	543	442	458	348	603	763	516	174	112	228	271
TROA	1534	1546	1293	544	329	307	309	621	805	551	215	116	137	202
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	275	289	158	90	68	89	23	227	253	133	63	26	44	5
NA	273	282	158	89	67	73	29	229	253	130	60	24	34	12
LWSA	273	282	158	89	66	72	31	229	253	130	61	24	32	14
TROA	272	391	247	105	68	61	41	201	260	142	64	22	35	21

Table RIPARIAN 2. Mean monthly flows (cfs) in the Truckee River at the Little Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 100 cfs are not met.

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	2489	3329	2213	907	657	570	697	865	1319	1051	619	553	502	482
NA	2396	3265	2195	894	590	549	773	847	1277	1012	588	520	498	526
LWSA	2397	3264	2196	893	590	549	775	849	1277	1010	588	520	498	525
TROA	2507	3405	2269	898	531	484	683	898	1315	1022	542	479	450	512
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	527	774	626	502	444	323	202	478	553	472	394	186	135	77
NA	531	741	611	518	448	347	201	474	548	512	406	219	99	90
LWSA	531	741	611	519	447	344	199	476	548	515	403	217	95	91
TROA	511	699	575	472	436	376	235	478	518	517	417	287	187	135

Table RIPARIAN 3. Mean monthly flows (cfs) in the Trophy Reach of the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 200 cfs are not met.

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	2513	3216	2077	812	607	525	691	853	1235	968	553	506	450	477
NA	2400	3147	2091	833	573	542	777	838	1189	958	556	500	482	528
LWSA	2401	3147	2091	833	573	542	779	839	1189	953	556	500	482	528
TROA	2508	3345	2168	856	532	485	680	906	1246	986	532	482	452	516
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	524	748	555	441	400	297	204	500	516	407	352	170	137	84
NA	522	710	575	492	443	354	209	492	506	471	388	224	104	102
LWSA	523	710	575	492	441	350	207	492	506	473	385	221	101	102
TROA	529	685	562	465	450	402	248	491	491	493	413	294	195	149

Table RIPARIAN 4. Mean monthly flows (cfs) in the Mayberry Reach of the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 200 cfs are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	2519	3194	2037	775	543	495	663	836	1202	924	535	445	419	448
NA	2394	3107	2040	795	523	495	746	807	1136	907	506	450	435	494
LWSA	2394	3107	2040	794	523	495	747	806	1136	902	506	450	435	494
TROA	2500	3299	2128	816	484	443	648	864	1194	934	486	436	408	482
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	494	678	496	366	320	228	162	450	458	334	280	111	87	45
NA	489	659	522	443	393	317	187	453	455	420	348	193	86	80
LWSA	490	660	521	443	392	312	183	452	455	422	345	191	84	80
TROA	488	636	511	421	405	366	222	445	441	445	370	257	162	125

Table RIPARIAN 5. Mean monthly flows (cfs) in the Oxbox Reach of the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 200 cfs (Aug-Sep) or 100 cfs (Oct) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	2540	3096	1936	686	429	371	628	812	1099	816	398	344	319	400
NA	2348	3038	1942	709	429	392	688	736	1056	805	404	357	333	430
LWSA	2346	3038	1942	708	429	391	685	735	1055	802	404	356	333	430
TROA	2460	3242	2056	750	407	362	595	795	1132	852	408	369	323	420
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	477	621	396	286	229	167	147	434	388	268	212	68	68	33
NA	411	576	416	347	304	227	142	372	373	324	264	139	49	37
LWSA	410	576	416	346	303	223	138	371	373	324	261	138	49	36
TROA	421	574	427	345	334	291	165	367	379	366	300	199	97	74

Table RIPARIAN 6. Mean monthly flows (cfs) in the Spice Reach of the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 150 cfs (Aug-Sep) or 100 cfs (Oct) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	2518	3062	1897	638	396	326	601	790	1062	774	347	304	275	372
NA	2308	2965	1865	633	355	339	654	696	980	726	325	282	280	394
LWSA	2306	2964	1865	632	355	339	650	694	979	724	325	281	280	394
TROA	2441	3175	1984	682	338	318	561	776	1062	780	340	300	275	386
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	455	579	355	235	186	120	125	408	346	224	167	35	41	13
NA	369	500	336	270	235	181	115	331	298	251	195	90	28	12
LWSA	368	500	336	271	235	177	213	329	298	250	192	89	29	12
TROA	402	505	354	275	273	252	133	347	311	299	238	143	62	44

Table RIPARIAN 7. Mean monthly flows (cfs) in the Lockwood Reach of the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended ecosystem flows (Truckee River Recovery Implentation Team, 2003) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	2710	3164	1980	732	456	391	683	884	1142	835	405	370	339	434
NA	2527	3092	1949	722	422	401	729	825	1054	785	374	339	338	460
LWSA	2525	3092	1949	721	422	400	729	823	1054	784	374	338	337	460
TROA	2665	3264	2041	764	401	391	651	910	1152	846	391	360	330	452
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	531	634	410	293	242	186	182	467	402	277	218	85	85	63
NA	454	565	395	322	288	246	180	411	363	309	243	141	81	79
LWSA	452	565	394	322	288	242	177	409	363	309	241	141	82	79
TROA	496	566	409	322	323	306	207	420	371	353	289	196	115	114

Table RIPARIAN 8. Mean monthly flows (cfs) below Derby Dam on the Truckee River based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended ecosystem flows (Truckee River Recovery Implementation Team, 2003) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	2692	3095	1906	626	300	300	674	821	1012	667	300	200	246	396
NA	2514	3055	1889	647	300	338	711	745	1000	657	300	264	291	429
LWSA	2512	3054	1889	646	300	338	710	743	1000	658	300	265	291	429
TROA	2656	3224	1979	690	300	300	631	833	1041	748	300	262	284	432
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	200	300	170	120	109	100	100	60	85	57	50	27	49	25
NA	200	300	170	120	110	106	109	73	110	127	83	79	29	35
LWSA	200	300	170	120	110	106	109	73	110	127	83	79	30	35
TROA	200	300	170	120	122	104	104	124	108	137	118	110	70	56

Table RIPARIAN 9. Mean monthly flows (cfs) in Donner Creek based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 8 cfs are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	119	141	140	20	3	54	64	72	49	35	3	3	49	20
NA	119	141	140	20	3	54	67	72	49	35	3	3	49	22
LWSA	119	141	140	20	3	54	67	72	49	35	3	3	48	22
TROA	119	141	140	20	7	10	72	72	49	35	6	6	10	50
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	25	8	2	2	2	4	3	19	2	2	2	2	2	3
NA	25	8	2	2	2	3	5	19	2	2	2	2	2	3
LWSA	25	8	2	2	2	3	6	19	2	2	2	2	2	3
TROA	25	7	3	3	3	10	25	18	2	3	3	3	9	18

Table RIPARIAN 10. Mean monthly flows (cfs) in Prosser Creek based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 16 cfs are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	172	510	215	237	144	32	329	72	82	121	72	11	8	90
NA	172	510	234	202	122	32	341	72	84	114	60	12	8	138
LWSA	172	510	231	202	122	32	341	72	84	114	60	12	8	138
TROA	186	512	187	96	67	158	301	72	88	111	46	16	45	189
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	5	51	37	10	5	5	7	5	16	21	8	5	5	7
NA	5	45	26	5	5	5	8	5	22	15	5	5	5	7
LWSA	5	45	26	5	5	5	8	5	22	15	5	5	5	7
TROA	7	27	25	11	10	11	12	5	18	18	10	8	8	9

Table RIPARIAN 11. Mean monthly flows (cfs) in Independence Creek based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 6 cfs (Apr-Jul), 4 cfs (Aug-Sep), or 7 cfs (Oct) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	65	91	105	54	23	32	28	34	53	44	17	4	19	90
NA	65	91	105	56	23	33	27	34	52	42	17	3	18	138
LWSA	65	91	105	52	23	33	27	34	52	42	17	3	18	138
TROA	65	91	103	50	21	29	31	33	52	45	18	10	12	189
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	6	16	5	2	2	2	9	3	7	5	2	2	2	4
NA	4	14	3	2	2	2	11	2	5	3	2	2	2	7
LWSA	4	14	3	2	2	2	11	2	5	3	2	2	2	7
TROA	5	16	8	6	5	8	9	4	8	8	5	3	7	7

Table RIPARIAN 12. Mean monthly flows (cfs) in Little Truckee River above Stampede Reservoir based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 35 cfs (Apr-Jul), 14 cfs (Aug-Sep), or 30 cfs (Oct) are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	363	713	710	195	38	43	43	213	428	279	40	14	26	26
NA	363	713	710	195	40	46	44	212	428	279	42	13	26	27
LWSA	363	713	710	195	41	46	44	212	428	279	43	13	26	26
TROA	363	713	710	195	39	44	50	214	428	279	45	18	19	25
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	74	162	55	8	5	7	16	58	105	33	6	3	5	11
NA	74	163	58	7	4	7	17	58	105	31	5	3	6	14
LWSA	74	163	58	7	4	7	17	58	105	31	5	3	5	13
TROA	76	163	62	11	9	12	17	64	113	34	9	8	10	13

Table RIPARIAN 13. Mean monthly flows (cfs) in Little Truckee River below Stampede Reservoir based on model results in wet, median, dry, and extremely dry hydrologic conditions. Shaded boxes indicate when recommended minimum flows of 45 cfs are not met.

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	547	910	563	277	179	80	279	284	330	264	144	94	30	30
NA	558	891	556	242	160	76	321	292	358	265	138	75	30	30
LWSA	559	891	556	242	160	76	320	293	359	265	138	74	30	30
TROA	529	973	483	200	161	125	340	233	314	225	122	85	45	43
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	64	48	30	54	30	30	30	56	34	30	31	30	30	30
NA	62	48	30	74	30	30	30	46	34	30	53	30	30	30
LWSA	62	48	30	74	30	30	30	46	34	30	54	30	30	30

Table RIPARIAN 14. No Action, LWSA, and TROA flow compared to current conditions in the Lake Tahoe to Donner Creek reach based on model results for wet, median, dry and extremely dry hydrologic conditions.(ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LWSA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	24.3%	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	ND	NS	NS	-18.0%	26.1%	NS	ND	NS	NS	NS	-22.7%	140.0%
LWSA	NS	NS	ND	NS	NS	-19.1%	34.8%	NS	ND	NS	NS	NS	-27.3%	180.0%
TROA	NS	35.3%	56.3%	16.7%	ND	-31.5%	78.3%	NS	NS	NS	NS	-15.4%	-20.5%	320.0%

Table RIPARIAN 15. No Action, LWSA, and TROA flows compared to current conditions in the Truckee River in the Donner Creek to Little Truckee River reach based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	10.9%	NS	NS	NS	NS	NS	NS	NS
LWSA	NS	NS	NS	NS	NS	NS	11.2%	NS	NS	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	17.7%	-26.7%	16.9%
LWSA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	16.7%	-29.6%	18.2%
TROA	NS	NS	NS	NS	NS	16.4%	16.3%	NS	NS	NS	NS	54.3%	38.5%	75.3%

Table RIPARIAN 16. No Action, LWSA, and TROA flows compared to current conditions in the Trophy reach of the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	12.4%	NS	NS	NS	NS	NS	NS	10.7%
LWSA	NS	NS	NS	NS	NS	NS	12.7%	NS	NS	NS	NS	NS	NS	10.7%
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	11.6%	10.8%	19.2%	NS	NS	NS	15.7%	10.2%	31.8%	-24.1%	21.4%
LWSA	NS	NS	NS	11.6%	10.3%	17.8%	NS	NS	NS	16.2%	NS	30.0%	-26.3%	21.4%
TROA	NS	NS	NS	NS	12.5%	35.4%	21.6%	NS	NS	21.1%	17.3%	72.9%	42.3%	77.4%

Table RIPARIAN 17. No Action, LWSA, and TROA flows compared to current conditions in the Mayberry reach of the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	ND	12.5%	NS	NS	NS	NS	NS	NS	10.3%
LWSA	NS	NS	NS	NS	NS	ND	12.7%	NS	NS	NS	NS	NS	NS	10.3%
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	21.0%	22.8%	39.0%	15.4%	NS	NS	25.7%	24.3%	73.9%	NS	77.8%
LWSA	NS	NS	NS	21.0%	22.5%	36.8%	13.0%	NS	NS	26.3%	23.2%	72.1%	NS	77.8%
TROA	NS	NS	NS	15.0%	26.6%	60.5%	37.0%	NS	NS	33.2%	32.1%	131.5%	86.2%	177.8%

Table RIPARIAN 18. No Action, LWSA, and TROA flows compared to current conditions in the Oxbow reach of the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
LWSA	NS	NS	NS	NS	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	21.3%	32.8%	35.9%	NS	NS	NS	20.9%	24.5%	104.4%	-27.9%	12.1%
LWSA	NS	NS	NS	21.0%	32.3%	33.5%	NS	NS	NS	20.9%	23.1%	102.9%	-27.9%	NS
TROA	NS	NS	NS	20.6%	45.9%	74.3%	12.2%	NS	NS	36.6%	41.5%	192.6%	42.6%	124.2%

Table RIPARIAN 19. No Action, LWSA, and TROA flows compared to current conditions in the Spice reach of the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LWSA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	**-14.5%**	**-10.9%**	**NS**	**NS**	**19.0%**	**32.3%**	**NS**	**-12.0%**	**NS**	**11.6%**	**11.5%**	**65.9%**	**NS**	**25.4%**
LWSA	**-14.9%**	**-10.9%**	**NS**	**NS**	**19.0%**	**30.1%**	**NS**	**-12.4%**	**NS**	**11.6%**	**10.6%**	**65.9%**	**NS**	**25.4%**
TROA	**NS**	**-10.7%**	**NS**	**NS**	**33.5%**	**64.5%**	**13.7%**	**-10.1%**	**NS**	**27.4%**	**32.6%**	**130.6%**	**35.3%**	**81.0%**

Table RIPARIAN 20. No Action, LWSA, and TROA flows compared to current conditions in the Lockwood reach of the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LWSA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	**14.9%**	**26.3%**	**50.8%**	NS	NS	NS	**12.1%**	**16.8%**	**157.1%**	**-31.7%**	NS
LWSA	NS	NS	NS	**15.3%**	**26.3%**	**47.5%**	**70.4%**	NS	NS	**11.6%**	**15.0%**	**154.3%**	**-29.3%**	NS
TROA	NS	NS	NS	17.0%	**46.8%**	**110.0%**	NS	NS	NS	33.5%	**42.5%**	**308.6%**	**51.2%**	**238.5%**

Table RIPARIAN 21. No Action, LWSA, and TROA flows compared to current conditions in reaches 14-15 (below Derby Dam) of the Truckee River based on operation model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	ND	12.7%	NS	NS	NS	NS	ND	32.0%	18.3%	NS
LWSA	NS	NS	NS	NS	ND	12.7%	NS	NS	NS	NS	ND	32.5%	18.3%	NS
TROA	NS	NS	NS	10.2%	ND	NS	NS	NS	NS	12.1%	ND	31.0%	15.4%	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	ND	ND	NS	NS	NS	21.7%	29.4%	122.8%	66.0%	192.6%	-40.8%	40.0%
LWSA	ND	ND	ND	ND	NS	NS	NS	21.7%	29.4%	122.8%	66.0%	192.6%	-38.8%	40.0%
TROA	ND	ND	ND	ND	11.9%	NS	NS	106.7%	27.1%	140.4%	136.0%	307.4%	42.9%	124.0%

Table RIPARIAN 22. No Action, LWSA, and TROA flows compared to current conditions between Donner Lake and the Truckee River based on operation model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.0%
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.0%
TROA	ND	ND	ND	ND	133.3%	ND	ND	ND	ND	ND	100.0%	100.0%	ND	150.0%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	ND	ND	ND	-25.0%	66.7%	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	-25.0%	100.0%	ND	ND	ND	ND	ND	ND	ND
TROA	ND	-12.5%	50.0%	50.0%	50.0%	150.0%	733.3%	ND	ND	50.0%	50.0%	50.0%	350.0%	500.0%

Table RIPARIAN 23. No Action, LWSA, and TROA flows as compared to current conditions between Prosser Reservoir and the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	NS	NS	NS	ND	NS	ND	NS	NS	NS	NS	ND	**53.3%**
LWSA	ND	ND	NS	NS	NS	ND	NS	ND	NS	NS	NS	NS	ND	**53.3%**
TROA	NS	NS	NS	NS	NS	**393.8%**	NS	ND	NS	NS	NS	**45.5%**	**462.5%**	**110.0%**
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	NS	NS	**-50.0%**	ND	ND	**14.3%**	ND	**37.5%**	NS	**-37.5%**	ND	ND	ND
LWSA	ND	NS	NS	**-50.0%**	ND	ND	**14.3%**	ND	**37.5%**	NS	**-37.5%**	ND	ND	ND
TROA	**40.0%**	NS	NS	**10.0%**	**100.0%**	**120.0%**	**71.4%**	ND	**12.5%**	NS	**25.0%**	**60.0%**	**60.0%**	**28.6%**

Table RIPARIAN 24. No Action, LWSA, and TROA flows as compared to current conditions between Independence Lake and the Little Truckee River based on operation model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	ND	NS	ND	NS	NS	ND	NS	NS	ND	-25.0%	NS	53.3%
LWSA	ND	ND	ND	NS	ND	NS	NS	ND	NS	NS	ND	-25.0%	NS	53.3%
TROA	ND	ND	NS	NS	NS	NS	10.7%	NS	NS	NS	NS	150.0%	NS	110.0%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	-33.3%	NS	-40.0%	ND	ND	ND	22.2%	-33.3%	-28.6%	-40.0%	ND	ND	ND	75.0%
LWSA	-33.3%	NS	-40.0%	ND	ND	ND	22.2%	-33.3%	-28.6%	-40.0%	ND	ND	ND	75.0%
TROA	-16.7%	ND	60.0%	200.0%	150.0%	300.0%	ND	33.3%	14.3%	60.0%	150.0%	50.0%	250.0%	75.0%

Table RIPARIAN 25. No Action, LWSA, and TROA flows in the Little Truckee River from Independence Creek to Stampede Reservoir compared to current conditions based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	ND	ND	ND	NS	NS	NS	NS	ND	ND	NS	NS	ND	NS
LWSA	ND	ND	ND	ND	NS	NS	NS	NS	ND	ND	NS	NS	ND	ND
TROA	ND	ND	ND	ND	NS	NS	16.3%	NS	ND	ND	12.5%	28.6%	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	ND	NS	NS	-12.5%	NS	ND	NS	ND	ND	NS	-16.7%	ND	20.0%	27.3%
LWSA	ND	NS	NS	-12.5%	NS	ND	NS	ND	ND	NS	-16.7%	ND	ND	18.2%
TROA	NS	NS	12.7%	37.5%	80.0%	71.4%	NS	10.3%	NS	NS	50.0%	166.7%	100.0%	18.2%

Table RIPARIAN 26. No Action, LWSA, and TROA flows as compared to current conditions between Stampede Reservoir and the Truckee River based on operation model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	NS	NS	NS	NS	NS	15.1%	NS	NS	NS	NS	NS	ND	ND
LWSA	NS	NS	NS	NS	NS	NS	14.7%	NS	NS	NS	NS	NS	ND	ND
TROA	NS	NS	NS	NS	NS	56.3%	21.9%	NS	NS	NS	NS	NS	50.0%	43.3%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
CC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NS	ND	ND	37.0%	ND	ND	ND	NS	ND	ND	71.0%	ND	ND	ND
LWSA	NS	ND	ND	37.0%	ND	ND	ND	NS	ND	ND	74.2%	ND	ND	ND
TROA	NS	14.6%	70.0%	NS	50.0%	50.0%	60.0%	NS	32.4%	50.0%	45.2%	50.0%	50.0%	43.3%

Table RIPARIAN 27. LWSA, and TROA flows compared to No Action flows between Lake Tahoe and Donner Creek based on operation model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	NS	ND	NS	NS	NS	NS	ND	ND	NS	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	23.6%	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	NS	NS	NS	ND	ND	ND	NS	ND	NS	16.7%
TROA	NS	38.7%	56.3%	18.0%	NS	-16.4%	41.4%	NS	NS	NS	NS	NS	NS	75.0%

Table RIPARIAN 28. LWSA, and TROA flows compared to No Action flows in the Truckee River from Donner Creek to the confluence of the Little Truckee River (reach 7) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	NS	NS	NS	ND	ND	NS	NS	ND	NS	ND	ND	ND	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	NS	NS	NS	NS	NS	ND	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	NS	NS	16.9%	NS	NS	NS	NS	31.1%	88.9%	50.0%

Table RIPARIAN 29. LWSA, and TROA flows compared to No Action flows in the Trophy reach of the Truckee River (reach 9 based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	ND	ND	ND	ND	NS	NS	ND	NS	ND	ND	ND	NS
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	ND	ND	NS	NS	NS	ND	ND	NS	NS	NS	NS	ND
TROA	NS	NS	NS	NS	NS	**13.6%**	**18.7%**	NS	NS	NS	NS	**31.3%**	**87.5%**	**46.1%**

Table RIPARIAN 30. LWSA, and TROA flows compared to No Action flows in the Mayberry reach of the Truckee River (reach 10) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	NS	NS	ND	NS	NS	ND	NS	ND	ND	ND	ND
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	NS	NS	ND	NS	NS	NS	NS	ND	NS	NS	NS	NS	ND
TROA	NS	NS	NS	NS	NS	**15.5%**	**18.7%**	NS	NS	NS	NS	**33.2%**	**88.4%**	**56.3%**

Table RIPARIAN 31. LWSA, and TROA flows compared to No Action flows in the Oxbow reach of the Truckee River (reach 11) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	NS	ND	NS	NS	NS	NS	NS	ND	NS	ND	ND
TROA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dry							**Extremely Dry**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	ND	NS	NS	NS	NS	NS	ND	ND	NS	NS	ND	NS
TROA	NS	NS	NS	NS	NS	**28.2%**	**16.2%**	NS	NS	**13.0%**	**13.6%**	**43.2%**	**98.0%**	**100.0%**

Table RIPARIAN 32. LWSA, and TROA flows compared to No Action flows in the Spice reach of the Truckee River (reach 12) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	NS	ND	NS	ND	NS	NS	NS	NS	NS	ND	NS	ND	ND
TROA	NS	NS	NS	NS	NS	NS	NS	11.5%	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	ND	NS	ND	NS	85.2%	NS	ND	NS	NS	NS	NS	NS
TROA	NS	NS	NS	NS	16.2%	39.2%	15.7%	NS	NS	19.1%	22.1%	58.9%	121.4%	266.7%

Table RIPARIAN 33. LWSA, and TROA flows compared to No Action flows in the Lockwood reach (reach 13) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	ND	NS	ND	NS	ND	NS	ND	NS	ND	NS	NS	ND
TROA	NS	NS	NS	NS	NS	NS	NS	10.3%	NS	NS	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	ND	NS	ND	ND	NS	NS	NS	ND	ND	NS	ND	NS	ND
TROA	NS	NS	NS	ND	12.2%	24.4%	15.0%	NS	NS	14.2%	18.9%	39.0%	42.0%	44.3%

Table RIPARIAN 34. LWSA, and TROA flows compared to No Action flows in reaches 14 and 15 (below Derby Dam) based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	NS	NS	ND	NS	ND	ND	NS	NS	ND	NS	ND	NS	ND	ND
TROA	NS	NS	NS	NS	NS	NS	NS	11.8%	NS	13.9%	NS	NS	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND
TROA	ND	ND	ND	ND	10.9%	NS	NS	69.9%	NS	NS	42.2%	39.2%	141.4%	60.0%

Table RIPARIAN 35. LWSA, and TROA flows compared to No Action flows between Donner Lake and the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TROA	ND	ND	ND	ND	133.3%	ND	ND	ND	ND	ND	100.0%	100.0%	ND	127.3%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	20.0%	ND	ND	ND	ND	ND	ND	ND
TROA	ND	-12.5%	50.0%	50.0%	50.0%	233.3%	400.0%	ND	ND	50.0%	50.0%	50.0%	350.0%	500.0%

Table RIPARIAN 36. LWSA, and TROA flows compared to No Action flows between Prosser Reservoir and the Truckee River based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TROA	NS	NS	NS	NS	NS	393.8%	NS	ND	NS	NS	NS	33.3%	462.5%	37.0%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TROA	40.0%	NS	NS	120.0%	100.0%	120.0%	50.0%	ND	NS	20.0%	100.0%	60.0%	60.0%	28.6%

Table RIPARIAN 37. LWSA, and TROA flows from Independence Lake to the confluence of the Little Truckee River compared to No Action flows based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TROA	ND	ND	NS	NS	NS	NS	14.8%	NS	ND	NS	NS	233.3%	NS	37.0%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TROA	25.0%	NS	166.7%	200.0%	150.0%	300.0%	NS	100.0%	60.0%	166.7%	150.0%	50.0%	250.0%	ND

Table RIPARIAN 38. LWSA, and TROA flows in Little Truckee River from Independence Creek to Stampede Reservoir compared to No Action flows based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	NS	ND	ND	ND	ND	ND	NS	ND	ND	NS
TROA	ND	ND	ND	ND	NS	NS	13.6%	NS	ND	ND	NS	38.5%	NS	NS
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS
TROA	NS	ND	NS	57.1%	125.0%	71.4%	ND	10.3%	NS	NS	80.0%	166.7%	66.7%	NS

Table RIPARIAN 39. LWSA, and TROA flows in Little Truckee River from Stampede Reservoir to the Truckee River compared to No Action flows based on model results for wet, median, dry and extremely dry hydrologic conditions. (ND=No Difference; NS = Not Significant).

	Wet							Median						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA		ND	ND	ND	ND	ND	NS	NS	NS	ND	ND	NS	ND	ND
TROA	NS	NS	NS	NS	NS	64.5%	NS	NS	NS	NS	NS	13.3%	50.0%	43.3%
	Dry							Extremely Dry						
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct
NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND	ND
TROA	11.3%	14.6%	70.0%	NS	50.0%	50.0%	60.0%	19.6%	32.4%	50.0%	-15.1%	50.0%	50.0%	43.3%