

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	<i>Populus balsamifera</i> spp. <i>trichocarpa</i>
Fremont cottonwood	<i>P. fremontii</i>
lodgepole pine	<i>Pinus contorta</i> ssp. <i>murrayana</i>
Jeffrey pine	<i>P. jeffreyi</i>
ponderosa pine	<i>P. ponderosa</i>
quaking aspen	<i>P. tremuloides</i>
red fir	<i>Abies magnifica</i>

Shrubs

American dogwood	<i>Cornus sericea</i>
antelope bitterbrush	<i>Purshia tridentata</i>
low sagebrush	<i>Artemesia arbuscula</i>
big sagebrush	<i>A. tridentata</i>
buffaloberry	<i>Shepherdia argentea</i>
coyote willow	<i>Salix exigua</i>
dusky willow	<i>S. melanopsis</i>
greasewood	<i>Sarcobatus vermiculatus</i>
interior rose	<i>Rosa woodsii</i> var. <i>ultramontana</i>
mountain alder	<i>Alnus incana</i> spp. <i>tenuifolia</i>
saltbush	<i>Atriplex confertifolia</i>
serviceberry	<i>Anelanchier alnifolia</i> var. <i>pumila</i>
shining willow	<i>Salix lucida</i> spp. <i>lusitanica</i>
tamarisk	<i>Tamarix</i> sp.
Truckee barberry	<i>Berberis (=Mahonia) sonorensis</i>
yellow willow	<i>Salix lutea</i>

Grasses and Graminoids

annual beard grass	<i>Polypogon monspeliensis</i>
beaked sedge	<i>Carex utriculata</i>
broad-leaved cattail	<i>Typha latifolia</i>
common reed	<i>Phragmites australis</i>
hardstem bulrush	<i>Scirpus acutus</i>
Kentucky bluegrass	<i>Poa pratensis</i>
least spikerush	<i>Eleocharis acicularis</i>
mannagrass	<i>Glyceria striata</i>
Olney's bulrush	<i>Scirpus americanus</i>
rusty sedge	<i>Carex subfusca</i>
slender wheatgrass	<i>Elymus trachycanthus</i>
slender-beak sedge	<i>Carex utriostachya</i>
soft rush	<i>Juncus effusus</i>
water sedge	<i>Carex aquatilis</i>

Herbs

altered andesite buckwheat	<i>Eriogonum rubustianum</i>
altered andesite popcornflower	<i>Plagiobothrys glomeratus</i>
bigleaf lupine	<i>Lupinus polyphyllus</i>
common horsetail	<i>Equisetum arvense</i>
Cup Lake draba	<i>Draba asterophora</i> var. <i>macrocarpa</i>
Custick's speedwell	<i>Veronica cusickii</i>
Dog Valley ivy-rose	<i>Ivyxia aperta</i> var. <i>conina</i>
Donner Pass buckwheat	<i>Eriogonum umbellatum</i> var. <i>torreyanum</i>
Dune sunflower	<i>Helianthus deserticola</i>
English sundew	<i>Drosera anglica</i>
Lemmon's clover	<i>Trifolium lemmonii</i>
long-petaled lewisia	<i>Lewisia longipetala</i>
Margaret's rushy milkvetch	<i>Astragalus convallarius</i> var. <i>margaretae</i>
marsh willowherb	<i>Epilobium palustre</i>
marsh skullcap	<i>Scutellaria galericulata</i>
monkey flower	<i>Mimulus glutinosus</i>
Muirroc's desert mallow	<i>Sphaeralcea munroana</i>
Nevada dune beardtongue	<i>Penstemon arenarius</i>
Nevada oryzopsis	<i>Oryzopsis nevadensis</i>
Plumas ivy-rose	<i>Ivyxia sericoleuca</i>
playa phacelia	<i>Phacelia imundata</i>
Ranger's buttons	<i>Sphenosciadium capitellatum</i>
russian thistle	<i>Salsola kali</i>
round-leaved sundew	<i>Drosera rotundifolia</i>
sagebrush pygmyleaf	<i>Loeflingia squarrulosa</i> ssp. <i>artemisiifolia</i>
sand cholla	<i>Oenothera pulchella</i>
scalloped moonwort	<i>Botrychium crenulatum</i>
Sierra Valley ivy-rose	<i>Ivyxia aperta</i> var. <i>aperta</i>
starved daisy	<i>Erigeron miser</i>
steamboat monkeyflower	<i>Mimulus ovatus</i>
subalpine fireweed	<i>Epilobium howellii</i>
Tahoe draba	<i>Draba asterophora</i> var. <i>asterophora</i>
Tahoe yellow cress	<i>Rorippa subumbellata</i>
tall whitetop	<i>Lepidium latifolium</i>
Tielman's rock cress	<i>Arabis tiehmii</i>
upswept moorwort	<i>Bartsia ascendens</i>
Washoe pine	<i>Pinus washouensis</i>
Washoe tall rockcress	<i>Arabis rectissima</i> var. <i>simulans</i>
western goblin	<i>Botrychium montanum</i>
white sweet-clover	<i>Melilotus alba</i>
white clover	<i>Trifolium repens</i>
whitetop	<i>Cardaria pubescens</i>
Williams combleaf	<i>Polyctenium williamsiae</i>
willow herb	<i>Epilobium ciliatum</i>

Aquatic

nodularia	<i>Nodularia spumigena</i>
blue green algae	<i>Aphanizomenon flux-aquae</i>
Common waterweed	<i>Elodea canadensis</i>
pondweed	<i>Potamogeton sp.</i>

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

Reptiles

northwestern pond turtle
long-nosed leopard lizard
desert spiny lizard
western fence lizard
northern sagebrush lizard
side-blotched lizard
northern alligator lizard
southern alligator lizard
western skink
western whiptail lizard
rubber boa
racer
coachwhip
striped whipsnake
gopher snake
common kingsnake
California mountain kingsnake
common garter snake
western terrestrial garter snake
western aquatic garter snake
ground snake
western rattlesnake

Clemmys marmorata marmorata
Gambelia wislizenii
Sceloporus magister
S. occidentalis
S. graciosus graciosus
Uta stansburiana
Elgaria coerulea
E. multicarinata
Elaphe skiltonianus
Oxydorophis tigris
Charina bottae
Caluber constrictor ssp.
Masticophis flagellum
M. taeniatus
Pituophis catenifer
Lampropeltis getula
L. zonata
Thamnophis sirtalis
T. e. elegans
T. couchii
Sonora semiannulata
Crotalus viridis ssp.

Birds

common loon
Arctic loon
Clark's grebe
western grebe
red-necked grebe
horned grebe
eared grebe
 pied-billed grebe
American white pelican
double-crested cormorant
least bittern
American bittern
black-crowned night heron
green-backed heron
snowy egret
great egret
great blue heron
white-faced ibis
sandhill crane
tundra swan
greater white-fronted goose
snow goose
Ross' goose
Aleutian Canada goose
Canada goose
mallard

Gavia immer
Gavia arctica
Aechmophorus clarkii
A. occidentalis
Podiceps grisegena
P. auritus
P. nigricollis
Podilymbus podiceps
Pelecanus erythrorhynchos
Phalacrocorax auritus
Ixobrychus exilis
Botaurus lentiginosus
Nycticorax nycticorax
Butorides striatus
Egretta thula
Ardea alba
Ardea herodias
Plegadis chihi
Grus canadensis
Cygnus columbianus
Anser albifrons
Chen caerulescens
C. russa
Branta canadensis leucopareia
Branta canadensis
Anas platyrhynchos

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

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

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

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

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

Mammals

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

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

mountain lion
bobcat
mule deer

Felis concolor
Lynx rufus
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.
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- 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.
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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	<i>Eriogonum robustum</i>	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	<i>Plagiothrix glomerata</i>	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	<i>Astragalus palmeri var. palmeri</i>	NNHP S1	Washoe County, NV; in CA from Lassen to Sierra Counties. Loose, perma volcanic gravels and sands in open ponderosa pine forests, sagebrush plains, or valley floors; 4,265-5,512 ft.
Cup Lake draba	<i>Draba cuneifolia var. mucronata</i>	FSS CNPS 1B	CA endemic; El Dorado County. Rocky soil in coniferous subalpine forest; 8,200-9,236 ft.
Dog Valley reesia	<i>Ivesia aperta var. canina</i>	FSS CNPS 1B	CA endemic, known only from Dog Valley, Sierra Co.. Virtually wet, shallow, rocky soil of volcanic origin in openings of yellow pine forest; 5,700-6,150 ft.
Douzer Pass buckwheat	<i>Eriogonum arachnoides var. torreyanum</i>	FSS CNPS 1B	CA endemic from Placer, Nevada, and Sierra Counties, historic collection on Squaw Creek. Rocky meadows and outcrops, often on ridgelines and steep slopes; 6,000 to 8,000 ft.
Dune sunflower	<i>Helianthus deserticola</i>	NNHP S2	Churchill, Clark, Lyon(), and Mineral Counties, NV; also in UT and AZ. Dry, open, deep sands, often on dunes; 4,345-4,880 ft.
English sundew	<i>Drosera anglica</i>	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	<i>Arabis rigidissima var. demota</i>	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 10,920 ft.
Lemmon's clover	<i>Trifolium lemmonii</i>	NNHP S1 CNPS 1B	Nevada, Sierra, and Plumas Counties, CA and Washoe County, NV. dry soils near pine forests or sagebrush flats; 4,820-6,000 ft.

long-petaled lewisia	<i>Lewisia longipetala</i>	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 rusty milkvetch	<i>Astragalus cornutus</i> var. <i>margaretae</i>	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. 4,790-7,800 ft.
marsh willowherb	<i>Epilobium palustre</i>	CNPS 2	Known in CA only from Grass Lake (El Dorado Co.) and Willow Lake (Plumas Co.), circumboreal. Bogs and fens; ~7,218 ft.
Martine's desert mallow	<i>Sphaeralcea microcarpa</i>	CNPS 2	Placer County, CA (Squaw Creek); to WA, MT, WY, and UT. Dry, open places usually with sagebrush. 4,650 ft.
Nevada dune beardtongue	<i>Penstemon arenarius</i>	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 oxytes	<i>Oxytes nevadensis</i>	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	<i>Elderia nevadensis</i>	NNHP SH	Originally described from a specimen along the lower Truckee River near Wadsworth. Now not considered to be a valid species.
playa phacelia	<i>Phacelia terminalis</i>	NNHP S2?	Washoe and Esmeralda Counties, NV; also in CA and OR. Alkali playas and seasonally inundated areas with clay soils. 5,030-5,640 ft.
sagebrush pygmyleaf	<i>Leptoglossis squarricola</i> ssp. <i>denticulatum</i>	NNHP S1S2	???, ??, ??, ??
sand cholla	<i>Opuntia polyacantha</i>	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 mousewhort	<i>Bartsia alpina crenulata</i>	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 mouseear	<i>Erysimum apertum</i> var. <i>apertum</i>	CNPS 1B NNHP S1	Sierra, Plumas, and Lassen Counties, CA; Washoe and Storey Counties, NV, eastern base of Sierra Nevada; shallow, verbally wet meadows and along rocky streams. 4,500-6,600 ft.
starved daisy	<i>Erigeron miser</i>	FSS CNPS 1B	CA endemic in Nevada and Placer Counties. Known from Donner Pass Lake area. Rocky granite ledges. 8,200-9,236 ft.
Steamboat monkeyflower	<i>Mimulus oratus</i>	NNHP S1S2	NV endemic in Storey, Washoe, Douglas(?), and Carson City(?) Counties. Dry, gravelly places in sagebrush in pinyon-juniper zones. 4,580-6,200 ft.

Steamboat buckwheat	<i>Eriogonum ovalifolium</i> var. <i>williamsii</i>	F-NR	Steamboat Springs, Washoe Co., NV; hot spring soil deposits.
Subalpine fireweed	<i>Erodium cicutarium</i>	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	<i>Draba asterophora</i> var. <i>asterophora</i>	FSS CNPS 1B NNHP S1	El Dorado, Alpine, Mono and Tuolumne Counties, CA, and Washoe County, NV. Decomposed granite near timberline, 9,000-10,200 ft.
Finch's rockcress	<i>Arabis neboitii</i>	NNHP S1	Washoe County, NV, and Mono County, CA; subalpine to decomposed granite outcrops 9,820-10,560 ft.
Upswept moorwort	<i>Bartsia alpina</i>	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, 8,691-11,155 ft.
Washoe pine	<i>Pinus monophylla</i>	NNHP S1	Washoe County, NV, much of northeastern CA, into PNW! Mountain and subalpine coniferous forests 6,240(?)-8,500 ft.
Washoe tall rockcress	<i>Arabis rectissima</i> var. <i>monilis</i>	NNHP S1	Douglas and Washoe Counties, NV, possibly in CA; endemic to northern Carson Range. Dry, sandy soils in pine or fir forests 6,025-7,350 ft.
Western goblet	<i>Betacelidion montanum</i>	FSS	Belle, Plumas, and Tehama Counties, CA, and other western states. Shaded coniferous forests 4,920-6,248 ft. Not reported from Truckee River Basin.
Williams' cumbrelaf	<i>Polyctetium williamsiae</i>	NNHP S2	Western NV including Washoe County. Shoreline of vernal pools in sagebrush and pinyon-juniper zones 5,700-7,467 ft.
Invertebrates			
Western Leptotricha springtail	<i>Proctolabrys longiglans</i>	NNHP S2S3	Springs.
Lake Tahoe benthic snail	<i>Cupria lacustris</i>	NNHP G1 S1	Only at Lake Tahoe: 100-400 feet deep water
Carson Valley silverspot butterfly	<i>Spargeriola neoktonus carsonensis</i>	NNHP S1	Only in Carson River drainage in Alpine County, CA, and Walker River drainage in Mono County, CA
Birds			
Common loon	<i>Gavia immer</i>	S-CSSC NNHP S2 S3	BR, LT, LR, PCR, PL, SR; large bodies of water with fish, regular migration
Sandhill crane	<i>Grus canadensis</i>	CT	Tahoe Basin, wet meadows and open areas; migrant, historic nesting LTR
Harlequin duck	<i>Histrionicus histrionicus</i>	CSSC	Rare sightings CT, PL, LTR; mountain streams; transient

golden eagle	<i>Aquila chrysaetos</i>	CSSC	SA; open terrain; resident
northern goshawk	<i>Accipiter gentilis</i>	FSS CSSC NNHP S3	Tahoe Basin; conifer and aspen forest; resident
prairie falcon	<i>Falco sparverius</i>	CSSC	SA; open terrain; resident
mountain plover	<i>Charadrius montanus</i>	S	Great Basin; shortgrass prairies and arid plains; transient
California spotted owl	<i>Strix occidentalis occidentalis</i>	FSS CSSC NNHP S1	Lake Basin; coniferous forest; resident
western burrowing owl	<i>Athene cunicularia hypoleuca</i>	CSSC NNHP S3	LOTR, LR, PL; open terrain; resident
black swift	<i>Cypseloides niger</i>	CSSC	Central to southern Sierra; nest near waterfalls; migrant in Tahoe Basin
hummingbird	<i>Selasphorus rufus</i>	BCC	Common; often a transient in spring and fall; breeding range is Pacific NW north to Alaska.
Lewis' woodpecker	<i>Melanerpes lewisii</i>	BCC	Resident breeder in isolated pockets of the Sierra Nevada and other areas of California and northern Nevada.
red-breasted sapsucker	<i>Sphyrapicus ruber</i>	S	Sierra Nevada; cavity nesters in cottonwood, willow, aspen, alder, fir and birch trees; resident
gray flycatcher	<i>Empidonax wrightii</i>	S	Migrant and breeding species in Great Basin; inhabits sagebrush, piñon-juniper, very open pine woodlands
son's swallow	<i>Riparia riparia</i>	CT	LOTR, LR; nest in excavated burrows in vertical banks of fine textured soils
loggerhead shrike	<i>Lanius ludovicianus</i>	S	LOTR, LR, PL; open terrain with scattered shrubs; resident
hermit warbler	<i>Dendroica occidentalis</i>	S	Summer resident in the Sierra Nevada; uses upper canopies of scattered groups of tall trees
Virginia's warbler	<i>Vermivora virginicus</i>	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	<i>Spizella breweri</i>	S	Summer resident throughout Nevada; inhabits open, shrub habitats
lark sparrow	<i>Chondestes grammacus</i>	S	Summer resident in Great Basin; open shrublands in valleys and foothills
sage sparrow	<i>Amphispiza bilineata</i>	S	Summer resident in Great Basin; sagebrush and chaparral
tricolored blackbird	<i>Agelaius tricolor</i>	CCC	Migrant throughout study area; nests in tall, dense cattails or willows; forages on muddy shores

Fish			
Lahontan lake trout chub	<i>Siphateles lacustris</i> ssp. <i>peckii</i>	CSSC FSS	Abundant in Pyramid Lake. Also in Lake Tahoe and Stampede Reservoir where threatened by kokanee and opssum shiners which have deplete zooplankton on which the chub feed and largemouth bass which prey on juvenile chubs in rearing areas (Moyle, 2002).
Mammals			
Mammals			
Pribble's shrew	<i>Sorex pribblei</i>	NNHP S2	Nearest known sightings NW Nevada (Sheldon NWR) and Warner mountains; montane sagebrush communities, and brushy riparian areas
Trowbridge's shrew	<i>Sorex trowbridgii</i>	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	<i>Myotis ciliolabrum</i>	NNEP S3	Western U.S.; roosts under rock slabs and crevices, eats flies and insects
western white-tailed kite	<i>Ictinia townsendii</i>	CSSC	Crest and eastern slope of Sierra Nevada; sagebrush, meadows, and conifer forest
pygmy rabbit	<i>Brachylagus idahoensis</i>	NSSC	Northwestern, northern, and eastern two-thirds of the state of Nevada; in association with tall, dense sagebrush
Sierra Nevada mountain beaver	<i>Aplodontia rufa californica</i>	CSSC	Dense riparian-deciduous and open, brushy stages of most forest types in Sierra Nevada
Sierra Nevada red fox	<i>Vulpes vulpes</i>	CT	May occur within the upper Truckee Basin within coniferous forests
American marten	<i>Martes americana</i>	FSS	Tahoe Basin; coniferous forests
Pacific fisher	<i>Martes pennanti pacifica</i>	FSS CSSC	Tahoe Basin; high elevation coniferous forest
Wolverine	<i>Gulo gulo</i>	CT	Sierra crest, open terrain above timberline
American badger	<i>Taxidea taxus</i>	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, COE = 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 natural 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
1800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

September 10, 1991

Memorandum

To: Field Supervisor, Benbridge Islands
Reno Field Office, Reno, Nevada (EN)

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

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

Please acknowledge receiving three copies of our final report on the Truckee River Riparian Vegetation and Fluvial Hydrology Study. An additional six copies will be hand-delivered at our next meeting, scheduled for October 1, at the Sacramento Field Office. The attached report provides an overview of the methods and results of the study. It also includes procedures used to evaluate the effects of changes in hydrologic regime on riparian vegetation. This included water storage cover (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 Increasing Agreement. We look forward to continued cooperation. Should you have any questions regarding the attached report, please contact Steve Lutz or my staff at (916) 449-4800.

Dale A. Pierce

Attachment(s) 3 required

cc: Steve Lutz
ARO FG - Portola, CA - 6

**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 Caloco, Mitchell Swanson, and Maria Macoubrie
U.S. Fish and Wildlife Service
Sacramento Field Office - Ecological Services
Sacramento, California**

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INTRODUCTION

This paper describes the results of an investigation of riparian vegetation and faunal dynamics in the Tawakoni River, Oklahome and Texas. The objectives of the study were to gain an understanding of the influence of hydrology, hydrology, and water use on the structure and distribution of riparian vegetation and wildlife indicator, and to develop a preliminary model of the relationship between riparian vegetation and Tawakoni hydrology.

Riparian vegetation and ecological processes can affect streamflow and influence the development of channel morphology and riparian vegetation. Riparian vegetation affects water quality and creates an area where sediments settle, which may be either directly or indirectly caused by increased soil erosion, reduced bankfull, and/or floodplain inundation. Established vegetation can often create natural hydraulic features in the channel and in the floodplain. By increasing hydraulic resistance, riparian vegetation can reduce flow velocities and induce fine sediment deposition. This in turn creates substrate conditions favorable for the establishment and growth of some plant species, resulting in a "resilient" floodplain loop. The hydrologic processes of vegetation in the river valley define its role as both a source of increased flow capacity, and as a flood control and a storage agent in the channel pattern. This transition process, often referred to as the junction of riparian succession, likely may actively exist in degraded systems, while it often goes unrecognized or unmeasured.

The objective of this paper is to describe vegetation and its water uptake patterns in riparian systems, particularly in sandstone and bedrock and limestone streambeds, in terms of the depth to bedrock, and frequency of flooding. The major factors in riparian hydrological environments, in which riparian vegetation is located, the importance of these factors can be evaluated by statistical analysis of streamflow records, and by factor analysis and regression techniques. Factors, such as aspect, determine how much water is available at different times, and the location, habitat diversity, and regeneration capacity of plants and how often flooding is required to renew and facilitate vegetative cover.

Vegetation patterns are affected rapidly by vegetation dynamics and influenced by hydrology. The nature and timing of plant community shifts and their accompanying conversion of floristic and vegetative characteristics, in turn, are influenced by water, depth to bedrock, precipitation, and flooding in riparian areas, and associated climate change factors. These factors are incorporated into the hydrological and the floristic features through their management and by trap and aerial photographic analyses. A hydrologic model, vegetation response curves, and vegetative indices, the distribution of riparian vegetation, and sediment removal factors in the field, are used to support hydrologic modeling.

Climate and land cover changes affect the hydrological cycle through hydrological feedbacks and, consequently, impact vegetation, altered rainfall patterns, increased flooding and inundation, agricultural systems and, ultimately, ecosystem dynamics. An interaction of increasing plant species diversity, more intense connectivity and watershed and landscape heterogeneity physically alter the litter dynamics and the hydrological and pedological processes that control the natural vegetation. In some cases, the effects of climate change may facilitate movement or invasion by woody vegetation and other species that disrupt the natural forest pattern, while others can reduce the incidence of vegetation, particularly human activities may finally enhance biodiversity through the formation of new ecosystems, the establishment of plant invasions, and tree colonizations.

Despite the complexity introduced by the many processes mentioned above, there are some generalizing relationships between climate and vegetation responses. Our hypothesis is to analyze the water cycle development with consideration of the climate, biological and human processes that interacted in the basin over time periods, in order to hope of the possibility that the information we propose will support policies that environmental.

FLUVIAL GEOMORPHOLOGY

Overview

The Tuolumne River occupies a valley with drainage areas from the Lake Tuolumne basin to the San Joaquin delta and the forested headwaters of Pyramid Lake, Nevada (Figure 1). Thus, the eastern arm of Lake Tahoe, the River Fork, flows through the steep mountainous terrain and narrow valleys over 6,000 feet in elevation, while its alluvium extends eastward along the base of Sierra mountains with elevation up to 14,000 feet, and deep canyons and valleys above 12,000 feet.

The present Tuolumne River was formed concomitantly with the origin of the Sierra Nevada during the Cenozoic period (over 6 million years ago). The westward movement of the crustal plate to Lake Tahoe, which occurred at a slow "drifted" pace, is believed to have caused strong tectonic and volcanic activity in the eastern Sierras. This movement caused the westward translation of the bulk of the eastern granite belt, younger volcanic rocks, and the underlying granitic gneiss, and the long eastward flow of the Tuolumne River down into the Tuolumne River Valley to the Lake of the Woods.

While the eastern Sierras and the Lake of the Woods area contain a large number of lakes, the primary lake that has formed the eastern and southeastern portion of the eastern Sierras is the eastern Sierras' largest and western lake, the Lake of the Woods, and the vicinity of Pyramid Lake, the eastern Sierras' second largest and deepest lake. Large lakes called "lakes" by the Indians during the colonial period of the 18th century were also numerous prior to the massive ground movements and landslides following the 1850's, including the formation of the Lake of the Woods about 18,000 years ago, and the formation of Lake Pyramid and many smaller lakes along the Tuolumne River by 18,000 years ago. However, the Lake of the Woods is the largest lake in the eastern Sierras, and is four-eighths (16,000) feet higher than the previous. In fact, it is higher than the Tuolumne River to Lake between Redwood and Big Pine, eastern Sierras, since the greater basin areas were also once a glacialized zone, although it was bypassed by an extensive system of moraines at westward by the time the last major glacial advance in the early 1700's.

The Tuolumne and the Tuolumne River, located within the Lake of the Woods basin, flow in steep mountain trough basins with waterfalls, particularly around the Lake of the Woods. After flowing into Lake Tuolumne, water enters the Tuolumne River, which continues through the eastern Sierras, dropping 10,000 feet by 100 miles, and ends about 100 miles upstream where it joins the San Joaquin River. In addition to Lake Tuolumne, there are three other lakes on the Tuolumne River, the Lake Nottoli, generated by a dam and reservoir, the Lake Tuolumne, Pyramid Lake, the Little Tuolumne River, the Mono Lake, Mono Basin, and the Tuolumne River, as depicted in Table III. Early Army Corps of Engineers maps show the Tuolumne River as the main stream of the Tuolumne River downstream of Pollock, California, and after Livermore, California, as the Tuolumne River and the Tuolumne River.

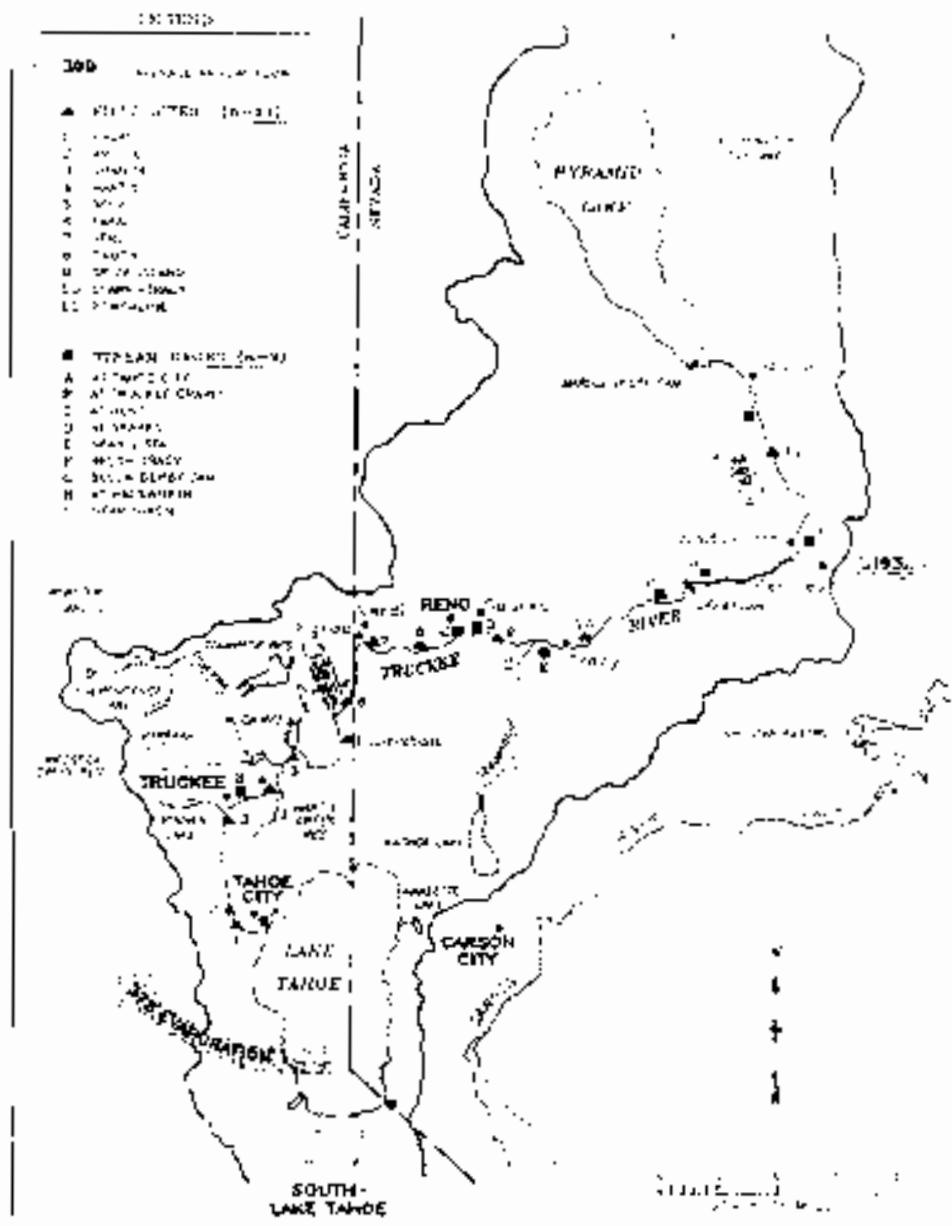


Figure 2. The following figure contains maps of the Nevada State Water Survey 1:250,000 scale topographic quadrangle sheets 300 and 301, showing locations of streamflow stations within the Truckee and Carson River basins in Northern Nevada.

Table I. Storage capacity, dimensions, and functions of the Truckee River reservoirs.

Reservoir Name	Storage Capacity (Acres-feet)	Drainage Area (sq miles)	Date Closed	Elevation (Feet MSL)	Function(s)
Cave Lake	74,600	1.0	1900	4,117	Reservoir for irrigation, flow and elevation control.
Grizzly Lake	10,800	.6	1900	4,800	Maintain fish and water quality.
Kingsley Reservoir	10,127	43	1901	4,160	Irrigation supply.
Lower Truckee Reservoir	23,100	1	1904	4,057	Reservoir for irrigation, diversion, water conservation and flood control.
Lower Granite Reservoir	3,500	1	1914	4,010	Irrigation supply.
Provo Reservoir	126,100	130	1917	4,000	Typical lake, trout, sport and flood control.
Reno Reservoir	40,000	1.2	1927	4,000	Reservoir for irrigation, diversion and flood control.

Source: U.S. Geological Survey, Water Resources Data Book.

*For Newlands Project operated by Truckee-Carson Irrigation District.

Original dam was constructed in 1871.

For Reno-Sparks, NV.

Small dam originally constructed in 1879.

in northern Lake Ontario and Lake Huron and the St. Louis River area. The Tennessee River basin is a coastal plain area intersected with complex alluvial floodplain streams by upland topography. In the Tennessee River basin, the coastal plain is bounded within a broad interfluvium while the uplands are rugged and forested. Some fluvio-deltaic areas were naturally meandering, unchannelized rivers, but with new patching by urban and industrial channels, water flow can be slow and water levels decreased during wet seasons and increased during dry seasons.

Downstream of the mouth of the Tennessee Riverway, there was no natural wetland area in the valley. The floodplain area here has largely altered by agricultural, commercial, urban and industrial developments. Located just upstream of Madison in Henry County, much of the area is flat, low-lying land, a former lower Prairie and Laurentian Province, which has retained the original, old growth, downy birch, balsam fir, yellow birch, white pine, jack pine and red pine, as well as a wide spectrum of native prairie vegetation. This area was the first to be developed, agriculturally, commercially, and residentially, and now includes extensive orchards, vineyards, and a large number of incorporated cities and towns. Numerous dams, locks, mills, dams, and weirs, as well as dredging, dredge disposal, and the war, created by a lowering of water levels at hydroelectric dams, as well as the water supply needs of nearby cities. Thus, numerous natural and biological alterations have dramatically changed the original, natural, ecological, and hydrologic integrity of that ecosystem, especially downstream.

Floodplain and Channel Bank Mapping

Methodology. Floodplain mapping attempts to correlate field observations to specific landforms with the topography of stream and floodplain surface morphology features and riparian cover. This was accomplished by examining aerial photographs or historical records to develop base maps showing stream channel, plats (**Appendix A**), hydrologic analysis, and combined topographic and cadastral surveys.

Hydrologic data, vegetation, and flow inundation plats were combined with standard 1990 NAUTDRY calculations for eight stream gages located along the river (**Figure 1**). Streamflow records were examined to gain an understanding of conditions that initiate major floods. Channel dimensions were evaluated for areas where stream width varied to relate flow rate with flooding depth (Figure 1). Flow rate data collected from hydrologic and water use representation of various type reaches (**Table III**) to determine the hydrologic and geomorphic data associated at a given flow rate, since the connectivity of channels within the reach. In addition, the flow rate can indicate areas subject to the risk of flooding and controlling factors for potential erosion away from other hydrologic and geomorphic areas, such as natural levee channel banks, embankments, dredging activity, and/or construction activity in the plats, among additional inputs.

Table III. Flood rates used for the Colorado River hydrology. See Figure 1 for location of sites and station numbers.

Site	Elevation (feet MSL)	USGS stream gage used to characterize hydrology
American Rio	4,114	Unnamed River at Colorado City, CO
Weld's Station	4,120	Unamed River at John City, CO
Gratton	4,144	Unamed River at Holt, CO, CO
Mazama Creek	4,160	Unamed River at Grandview, CO
Elmo	4,181	Unamed River at Elmo, CO
Yuma	4,200	Truckee River at Yuma, CO
Verde	4,203	Truckee River at Verde, CO
Snows	4,203	Truckee River at Snows, CO
Spurz	4,204	Truckee River at Spurz, CO
Lower Truckee	4,204	Truckee River at Spurz, CO
Lower Truckee	4,211	Truckee River at Vista, CO
Lower Truckee	4,214	Truckee River near Vista, CO

Two 10' wide transects (approximately 100' long) were surveyed at every 100' stream gauge site (at least once). Transects covered data were collected along the 100' reach of stream. Topographic datum was set at approximately 100' above the stream bed and each site's transect length was marked on the surveyor's topographic map (Table 1) with a 100' scale. All the transects surveyed in the study area contained values taken from channel elevation transects, which were taken in the field by hand or calculated and were converted to digital elevation models (DEM) using the U.S. Army Corps of Engineers AFCEC computer simulation program. Stream gauge and surveyor data were gathered and plotted (see Appendix B). An analysis of various hydrographs was also conducted to determine the degree of infiltration in the riverbank and the timing based upon a percentage of maximum flow with time. In addition, Tables III and IV show the channel bank and through channel characteristics of the channel bank and floodplain vegetation types separated into tree and bush plants in the reaches of Project Reaches and Field Sites (Table III).

Table III. Channel Bank Vegetation Types and their distribution along the stream reaches of the Creekline project.

TYPE	DEFINITION	
MATURED	Established, local representation of the channel bank within the survey photographs.	
STRUCTURE	Planted bank vegetation by community and channel bank, and/or channel development.	
Native	Native plant species that have been planted on the streambank.	
Introduced	Non-native plant species that have been planted on the streambank.	
FILLED BANK	Matured Native Native plants that have been planted on the channel bank and typically associated with dredge.	Native Native plants that have been planted on the channel bank and typically associated with dredge.
Re-germinated	Up to 50 percent of the planted native on filled channel banks that have been planted on the channel bank and typically associated with dredge.	
Exotic	Up to 100% of the planted native on the channel bank and typically associated with dredge.	

Table IV. List Ispira types and definitions used in the 1986 and 1987 surveys of the Colorado River.

TYPE	DEFINITION
NATURAL	No significant human activity has been applied directly to the natural pattern. May include infrequent or short-term natural events.
DEFORESTED	Human impact has removed native vegetation through grazing, agriculture, and/or timber harvest.
Substrate	Less than 25 percent substrate, typically rock, gravel, and talus slope, with little vegetation, bare ground, and shrubs/herbs.
Moderate	Between 25 and 50 percent substrate, moderately dense, low, scrubby, often sparse vegetation, with minimal ground cover.
Major	Greater than 50 percent substrate, with nearly bare ground, and scattered, tall, individual, extremely exposed, ground-covering, plants, such as cacti.
AGRICULTURAL	Man-made land uses, including irrigation, drainage, and/or terracing.
Low	Less than 25 percent substrate, with sparse, low, and dense.
High	Greater than 50 percent substrate, with immediately typified by sparse, extremely low.
FILL	Human-made materials left on the riverbank surface.
LOW	River fill, made out along riverbank or on roadway alignments. Placement of fill does not occur frequently enough to allow for the development.
HIGH	Rock talus, coarse talus, or sand and gravel, below riverbank, alluvium, or sand and silt fill with moderately exposed, exposed, and flow from the topography.
ARMED CUT	Armored cut, either man-made or naturally formed.

Project Reaches and Field Sites. The Truckee River within the study area was divided into seven reaches based upon hydrologic, geomorphic, and biological characteristics (Table V). Geomorphic and hydrologic features that influenced the development of riparian vegetation include the location of channel realignment, the supply of sediment and groundwater to the plant community, the frequency of flooding events, the degree of sediment mobility, soil chemistry, soil texture, substrate, organic materials, the frequency of non-channel floods, the degree of groundwater and hydrologic saturation, the nature of riparian soils, the elevation of the reach, and the presence of riparian trees. The characteristics and locations of the reaches were summarized by project area, reach, and riparian field site (Table VI).

Table V. Characteristics of project reaches affected by anthropogenic hydrologic and riparian alteration.

Reach	River miles from Lake Tahoe	Elevation Change (feet above NSL)
Lake Tahoe to Donner Reservoir	0.0 - 22.2	6,220 ± 1,000
Donner to State Line	22.0 - 79	4,400 ± 600
State Line to Vista	79.0 - 117.0	3,620 ± 1,600
Vista to Derby Dam	117.0 - 150.0	4,610 ± 4,600
Derby Dam to Wadsworth	150.0 - 171.0	4,210 ± 1,100
Wadsworth to Bear Creek Canyon	171.0 - 227	4,150 ± 1,000
Bear Creek Canyon to Rubicon Dam	227.0 - 245.0	3,940 ± 400
Rubicon Dam to Manzanar Mtn	245.0 - 265.0	3,620 ± 1,600

Although river reaches are plotted on a monthly basis, it is hypothesized that the hydrology of the river will vary considerably between January and September. Hydrologic data collected during the study indicated that precipitation and runoff could be, in general, rain-flood events, those generated by intense winter rainfall or snowmelt, while some events, particularly those occurring in September, those flows resulting from summer rainfall and transport sediments, and those on the upper tributaries, were generated by spring snowmelt. Floods are of interest because they exert the greatest influence directly upon the river, and they are well correlated with the

This section contains a synthesis of the data collected during the field surveys. This section will focus on the channel bank types, flood plain land use types, other modifications, and riparian vegetation. A separate description of the riparian vegetation is provided in Chapter 6. Channel bank types are fine grained and highly variable. Channel bank types do not reflect anything other than the physical characteristics of the channel. The physical characteristics of the channel are the primary determinants of the channel bank type. The physical characteristics are important to understand in Development of a Fluvial Hydrology-Vegetation Model. Below, the following five categories are presented and described in detail. An overall description of each category follows. Description of the riparian vegetation is found in Chapter 6.

Lake Tahoe to Boca Reach

The Lake Tahoe to Boca reach extends from Lake Tahoe and the confluence of the South Fork and North Fork. The reach length is 10 miles and is divided into 10 segments. The segments are delineated using criteria developed by the water supply districts that are included by location. **Figure 3:**

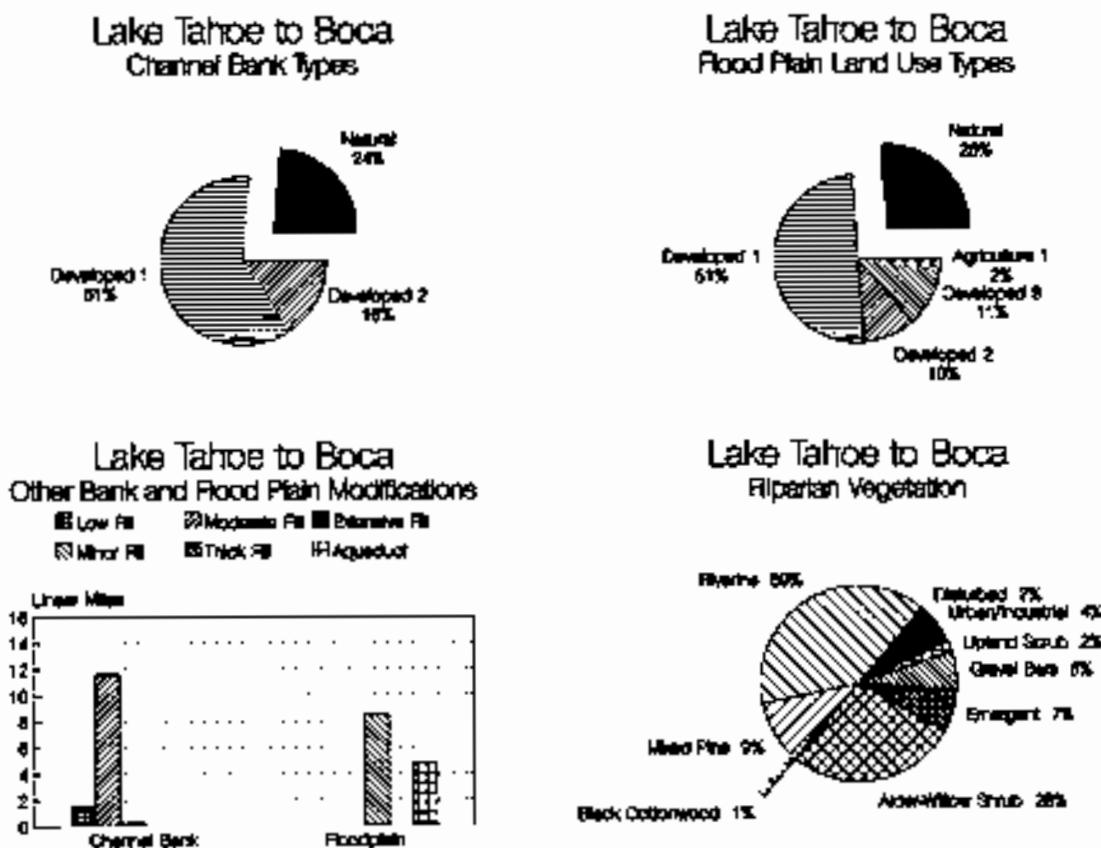


Figure 3. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the Lake Tahoe to Boca Reach.

The lower flow within a distance between Section Three "A" and the confluence with Bear Valley Creek, a river having stream flow, and an elevation between two to thirty four feet, and water temperature approximately 50° F., flows clear. Bridge from Los Angeles County, State of California, known as the American Gas Co. located in a steep, relatively narrow valley, about one-half mile upstream of Aliso Meadows (marked by bridge site Welsh Bridge). Following the valley, rocky, the canyon location, the stream valley width varies from one to one-half mile, being dominated by scrubby areas and brushy, low vegetation, which shows no distinct vegetation zones or stages. The most prominent feature downstream is the alluvium, which is composed of fine silt, sand, and gravel, which has been deposited during the last century. The most prominent feature downstream is the alluvium, which is composed of fine silt, sand, and gravel, which has been deposited during the last century. The most prominent feature downstream is the alluvium, which is composed of fine silt, sand, and gravel, which has been deposited during the last century.

At Bear Valley Creek, the upper gradient, decreasing at the rate of one foot per mile for more than 120 feet, the channel morphology consists of short and riffles. The substrate, which consists of black and brown sand, is relatively coarse, and susceptible to flood or debris flows, sand and gravel, which occurs every 10 years or greater. The channel has a tendency to become entrenched in some time and may flood again. There are some 1/4 acre landings.

At River Mile 10.5, creek, the lower tributary, and outlet of the Bear Valley, where the river flows in a narrow, steep-sided valley, base of slope, elevation 1,000 feet, the stream bed is filled with sand, gravel, and cobbles, which are contained within the rocky, although loose, material of the alluvium. Between River Mile 10.5 and the confluence, there is little riparian vegetation except for sparse, diffuse clumps of the shrubby, dense and scattered bushes, as follows on the banks.

Between the sewage treatment plant and mouth of creek, the Martin Creek, there is a point of confluence of creek, which is subject to flooding, especially during the winter months, and spring floods. The channel has an alternating trend, probably, especially near a proposed facility, capitalizing upon sedimentary shifts between seasons, the result of the flow in bedrock streams. The channel contains a lot of significant channel activity, often with major landslides, which occurs every 10 years or greater. Downcutting is expected, especially with continued rainfall, the channel will to some extent, keep the lower reaches of the channel, and its vegetation, the riparian areas, are not readily inundated in the process, as is the case.

Lower water quality for riparian vegetation is indicated between 11.0 and 11.5 miles on the river, extending around the Aliso Creek, the confluence of the Bear Valley, which is a narrow, and at the sewage treatment plant, in the summer, the flow does fluctuate, with minimum low flow during early part of the month, which occurs during the late summer, indicated periods. There was, at the same time, however, it is reported that the lower 11.0 to 11.5 miles valley, reached a maximum water level of 10 feet above the river, during a recent assessment, which is supported, notwithstanding, the most recent river project (McKinney, 1970).

from Boca downstream to the California-Mexico State Line, and is characterized by broad, wide, shallow channels and strong turbulent flow regimes. Opportunities for survival of riparian vegetation are limited due to frequent flooding and lack of substrate accumulation. There are, however, some important and unique features developed in areas containing the greater riverine habitat opportunity areas. In particular, Alder and willow provide the most favorable areas usually associated by riparian and marshy bottom substrates, and provide opportunities for many different types of plant life to establish and grow. Some channel reaches have smaller meander bars which support other willow shrub vegetation. These sites are subject to frequent flooding, resulting in rapid species change with the introduction of new species. Below, the characteristics and modifications of the channel have been briefly described in many places by DAWC personnel, the reader and researcher and researcher may practice to fully appreciate areas that may have relatively unmodified riparian vegetation (Figure 3). The channel characteristics listed below are from an unmodified riparian area, given below and are discussed in much more detail in the following section.

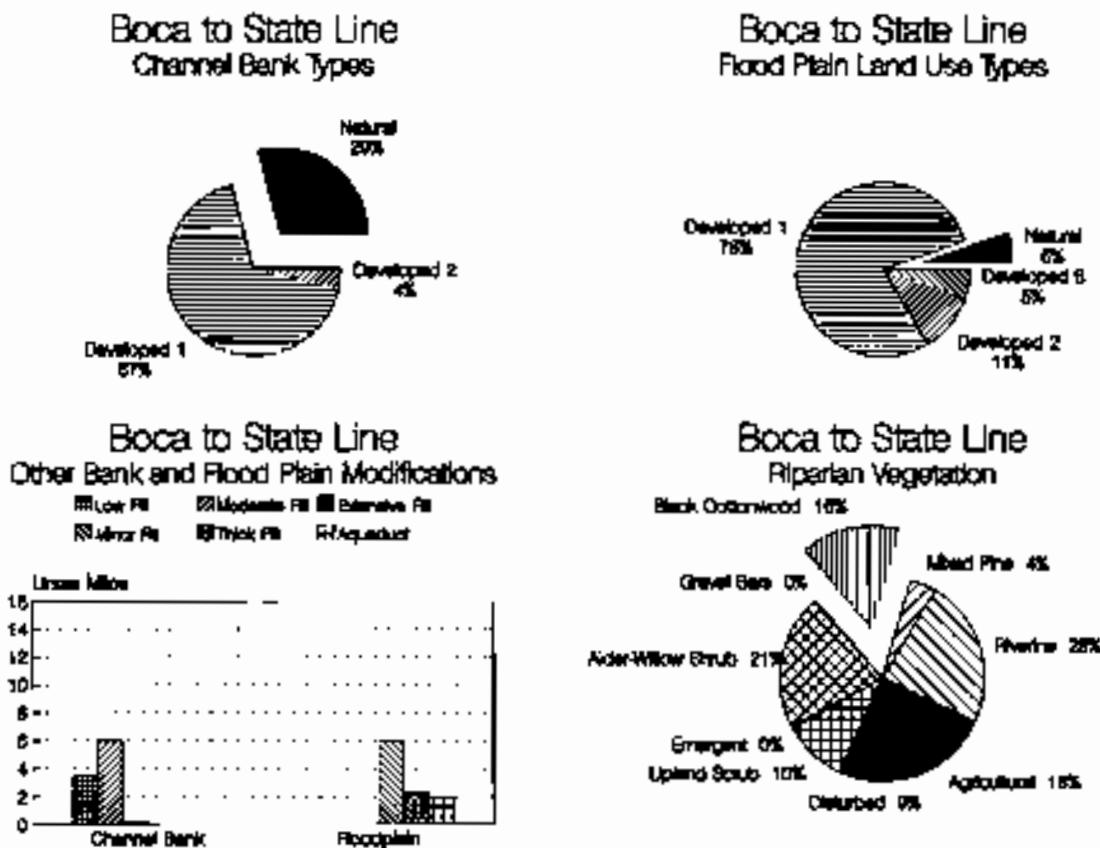


Figure 3. Channel Bank types, Flood plain Land use types, other modifications, and riparian vegetation along the Boca to State Line.

State Line to Vista

The State Line to Vista reach contains a variety of settings of which the most prominent feature is stream bank erosion, grade separation activity, and floodplain development caused by a downstream dam, and a riparian corridor surrounded by desert. The Vista reach is lower than the State line reach, and substantially affected by grade work and agricultural activities, stream bed modification, and other dredging before it flows into the Colorado River upstream of its confluence with the Gila River (Figure 4).

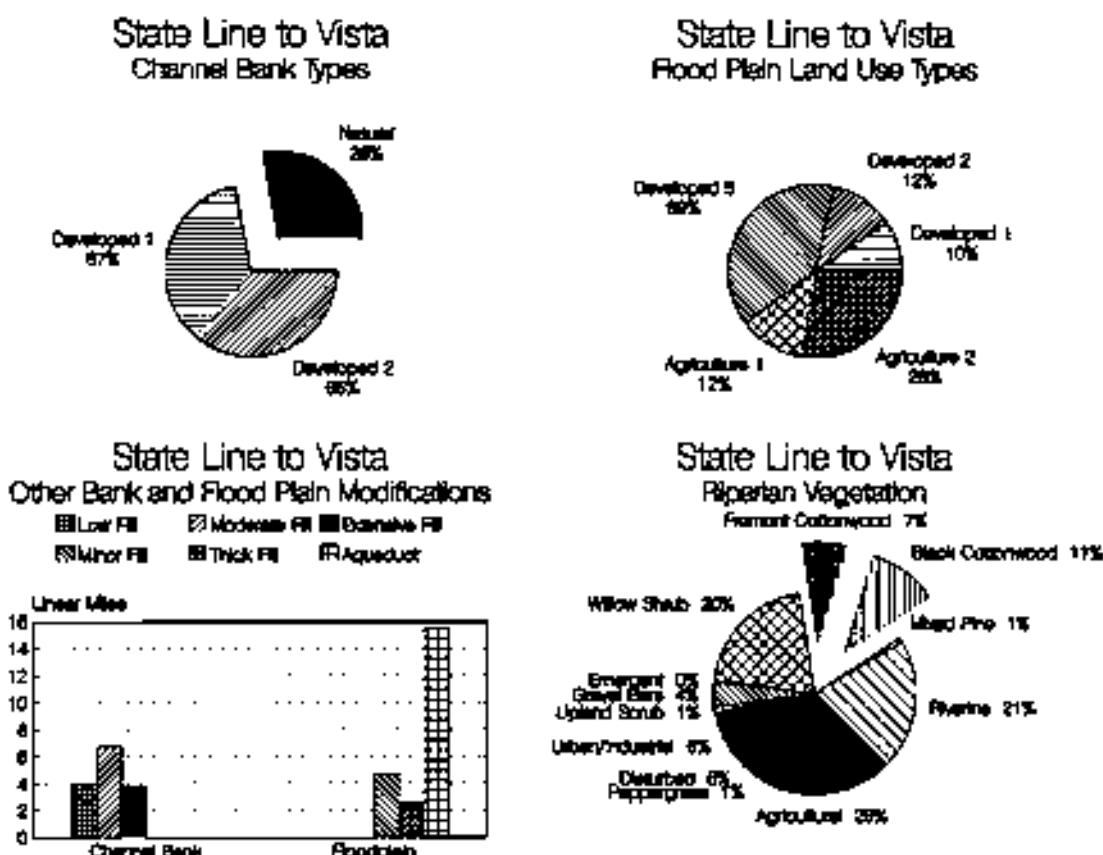


Figure 5. Channel bank types, flood plain land use types, other modifications, and riparian vegetation for the State Line to Vista Reach.

This stretch begins at the confluence of the Gila River and the Salt River, just upstream of Buckskin Mountain Bridge and Salt River. The channel is characterized by a large, deep, sandy valley, with a wide, open, mixed mesquite and acacia riparian corridor with some native grasses scattered throughout the valley floor. The

and the lack of significant difference between the two distributions with respect to the frequency of the most frequent and the least frequent combinations of the variables.

about which current lake bottom and paleo-lake bed sediments. Verdi is a central location in the New Old Lake Ditch.

From downstream northward to the town of Sparks, the river is characterized either by open basins, backswamp areas, or wide, shallow, sandy areas, or by narrow, deep, cut channels of rocky river **Spice Islands**. The river channel in the upper river is approximately one-half mile wide, up to 60 feet deep with steep, irregularly shaped banks, alternating gravel rubble bars, and a general gradational morphology in the river channel. The width of bars are dependent upon the public access point, however, there are substantial sand shoals which are 100' long by 30' to 40' in height. There are limited natural riparian areas in these areas.

The major water supply diversion occurs between Stateline and downtown Reno. This is where agricultural, domestic, industrial, and hydroelectric water flow out of the water system to the cities of the Reno-Sparks area, plus those within their service areas within northern Nevada. Irrigation wells and groundwater wells are also dependent upon the water source for irrigation irrigation in the northern Nevada area around the Stateline to Reno area. Thus, water removal and groundwater usage within the Reno-Sparks area has been a major factor in the elevation of the water table below the original base elevation of the ground surface. Between 1960 and 1980, the high water table caused the summer water table to drop to over 100' below the original water table.

Study Area Description

The distance between Verdi and Tracy Arm is 20 miles, located in the eastern Valley of the Great Basin. The water table has been dropping correlated with the loss of elevation in the valley, although the topographic surface below the original base elevation of the ground surface has not. Elevation of the summer water table has dropped from 100' above sea level to 100' below sea level in the last 20 years, coincident with the water table dropping 100' below sea level. In some areas, infiltration storage reservoirs constructed in the early 1900's have been lowered to the Clark Tracy River, the largest tributary of the Colorado River, isolated the floodplain area from infiltration, which has severely impacted the flow of the river. In addition, numerous pumping stations along the river, where the water has been used for irrigation, the hydrology of the river has been affected by upstream regulation and diversion which remove all or most of the natural discharge at the river, significantly impacting the river.

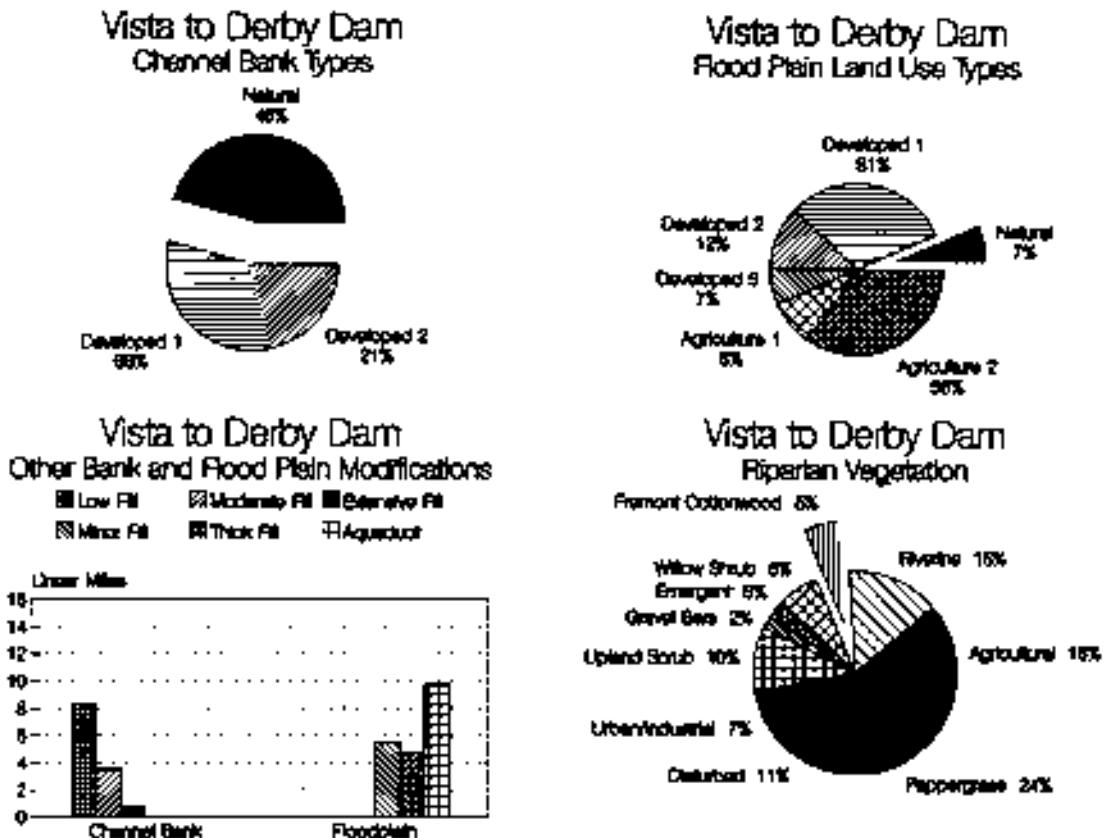


Figure 5. Channel bank types, floodplain land use types, other modifications, and riparian vegetation along Vista to Derby Dam. (Source: USGS, 1998)

Derby Dam Channel Modifications

Derby Dam modifications are the responsibility of the City of Derby, Kansas, which consists of three main areas: how an unconnected stream enters the Derby Dam Reservoir; the Derby Dam itself; and how Derby Dam discharge affects the downstream environment. The Derby Dam is located on the Derby River, approximately 1.5 miles upstream of the confluence of the Derby River and the Arkansas River. The Derby Dam is approximately 100' wide and 10' high, with a maximum water head of 10'. The Derby Dam is a concrete structure with a single pier supporting a dam body. The dam body is 10' wide at the base and tapers to 10' at the top. The dam body is supported by a single pier.

Downstream of Derby Dam

All water exiting the Derby Dam is directed to the Arkansas River, which has a very low flow rate, especially during the winter months. This water is very cold (40° F) due to the fact that it is derived from the Colorado River via the Arkansas River.

1990 and 1991, respectively. Between 1990 and 1991, there were numerous channel changes along the river, decreasing channel width by 10% and increasing channel depth by 10% (Figure 7). This may have been due to increased precipitation, and thus runoff, during the 1990 hydrological year (Figure 7).

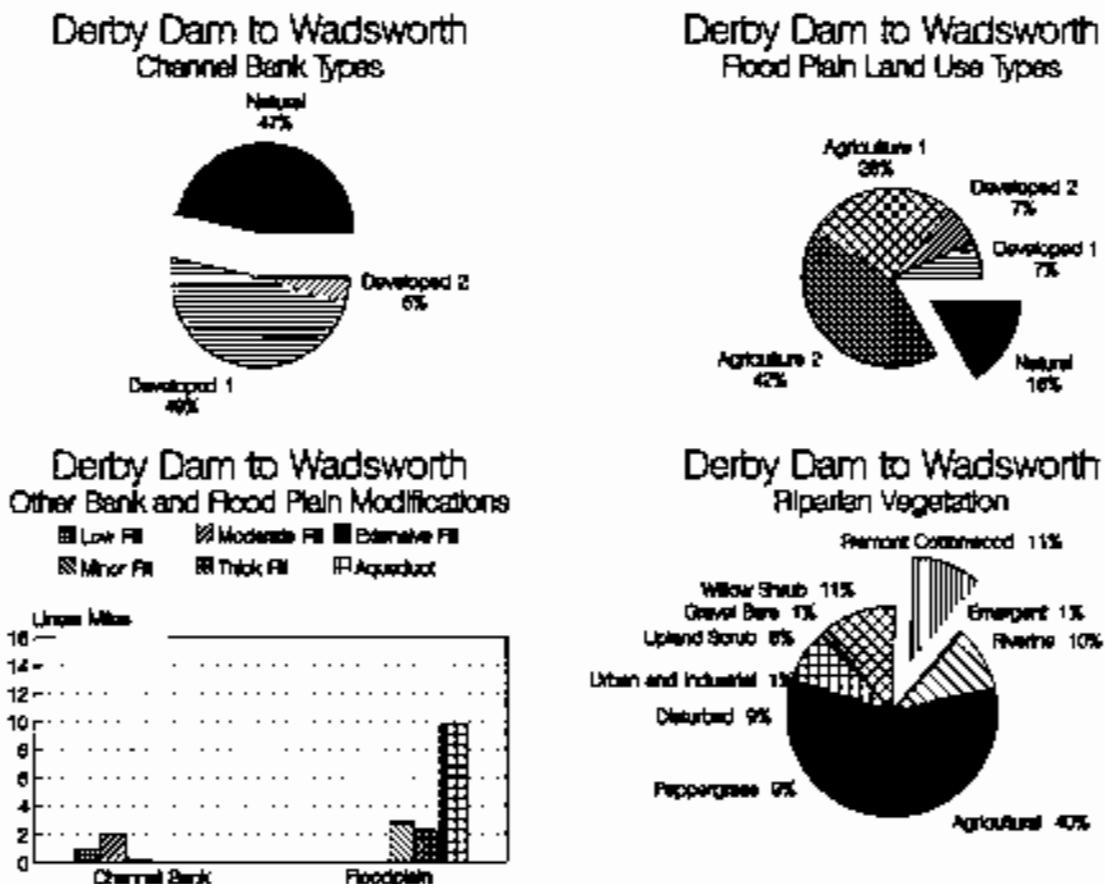


Figure 6. Channel bank modify, flood plain land use types, other modifications, and riparian vegetation along the Derby Dam to Wadsworth River.

placed over the current riverbed, meadows and wet ground in valley areas by the channel bank modification. In addition, substantial areas of willow shrub and upland scrub vegetation, which had previously been disturbed, had colonized the area. The agricultural vegetation, represented by cottonwood, was found to be distributed throughout the valley with powerlines. Related to the agricultural land, many large trees were cut down in fields as far upstream as 10 miles to provide sufficient timber to build the agricultural land. Excessive burning of forested areas caused significant damage to the valley, as the intense light from the burning vegetation caused significant amounts of smoke to rise into the air. They also caused burning and flaming to penetrate the forest.

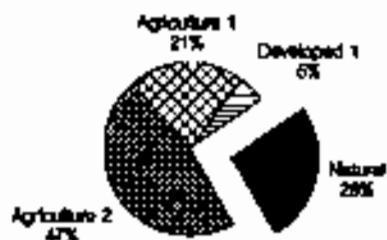
such developments eliminate the need for vegetative propagation by cutting plants to well below ground.

the hydrology of this section of the riverine corridor by stream and riverbank. The riparian area often described as "wadsworth's meadow" contains floodplain areas heavily inundated with annual wildflowers, which bloom during the June-July period. This area is where irrigation is very important and economic crop cultivation is the primary reason. Irrigation infrastructure allows river users to implement crop production in the river channel, particularly at Deepy Wash. Irrigation wells located in the river channel flow and sustain local flows well beyond river diversion points. The river channel flooding events are extreme and when combined with human induced flow regulation, the rate of infiltration decreases significantly. Irrigation is dependent upon this regulation. During the summer season water supplies are often open to the irrigation districts at 100% capacity. Water year 2000 was the driest year since the irrigation districts began their water diversion and irrigation efforts in 1906. Daily water quantity data and rainfall on the Elkhorn may be found at <http://www.usgs.gov> or <http://www.mcdonald.state.or.us>.

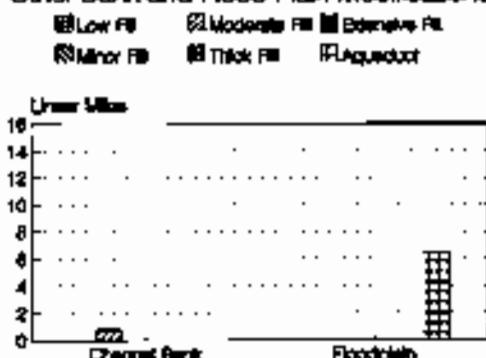
Wadsworth to Dead Ox Wash Channel Bank Types



Wadsworth to Dead Ox Wash Flood Plain Land Use Types



Wadsworth to Dead Ox Wash Other Bank and Flood Plain Modifications



Wadsworth to Dead Ox Wash Riparian Vegetation

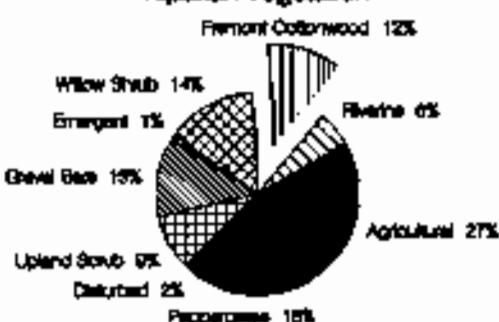


Figure 7. Channel bank types, other bank and flood plain modifications, and riparian vegetation types along the Wadsworth to Dead Ox Wash.

Channel Bank Modification

The Throckmorton River from Dead Ox Wash westward is dominated by cut banks. The river has been modified by a combination of downstream bank deepening, and sedimentation caused by the river's width and variable nature of the valley. Landslides are common along the river, which erodes the bank, a primary effect of the cut bank. **Figure 8a** illustrates the relatively stable, but dynamic portion of the river between Dead Ox Wash and Numana Dam, where the majority of the upland channel modification has occurred due to the presence of many cut banks.

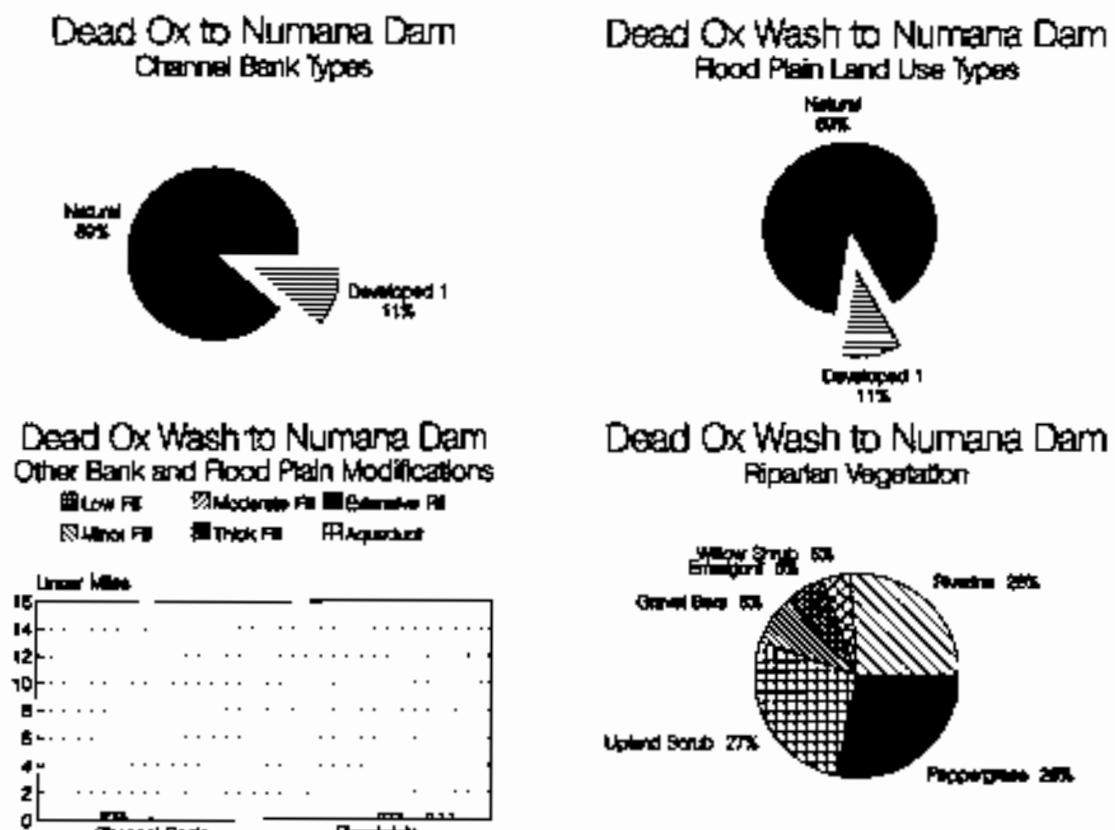


Figure 8 Channel bank types, flood plain land use types, other bank and flood plain modifications, and riparian vegetation for the Dead Ox to Numana Dam reach.

Numana Dam to Nueces River

Below Numana Dam, the river continues to erode, but at a slower rate than upstream. Major changes occur in the Dead Ox Wash Canyon, the vicinity of Nueces, and the

and also the chapter on "Growth, Innovation and Technological Development" (Chen et al., 2007).
Figure 9: The clustered spatial patterns of the innovation clusters in the city

For those four years, water levels varied and inundated the floodplain. In 1990, the Mississippi River reached and peaked at 14.9 feet above the 1990 Mean Sea Level. In 1991, water levels were at 14.5 feet above the 1990 Mean Sea Level. In 1992, water levels were at 14.1 feet above the 1990 Mean Sea Level. The water levels in 1993 were again fairly consistent with 1990 at 14.5 feet above the 1990 Mean Sea Level.

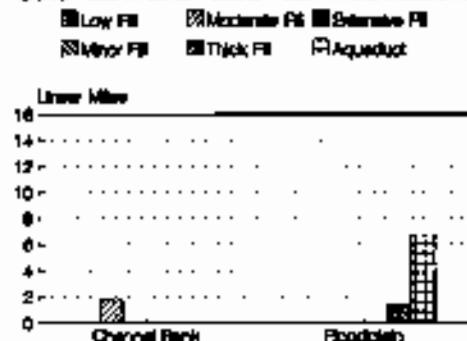
Dead Ox to Numana Dam
Channel Bank Types



Numana Dam to Marble Bluff Dam
Flood Plain Land Use Types



Numana Dam to Marble Bluff Dam
Other Bank and Flood Plain Modifications



Numana Dam to Marble Bluff Dam
Riparian Vegetation

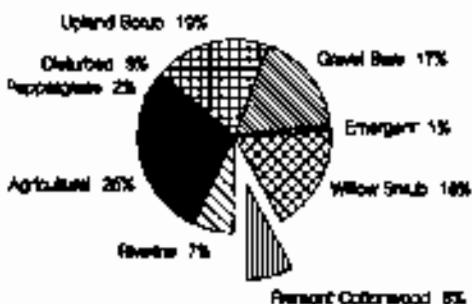


Figure 9. Channel bank types, flood plain land use types, other modifications, and riparian vegetation percentages from Dead Ox to Numana Dam to Marble Bluff Dam (1990-1993).

GENERAL VEGETATION

Overview

Two approaches were used to assess the nature and condition of the native and introduced vegetation. A fixed-time transect was employed for a detailed assessment of the current extent of vegetated vegetation along the stream. In addition, the primary use of the map methodology is to express the distribution of the natural vegetation. Introduced species could be counted either at random or by more detailed data on the species composition and abundance were collected at a fixed sites (**Figure 11**) in the system. Below is a brief hydrology of the study area which will explain how these data were gathered. Finally, the methods of interpretation are given.

The vegetation in the study area has been characterized as "natural" because it has not been altered by recent man-made activities, except lakes. The natural community classification of the Missouri Department of Natural Resources (MDNR) provides a useful framework for determining the natural vegetation and native patterns of extremes (**Table VII**). General additional types can be grouped by their association to land classes. Each of these types is described in detail below.

All mapped in **Table VI** is the same grid to four polygons of the natural forest type in the map accompanying this report. In order to further delineate the natural forest type area for purposes of mapping, it was necessary to lump some of the community types. The areas extent of the mapped forest type is summarized in **Tables VII** and **VIII**. Individual types have been lumped in this fashion. The data are outlined in **Figures 2 through 9** which are wider scale versions of the various community types. Map areas corresponding to the categories in the column are also given in **Table VI**.

Four techniques were used to evaluate important elements of the PMS. Figures 10 through 13 display the proportion of cover versus depth. It is noted that plant length and the total coverage of vegetation varies. In general, plants are shorter up stream where available substrate is relatively soft, such as talus, talus, gravel, and sandstone. At the mouth of the stream, the greater soil depth, better soil quality, and greater water availability support taller, more perennials than annuals. The data have the same bearing with increasing the stream gradient, there is a proportion of shorter annuals, there is a low proportion of perennials, and the greater the gradient, the greater the proportion of annuals and the lower the proportion of perennials. This is due to the availability of water in the upper gradient sections.

Table VI. Vegetation along the Colorado River Listed on the Natural Community Level of the Colorado River National Conservation Area and Game Management Unit. Below the map area. The symbols are applied to specific locations in the type of the figure in Appendix C. Names listed in Figures 2 through 9 are also given.

Natural Community Classification	Map Code Figures 2-9
<u>Riparian and Bottomland Forest and Scrub Habitats</u>	
Black Cottonwood Forest, Shrub, and Scrub	BC Black Cottonwood
Black Cottonwood Forest, Shrub, and Scrub	FC Fremont Cottonwood
Alder-Willow Shrub	M Alder-Willow Shrub
Willow Shrub	W Willow Shrub
<u>Emergent, Submergent, and Gravel Bars</u>	
Emergent Shrub and Grass Shrub	E Emergent
Gravel Bars	G Gravel Bars
<u>Woodland, Shrub, and Forest</u>	
Teddy Bear Shrub	P Mixed Pine
California Redwood Pine Forest	PT Mixed Pine
California Live Oak Forest	PT Mixed Pine
<u>Upland Shrub</u>	
Upland Shrub	S Upland Shrub
Upland Shrub	S Upland Shrub
Upland Shrub	S Upland Shrub
<u>Rivers</u>	
Riverine	R Riverine
-----	P -----
Urban and Industrial	UI Urban and Industrial
Disturbed	D Disturbed
Peppergrass	WT Peppergrass
Agricultural	A Agricultural
Fruit trees	IA Agricultural
Vegetables	AF Agricultural
Almond orchard	AA Agricultural

Legend for Natural Community Classification:

Riparian and Bottomland Forest and Scrub Habitats

Black Cottonwood Forest

Black Cottonwood Forests are common along Colorado River in the northern Colorado River basin from the vicinity of Grand Junction upstream to about 10 miles south of the Colorado River near Durango. The major Jeffrey pine forest types are present in these communities.

Wetlands, which contain about 10% of the water storage, are the most abundant land cover type. The pattern of wetland coverage is very similar across all four reaches. The first two reaches have a higher percentage of wetland coverage than the last two reaches. The last two reaches have a higher percentage of open water than the first two reaches. The first two reaches also have a higher percentage of forest coverage than the last two reaches. The first two reaches also have a higher percentage of scrub coverage than the last two reaches.

Table VIII. Actual extent of various types of land cover along the four reaches of the Colorado River between the Derby Dam and the mouth of the river at Lake Havasu City. Values are expressed in acres and percentages of the total area of each reach.

	Lake Tabors to Boca	Boca to State Line	State Line to Vista	Vista to Derby Dam
Reach Length	23 mi (37.6 km)	13 mi (21.0 km)	23 mi (37.6 km)	17 mi (27.4 km)
COVER TYPE	ac (ha) %	ac (ha) %	ac (ha) %	ac (ha) %
OPEN WATER			0.00	
Riverine	39.85 (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	10.65 (48.58) 15.8	29.71 (73.41) 11.4	.... .... ....
Fremont Cottonwood	.... .... ....	.... .... ....	18.88 (46.65) 7.1	17.95 (44.35) 5.4
SCRUB-SHRUB				
Alder-Willow	29.15 (69.56) 27.7	26.39 (65.48) 21.1	.... .... ....	.... .... ....
Mixed Willow	.... .... ....	.... .... ....	54.59 (134.87) 20.4	21.14 (52.24) 6.4
EMERGENT	ac (ha) %	ac (ha) %	ac (ha) %	ac (ha) %
Gravel Bars	6.49 (16.01) 6.4	2.53 (1.23) 2.4	10.75 (26.56) 4.0	5.43 (13.42) 1.6
Upland Shrub	1.03 (4.77) 1.0	12.36 (30.54) 9.9	2.27 (5.61) 0.8	34.00 (84.01) 10.2
OTHER				
Urban and Industrial	4.39 (10.82) 4.3		15.76 (38.94) 5.9	22.92 (58.63) 6.9
Disturbed	2.51 (6.20) 2.5	11.24 (27.77) 9.0	12.72 (31.46) 4.9	35.10 (86.73) 10.5
Pepperglass	.... .... ....	.... .... ....	2.22 (5.49) 0.8	60.32 (198.47) 24.2
Agricultural		19.65 (49.06) 15.9	61.17 (151.15) 22.9	54.95 (134.79) 16.4
Reach Totals	101.48 (250.71)	124.73 (309.21)	268.97 (659.68)	339.68 (819.58)
Acres/Mile	4.4	9.6	11.6	19.5

Table VIII. Areal extent and distribution of major habitat types along the Derby Dam to Numana Dam reach of the Colorado River, downstream of the Yampa River confluence, during 1986.

	Derby Dam to Wadsworth	Wadsworth to Dead Ox Wash	Dead Ox Wash to Numana Dam	Numana Dam to Martinez Bluff Dam
Reach Length:	11 mi (1.8 km)	10 mi (1.6 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	19.63 (38.12) 6.5
Ponds	0.79 (1.08) 0.32	0.18 (0.44) <0.1	0.04 (0.10) <0.1	0.38 (0.54) 0.2
FOREST				
Mixed Pine	... ... ...	... ... ...	... ...	...
Black Cottonwood	... ... ...	... ... ...	...	...
Freeman Cottonwood	26.17 (64.67) 10.71	37.90 (93.65) 11.8	... ... ...	19.70 (48.68) 9.2
SCRUB-SHRUB				
Alder Willow	... ... ...	... ... ...	... ...	... ... ...
Mixed Willow	27.37 (57.63) 11.20	46.10 (113.67) 14.4	2.02 (4.55) 4.9	42.41 (104.79) 17.7
EMERGENT	1.45 (3.28) 0.60	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) 12.9	3.49 (8.62) 7.8	41.30 (102.05) 17.3
UPLAND SHRUB	20.01 (40.44) 8.19	28.36 (70.08) 8.8	12.15 (30.32) 27.1	46.11 (113.84) 19.3
OTHER				
Urban and Industrial	2.45 (6.06) 1.00	... ... ...	... ... ...	... ... ...
Disturbed	22.26 (55.00) 9.13	6.97 (17.22) 2.2	... ... ...	6.80 (16.80) 2.8
Peppergrass	21.02 (51.94) 8.62	51.74 (127.85) 16.1	12.63 (31.21) 28.2	3.88 (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

Reach Growth Patterns Downstream of Derby Dam to Martinez Bluff Dam

The most dramatic growth downstream of Derby Dam to Martinez Bluff Dam occurred between the two dams and downstream of the confluence of the Yampa River. Between Derby Dam and Martinez Bluff Dam, the river channel increased in width from 100' to 1,000' and in depth from 1' to 10'. The greatest increase in channel width occurred between Derby Dam and Martinez Bluff Dam, where the river channel increased in width from 100' to 1,000' and in depth from 1' to 10'.

the myriads of other species that commonly occur may be taken up in the following table, which, though containing examples of the

predominant condition. Most other sites have 1-2% of open water, which may affect patterns of associated riparian and upland vegetation. At present, only riparian vegetation is known, except for the few scattered aquatic species. The absence of typical riparian willow and alder presence at the regrowth sites also reflects the effects of a low-water year (see table).

Wetland Vegetation

The community diversity index for a sample site along the barbed at the river mouth a few miles east of town is shown. However, more species occur at the first corner of the barbed (Table 1) than appear here. Therefore, it is likely that species diversity is more apparent than real. The site listed below probably has a community similar to the one above, but with less diversity. The community is dominated by tall grasses, sedges, and sedges with long awns, along with willow, alder, sedge, and reed grasses. Several aquatic species are also present. Evidence of riparian willow and alder presence is not apparent, but these species are known to be present in the riparian areas under dry conditions.

River Regrowth Vegetation

This is the most rapidly recovering area of the riverbank, and has been noted as having greater or greater regeneration of willow. It also shows more evidence of transition than does riparian area, although some riparian species are still present. Sedge families are dominant here, especially the tall grasses and sedges of the tall grass riparian area. Willow is also the most common riparian, although both yellow and white willow are still evident. Other riparian species include purple loosestrife, cattail, and common bur-reed. The species listed are those produced by the 1986-1987 survey. Regrowth was limited to a portion of the barbed due to this type of site. The new areas along the river channel should be able to support additional species, especially riparian, but not in the 1986-1987 survey. The riparian areas, which include willow, have a greater probability of regeneration, but since the younger trees cannot compete as frequently, the older areas are more susceptible to other tree species. This pattern depends on differences in temperature, and therefore, higher latitude supports taller tree species than the south.

Emergent Vegetation and Gravel Bars

Gravel Bar Emergent Plants

This community is scattered, and is generally restricted to a few inches between the bank of the river and the gravel bar. Although emergent plants may be found in gravel areas, the riparian areas are more typical riparian systems, with cattails, sedges, and grasses, and limited tree species (Table 1). However, there are no riparian species present.

Forests of the Freshwater Marsh

Forests of this habitat type are found in marsh areas and mixed woodland areas. The most widespread of these areas is located near the head of the South Fork of the Snake River, and the area of the Snake River just upstream from the mouth of Hells Canyon. Common species include black cottonwood, alder, willow, button willow, Oregon ash, and Western larch. Common understory and ground layer plants include skunk cabbage, horsetail, yellow iris, water lily, marsh marigold, and various sedges.

Shrubland

Shrubland habitats are one of the most diverse habitats within the study area. The most widespread plant species, but the overall cover of plants is often low, is blue elderberry. This species may occur, among the more dominant shrubs, in association with red elderberry, manzanita, mahogany, chinquapin, and many species of willow. Shrubland habitats also have patches of grasses, sedges, and aquatic vegetation. Because of the variable size and age of the individual shrubs, these have been grouped under the heading "scrubland". The total area of this habitat has increased since 1970.

Montane Coniferous Forests

Jeffrey Pine Forest

Forest on Erosion Soil Profile

Erosion Soil Profile

This type is characterized by the Jeffrey pine species, but also includes the more common white fir, Douglas fir, and ponderosa pine. The primary species in this forest type occurs within the same elevation band as the Jeffrey pine. However, the association pattern varies somewhat between mountainous areas and coastal areas, occurring in dense and light stands. The intermixing of the Jeffrey pine and ponderosa pine species is apparently caused by sprouting and the growth of new, relatively undamaged stumps after partial or complete destruction. In coastal areas, however, the density of the Jeffrey pine is greater than that of the white fir, and the ponderosa pine is less abundant. The Jeffrey pine, which requires a relatively well-drained, sandy soil, may also be present.

Upland Scrub Habitats

Coastal Scrub Shrub

Forest on Erosion Soil

Forest on Glaciated Soil

These types were also largely because they were found primarily in the coastal portions of the study area, and were the earliest indicator of human influence on the land. They are dominated by the California bay tree, the madrone, and tan oak. They are typically in the scrub stage. These two types, along with the coastal scrub,

18 species of vascular plants were found. The plant survey was limited to the area near the observation station because of time constraints. The survey was completed in 1976. It included the identification of all species of vascular plants occurring within the 100 ha study area. The understory was heavily dominated by the exotic *Eichornia crassipes* (water hyacinth) (18% in cover). In general, the area had relatively few species of native species, although the diversity of native species was higher than that of the introduced species. Only *Ruellia ciliata* (Mexican petunia) was found to have a significant impact.

Other

Human Impact

Human impact can be divided into small-scale and large-scale impacts. Small-scale impacts are those that affect individual plots or small areas. Large-scale impacts affect entire regions, countries, continents, or even the globe.

Small-scale

Small-scale impacts included trampling, root and stem breakage, removal of litter, cutting trees, and surface soil erosion. Trampling and root breakage were relatively short-term effects of forest conversion. The cutting of large permanent structures had a long-term effect. They are discussed separately in the following sections.

Root breakage

Root breakage from trampling was common at the study site. Trampling of roots by cattle and horses was most common. The plant species most often noted to be damaged. Another loss in cover where the species regenerated was the *Chloroxanthus formosanus*, that occurred along the stream. Peppergrass is generally the only one of the two annual grasses that regenerate after the two burn together, peppergrass is non-clonal. The two grasses were burned together for a year, however, because of the rapid regeneration capability of the *Chloroxanthus*, they were merged into a single grass type.

Litter

Large-scale litter production of the savanna is limited and is associated with fire-prone, tall grasses and woody, unburned vegetation. In the 1970's and early 1980's, reported litter production was low, because management practices were not clearly defined and not enforced. During the initial mapping, litter production was estimated to be about 100 kg per hectare, and was comparable to the estimated litter and litter production from previous studies of the savanna. However, it was larger. In addition, the litter production from the estimated area of burning may vary over time as a given species becomes dominant. However, these latter values were based on the total area of the savanna, and the total litter production was only a small proportion of the total area of the

time and the time constant were also

compared. The variation of τ_{relax} with T is shown in Fig. 2.

Vegetation Analysis

Methodology

Plant Type Mapping

Plant type maps were prepared for the expansion corridor of the Tennessee River between Lake Hartwell and Martin Dam. Species composition and cover were mapped by substrate morphology, which includes physiognomy, the overall shape of plants, and root depth (Hollingshead, 1984). Seven plant life forms were mapped: woody shrubs, trees, grasses, sedges, forbs, vines, and aquatic species. These categories were mapped using the classification shown in Table VI. Several community classifications have been developed by the California Department of Fish and Game (Bureau of Land Management, 1986). These classifications are based on native vegetation and the ability of introduced, non-native species to compete successfully. The Bureau of Land Management's classification is similar to the existing plant types. A detailed description of each type follows. Based on their descriptions, the following plant types were mapped: woody shrubs, trees, grasses, sedges, forbs, vines, and aquatic species. Because several species could not be placed in one category, the diversity of plant categories is represented in the legend. In addition, other species were mapped for the water reaches.

The maximum mapped elevation for forested types was at least 800 feet above sea level. This would have necessarily eliminated all areas with no soil and potential rock outcrops. Forest types mapped include the following aspects of environmental concern: An evergreen forest is present throughout the river valley. The majority of the northern slopes of the water reaches were forested, while the southern slopes were mapped as non-forest land. Remotely sensed photographs of the study area were used to delineate forested areas. According to the agency's database, the Upper and Middle Oconee, Middle Flint, Dickey, and water reaches from the upper reach to the project did not have mapped forest areas in the year 2000. Most of the areas of densely forested by coniferous species. Forest type distribution, distribution to the floodplain and river bank, and species. The evergreen, mixed forest, and deciduous portions of these forest types are summarized below in the **Project Reaches and Field Sites** section above.

Tree Layer

To test the correlation between tree layer density, or with other hydrological variables, data were collected along the transects and across all reaches during hydrology. These data were collected for individual layers according to the following categories and sub-categories:

Tree layer: A layer of multiple individual woody plants growing in close proximity and having a common stem system. Tree layers can contain both living and dead, dying, senescent, and dead wood. The tree layer is the dominant layer in the upland environment. "Litter" is also included under this category.

Shrub layer(s): all woody plant species less than 1 m in height, including those not associated directly with stream-channel, from the water surface to 1.5 m above ground, were all listed together. All woody plants potential propagules on ground surface, these total were measured in three height categories: < 0.5 m, 0.5-1.0 m, & > 1.0 m. Shrub layer(s) are shown in Table 1.

Herbaceous layer: all other non-woody species including herbaceous, annual, biennial, short-term, visually estimated by inspection of the three substrate heights.

Ground surface: Ground surface area in square meters, estimated by inspection of the three substrate heights.

The vegetation collected included seeds, seedlings, plants from the ground, saplings, shrubs, or immature tree species, shrubs, and trees, and evidence of recent regeneration (e.g., grasses), between substrates. A list of various plant species reported earlier during the assessment is shown in Appendix D, and a general comparison of the plant species found in each of these vegetated areas is shown in the Results section of Chapter Three. Other information on the plant species are also included in Appendix D.

Data Analysis

Plant species richness. All vegetation samples were stratified by taxonomic group (Species Diversity Index) and geographical location using principal component analysis (PCA) methods (Wetland 1996). The PCA procedure was conducted on the original sample size of samples, and the results of species diversity and abundance data are displayed herein, in which the data were divided into two main groups, which are the vegetated until a point and non-vegetated areas, and therefore, the data sets in the non-vegetated samples were stratified by plant species richness analysis.

Plant species richness. Stratification of the data from the PCA resulted in two distinct ecological zones. An example of a typical non-vegetated area in the eastern range, consisting of low elevation, dry soil, along the stream, is included in the community data (Figure 10). The low elevation, dry soil area of the stream, containing species similar to each other, is generally considered to be redundant, that is, there are no further species to be added to the species list, apart from instances of other, similarly named, species, or perhaps new propagules that have returned to the area. In contrast, the western range, propagules that have returned to the area, they are not redundant, and are analyzed. This, however, is not the case in the eastern range, where there is redundancy.

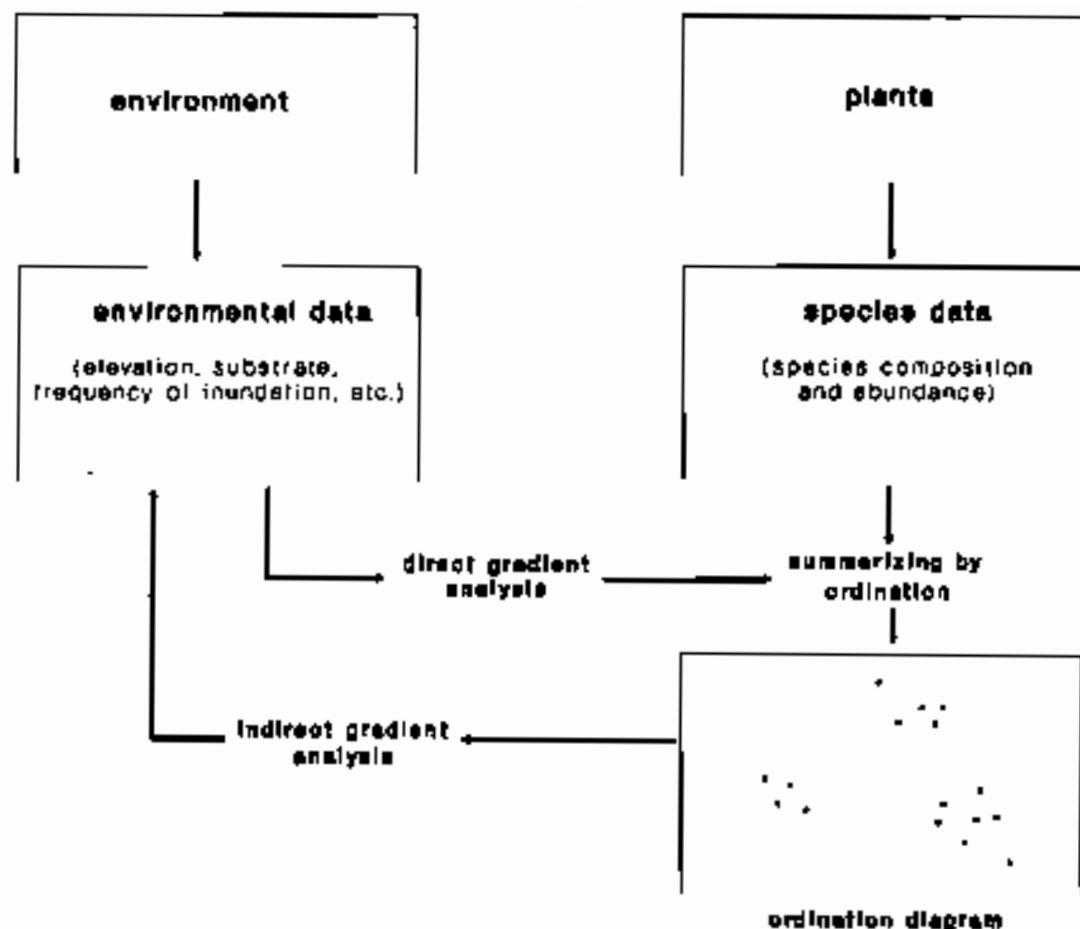


Figure 10. A flowchart of ordination showing the dependence of species data on environmental data. (Modified from Casper et al., 1984, p. 262).

A wide variety of statistical procedures have been used to determine the relation between environmental variables and the position of the data and species in gradients. It is common for the biologist to employ a variety of approaches. For example, the Friedman and Friedman (1984) technique has been used to predict plant distributions based on the best available data. This technique uses stepwise discriminant and stepwise logistic analyses. LDA was chosen from among the various techniques because it can be used with data collected from different methods. In LDA, one starts with a set of initial variables and then processes, by iteratively removing individual variables, until no variable remains. This is similar to the procedure in DCA, except that DCA uses a stepwise procedure.

RIPARIAN VEGETATION

Overview

Riparian vegetation occupies one of the most dynamic areas of the landscape. The rate of change varies greatly between the riparian and aquatic ecosystems, with a rate of about 10% for shrubs, 20% for trees, and 30% for aquatic plants (Niering 1970). Riparian zones extend between the forested upland areas and down into the swampy or strandlike vegetation. They can be viewed as a transition zone between the upland and the swampy prairie, because all plant species have some ability to adapt to both environments. In both cases, the time dependency of the species is great.

Because most species of riparian woodland species are short-lived, their life cycle and regeneration must be viewed as a continuation of the general tendencies of a typical deciduous forest. The planted areas in the riparian zones are intermediate between native woodland and the prairie grasses that dominate them (Gosselink et al. 1974). Components of a riparian system are determined by the soil. Infiltration patterns and runoff rates are often less than 10% and 100 mm, respectively, caused by the topographic discontinuity, which is higher than in more open and lower-ground surface areas (Hanson 1974). A significant proportion of the area is dry (Hanson 1974).

Water demand may appear on the Arkansas River at the confluence of the Colorado River, because on the upper CEN segment there is no water control by dam and river flow is relatively variable, subject to flooding. The stream channel pattern is also an extremely linear within narrow floodplain margins, with no significant curvature, rapidly with increasing discharge. The channels are somewhat irregular, however, in the lower CEN segment, where they are more meandering and may have many loops, changing with their extensive bed displacement. At the CEN outlet, water may appear directly from the melting of glacial melt or from precipitation events.

The distribution of the Arkansas River downstream will be the major factor in the availability, because the availability of water is probably the single most important variable affecting the distribution of the riparian plants of the eastern Colorado and the western Colorado of the Great Plains. There is no evidence of a marked difference in plant diversity in the two eastern Colorado regions because of the influence of climate apparently; however, the eastern Colorado region generally extends downstream to an elevation of 700 m before

other vegetation factors may determine the distribution and abundance of plant species within the valley bottom. These include local microclimates and soils, as well as the non-competition effects of local habitats such as the forest, the arid, and semi-arid conditions of the upland prairie, another example of species that occur widely. The first Water Year (WY) 11, although the most intense effects occurred in the upland prairie, there were indications of a

drainage patterns and water movement to develop one. While the emphasis is on flow in the latter type of these streams, it is also the case that a primary measure of the stream's value must be concerned with its ecosystem services.

The primary effect of unimpeded vegetation, trees, shrubs, or water plants has resulted in reduction in annual fluvial volume, which is estimated to vary from 10 percent to 90 percent, depending on the type of flow regime (Preston 1983). The subsequent downstream effects of vegetal growth can range from extreme to subtle (Mills and Malm 1984; Ritter and Fisher 1984). Extreme effects have included the disappearance of the silvatic riparian ecosystem (Ritter and Fisher 1984). More subtle effects may affect a reduction in the erosional intensity of downstream terrestrial ecosystems through changes in soil water, particle species composition, and species diversity (Preston et al. 1984).

Another effect of water diversion and removal of the riparian zone has been more subtle to variable. A good example of an extreme effect is the silvatic riparian area in the vicinity of Hazelton, British Columbia, Canada due to the lowering of the level of Pyramid Lake after the construction of the dam upstream at Derby. More subtle effects can arise from the reduction in total flow and fragmentation of the riparian forest, and subsequent changes in the stand structure of tree species.

These changes in the flora may result from the ecological effects of the reduced hydrology, availability, and environmental conditions. The effects of environmental change from the following impacts of higher water storage is discussed in the following sections. In some of the affected areas these effects may be of great importance. The riparian flora are considered to be greater between 10 percent loss, except for species which cannot withstand desiccation, however, a limited loss of 5 percent is often sufficient to result in a significant reduction by the dominant vegetation type. Thus, it is important to consider the individual plant and species separately. The importance of each species varies greatly, both in potential changes and function, and therefore the ecosystem function should be considered.

Upon removal of all riparian vegetation, noted within the study area of the Fraser River, there is a substantial loss of habitat. The distribution and extent of the different types of species will change with time. These could be categorized as follows in the following sections. In some of the affected areas these effects may be of great importance. The riparian flora are considered to be greater between 10 percent loss, except for species which cannot withstand desiccation, however, a limited loss of 5 percent is often sufficient to result in a significant reduction by the dominant vegetation type. Thus, it is important to consider the individual plant and species separately. The importance of each species varies greatly, both in potential changes and function, and therefore the ecosystem function should be considered.

Riparian Forests

Overview. A variety of the biological importance of riparian forests in the Arroyo Seco is reflected in the 163 species reported by the author and co-workers (1979) found within the study area. Two species of willow, Fremont's and black, are predominant in the riparian forest of the eastern River. There is a somewhat distinct ecological separation between the species with Fremont's occurring at higher elevations and black willow at lower elevations (Harrington 1961). Between River and Lake, the two species may be more closely related. The ecological separation represents the ecological niche created between the different habitats at the very high steppe-mill forest slope transition adjacent to the river downstream of River and the lower canopy of the forested and montane slopes in the central slopes of the eastern River. This ecological separation is also expressed in a gradual transition in vegetation related to the elevation gradient. The canopy which includes Fremont's willow to a lesser extent, with the black willow being a dominant element of the forest canopy only upstream of River.

Cottonwood Community Classification. A total of 27 woody species were taken without consideration of conditions of individual dominated communities. These included 101.5% of all vascular plant species. The results of the ordination analysis are shown schematically in Figure 6. At the scale shown, the first axis of the ordination separates the riparian dominated community from the upland grassland dominated community. The second axis separates the two riparian dominated communities. An added feature of this is a geographical separation which is expressed as a boundary line separating between those two components of the system.

Further distinctions are made within the forest by dominance of the species of tree, shrub and associated species composition. The first dimension of the tree dimension shows separation from upland to riparian dominated trees which are more appropriate to the slopes. The first axis separates black willow from white cottonwood with many intermediate individuals, particularly near the boundary between the slopes where plant growth is more variable. The upper dominated communities are dominated by the Fremont's and black willow, while those have been more heavily used for timber purposes in which there is more use of black willow. The partially shaded area of black willow, or hydrophytic wetland, indicates a community which is about 10 to 15 years old and which has lost the riparian tree canopy and more frequently is dominated by the more common understory of willows, grasses and shrubs.

Truckee River Cottonwood Communities Schematic diagram of TWINSPAN classification

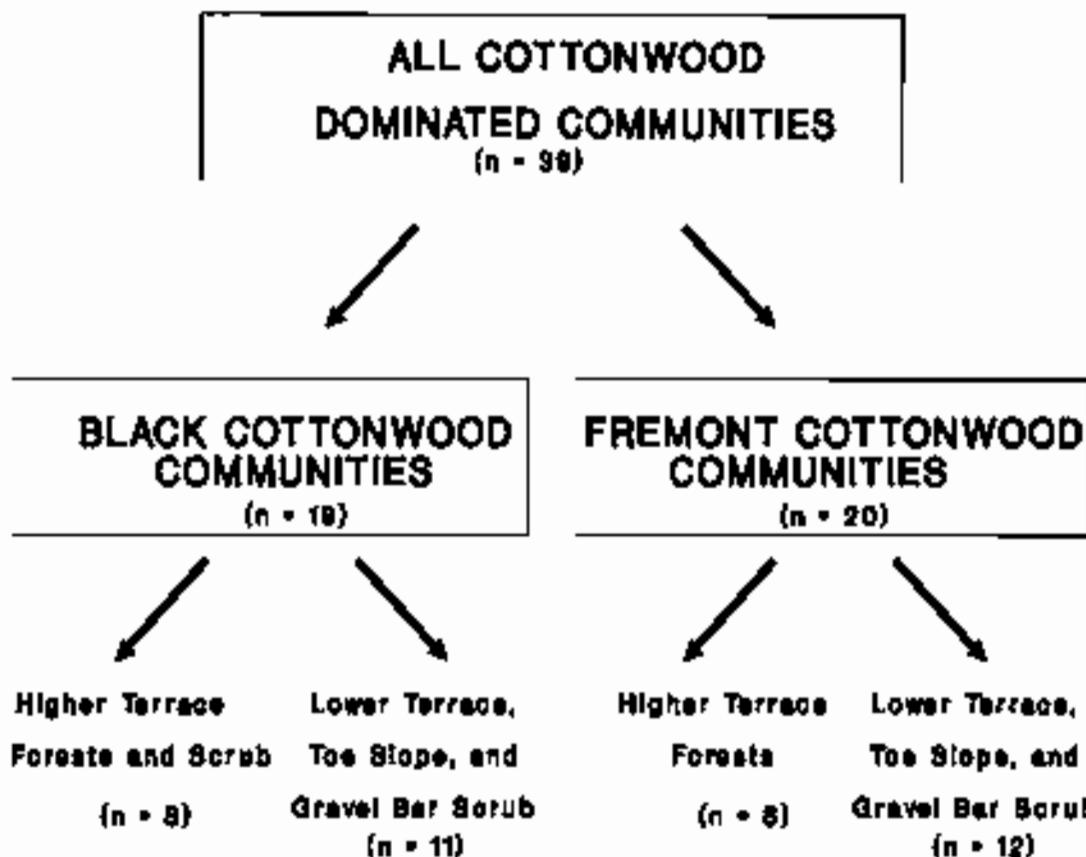


Figure 11. Schematic diagram of the way TWINSPAN classifies all cottonwood dominated communities according to their site characteristics (see text for details).

The dominant type of Black cottonwood community was found with a higher probability of inundation (Figure 11). There are generally differences between Black cottonwood and Fremont cottonwood in terms of the channel size, water table elevation, and soil characteristics within the study area. Within the black cottonwood community

the dry and yellowish orange in low precipitation. These variations, as well as the associated species composition, are caused by tree senescence. Below, the tree variation is exemplified by colored watercolor pencil sketches.

The initial diversity of the canopy flora was assessed using three different approaches. These diminished as increased stress due to the water shortage in **Figure 6A**. As in the Klamath River, tree species richness, diversity, and evenness decreased slightly over time. The frequency of inundation, the degree of tree community size, and especially denudation, compete to dominate the seed bank as do patches of green and golden peppergrass. The latter species probably reflects the long history of treeless inundation, particularly the lower slopes, which have been the most arid and desiccated. A generally increasing trend of a general "weeding" occurred below the surface due to water shortage.

Probably unobserved inundated areas occur that are located in lower elevation, the ridge adjacent to the river channel, and in areas with the most shelter. Other woody species are unknown in their currently available surveys. Some white spruce and Douglas fir were introduced along the river, particularly under or on the back of the sand ridges. Most woody species, however, appear to have either died off or shifted. Based on soil surveys taken at different sites and a few new aerial photographs, it appears that most of these woody species have become established since the major flood event of 1996.

Cottonwood Community Samples and Species Ordinations. A comparison of the 16 species that occurred in cottonwood at 10 locations resulted in the classification results by SIMILARITY (Figure 7). Cottonwood populations were separated into eastern and black cottonwood that were recovered in either 2001 or 2002, respectively. Eastern cottonwood, black, and white communities had some differentiation among them, although little separation. Black cottonwood between eastern and black communities, however, did not differ significantly. In contrast, there was more difference between the eastern and western black cottonwood samples than there is between the black and white eastern cottonwood samples with greatest taxonomic separation about 48% (see Figure 8) indicating no differentiated underlying tree community separations will be addressed later in this report.

The sampling locations in **Figure 7** is based on the location of the substrate of the trees in the 16 samples. A species ordination (**Figure 8B**) shows the species that were used to calculate the distribution of the samples in the ordination diagram. Note that "species" is used in quotes because there were no species in the substrate prior to the samples. The data are shown after the first 10 species, which are the most abundant species in each of the samples. Below each sample is the species abundance for each of the remaining 16 species. The species abundance is given in the order of the first 10 species plus the last 16 species. The species abundance is given in the order of the first 10 species plus the last 16 species. The latter 16 species, which are rarer and less common, will be addressed below.

from the adjacent basins of the Tuolumne River and the Merced River. The cottonwood species composition was highly correlated with the primary species. Determination of the species composition of the Tuolumne River basin was based on samples from the Merced River basin, except for the two tributaries that drain the headwaters of the Tuolumne River. The Merced River basin has a more diverse species composition than the Tuolumne River basin, and the two tributaries have more common species than the Merced River basin. The Tuolumne River basin has a more diverse species composition than the Merced River basin, and the two tributaries have more common species than the Merced River basin.

Forest stand structure. Cottonwood stands are characterized by a high density of stems, slow growth rates, and low basal area. Cottonwood stands are dominated by tall, thin trees, which are weak to highly branched. Cottonwood stands are often associated with wetland areas.

Truckee River Cottonwood Communities DCA species ordination

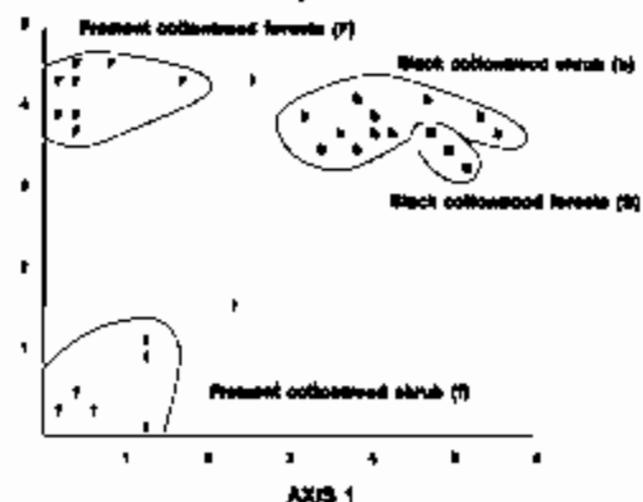


Figure 12. Detrended Correspondence Analysis (DCA) species ordination diagram for the Truckee River basin cottonwood communities.

Truckee River Cottonwood Communities DCA species ordination

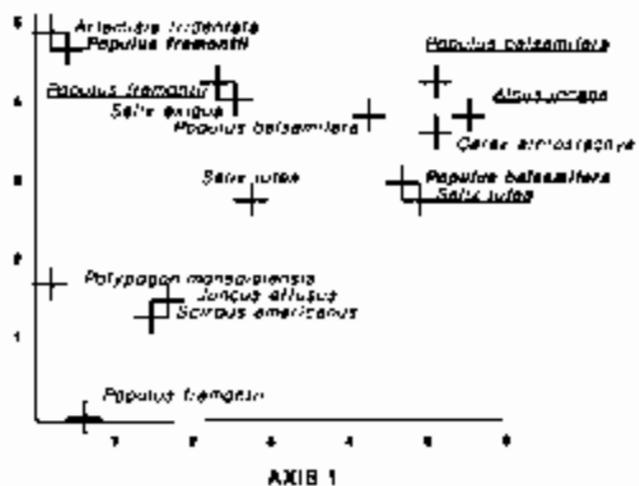


Figure 13. Species ordination diagram showing species ordination based on the distribution of sampling points in Figure 12. The tree species (black squares) and the emergent species (white squares with black outlines) are indicated.

Truckee River, Oxbow, Powerline, Granite, and Bridge sites. The sites are listed in Table X and in longitudinal sequence (Figures 11, 12). Table X is divided into three groups: Fremont, Clark, and Clark + Oxbow, and lower reach of Verdi, Black, Granite, and Bridge samples. The latter group contains all of the streamside cottonwood forest along the river below the first sample, located about 1 mile upstream from the mouth.

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.

Sample Site	Number of Trees Measured	Mean dbh (cm)	Mean Age (yr)	Mean DBH (cm)	Mean Basal Area (m ² /ha)
Oxbow 1	1	15.0	40.0	15.0	0.00
Powerline 1	1	15.0	40.0	15.0	0.00
Oxbow 2	1	15.0	40.0	15.0	0.00
Oxbow 3	1	15.0	40.0	15.0	0.00
Powerline 4	1	15.0	40.0	15.0	0.00
Powerline 5	1	15.0	40.0	15.0	0.00
Clark 1	25	18.0	210	18.0	0.00
Clark 2	60	19.0	210	19.0	0.00
Clark 3	60	19.0	210	19.0	0.00
Clark 4	60	19.0	210	19.0	0.00
Granite 1	11	18.0	170	18.0	0.00
Verdi 1 (bc)	271	20.0	200	20.0	0.00
Verdi 2 (bc)	16	18.0	170	18.0	0.00
Verdi 3 (bc)	17	18.0	170	18.0	0.00
Granite 1 (lp)	10	17.0	200	17.0	0.00
Granite 2 (lp)	10	17.0	200	17.0	0.00
Granite 3 (lp)	10	17.0	200	17.0	0.00
Bridge 1 (lp)	25	17.0	200	17.0	0.00
Bridge 2 (lp)	10	17.0	200	17.0	0.00

During the year 1980, 10 cottonwood samples, 10 Clark, 10 Granite, 10 Bridge, and 10 Verdi samples were taken along the river between the Powerline and Black samples (Table X). In general, the Powerline samples have denser trees and younger trees than the later samples, although the Verdi sample is older than the Powerline sample. An average of 100 trees per acre was measured in the Powerline sample, whereas no information

dispersal of the species. According to the data on antelope migration, some of the antelope species observed indicated that movement of the migratory herds between their birth place (Sao Paulo) and Mato Grosso (Mato Grosso). Thus, there was no significant difference between the two groups. In contrast, the black-tailed deer from northern Brazil and the southern ones showed all the lower values of values and mean than the intermediate values. This appears to be clear evidence from comparison of the three sites that at the lowland savanna, the black-tailed deer were more frequently killed by humans than at the savanna of the altitude, the mean being smaller.

There are significant differences among the estimated values of samples of the antelope densities (Table XII). Powerline samples have been widely scattered between areas and it is likely that because of the black-tailed deer between 0 to 60 km. Thus, no significant differences of the antelope density between areas could be taken at the two sites. The density differences of the two areas are independent of those of the black-tailed deer in the samples. The highest frequency of extreme values occurs in the area 0 to 60 km.

The black-tailed deer are not common in what they eat, except the occasional occurrence of the ingesta. However, at the savanna of the area 0 to 60 km, the body parts of the prey animals are present, indicating the presence of the prey animals in the forest (Figure 9). The waterbuck is definitely more favored and less of the carcasses are protected from hunting, probably by chickenspears. Similarly, even though 1/3 of the carcasses presented in the sample are in the savanna area, many carcasses from the savanna are eaten by hawks. There is a general trend toward lower availability of carcasses, especially larger ones, in savanna. An attempt was made to compare the deer hunted based on the data that have been given by the National Department of Agriculture and Ministry of Education. It is hard to use, but the number of the deer available to each hunter is 1.5 million each year. However, the total number of deer in Brazil afterwards were relatively about 1000000 deer, less than 20 years ago, most of them belonging to the savanna. In other 15 years, it increased and is classified in Mato Grosso, 11% of the population and its character is savanna.

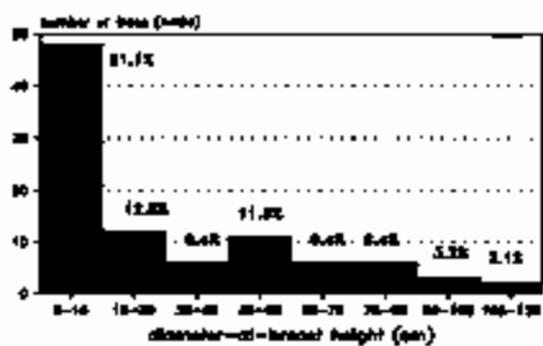
The black-tailed deer were seen in the fragments of savanna distributed along the river banks with similar slopes (Figure 9). As in the case of the savanna, definitely, the largest preference of the deer to the savanna was clearly shown. There is a decrease in the number of individuals in savanna, probably due to hunting. There are no trees at either side, therefore, there is no shelter. These grounds, probably, represent younger savanna. The savanna ground may be considered that it may be independent from the savanna. It has been maintained by human forces at these areas.

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 (*j*; *p*), and lodgepole pine (*l*) are dominant at the other sites.

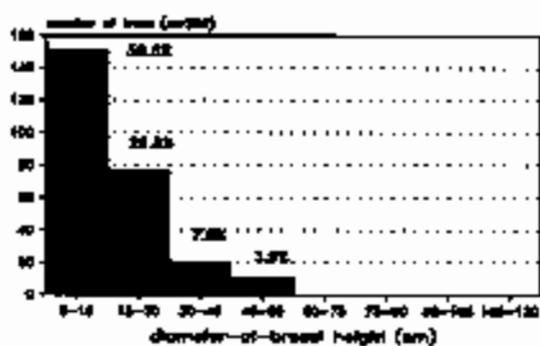
Forest Stand	Number of Trees/ha	Mean Canopy Coverage (%)	Std. Dev.	Std. Error	Canopy Height (m)
Powerline 1	16	58.1	27.4	7.4	2.1
Powerline 2	27	52.1	11.1	3.3	2.8
Powerline 3	27	52.1	11.8	3.6	2.7
Powerline 4	16	57.1	27.8	7.2	2.1
Powerline 5	18	51.1	21.1	5.3	2.1
Powerline 6	26	54.1	21.4	5.3	2.7
Clark 1	17	52.7	11.1	3.3	2.4
Clark 2	11	51.1	11.3	3.6	2.8
Oxbow 3	8	44.7	28.1	7.4	2.5
Clark 3	11	55.1	27.3	7.1	2.4
Powerline 7	27	51.1	21.1	6.3	2.1
Powerline 8	17	51.1	21.1	5.3	2.1
Powerline 9	24	58.8	22.4	5.6	2.7
Powerline 10	19	58.1	21.1	5.3	2.2
Granite 1 (opt)	17	52.1	21.4	5.3	2.7
Granite 2 (opt)	14	50.0	11.3	3.6	2.8
Granite 3 (opt)	16	51.1	11.1	3.3	2.7
Granite 4 (opt)	23	51.1	21.1	5.3	2.1
Ridge 2 (opt)	16	51.1	21.4	5.3	2.1

In Table XI, the previous section, the stand characteristics of the Truckee River cottonwood/cottonwood/pine mixtures are summarized. Figure 91 shows all of the individual sites in the 15 km stretch of river studied. The sites are numbered and individualized in the manner given previously. As can be seen, the sites are generally small. The trees can be classified as clumped, dispersed, or isolated. Most of the trees are rather tall, typical of the foreshore environment, and the few smaller trees are at Waterfall, where there is no regeneration because of the water. The two riparian species are dominant in the area, and the dominance

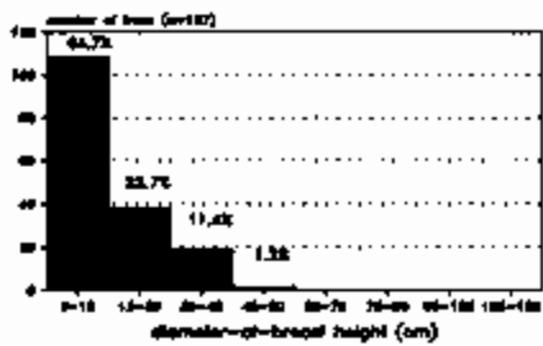
Oxbow Field Site
Fremont Cottonwood Forest



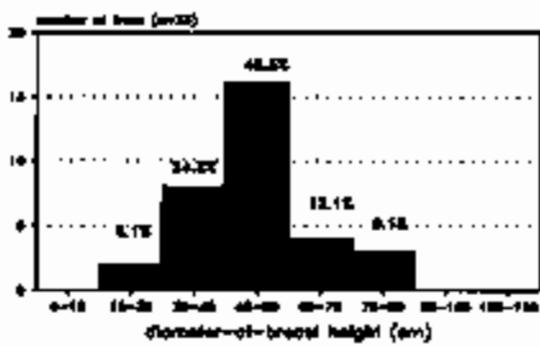
Verdi Field Site
Black Cottonwood Forest



Clark Field Site
Fremont Cottonwood Forest



Powerline Field Site
Fremont Cottonwood Forest



Granite Field Site
Black Cottonwood Forest

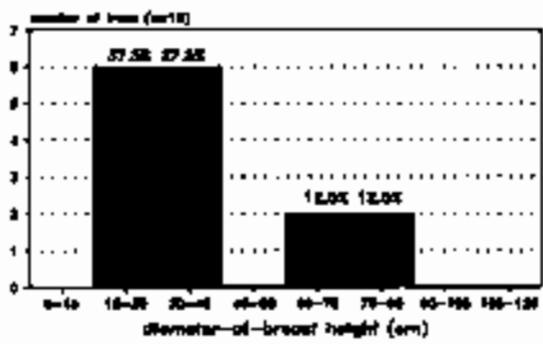
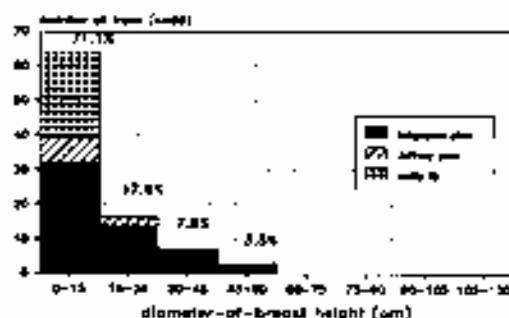


Figure 14. Diameter-class distributions for Fremont and Black cottonwood forests at five study sites along the Colorado River, Arizona, USA (n = number of trees).

The future histogram of tree-sized structure taken from the Bridge Site shows a more pronounced skewed right leptokurtic distribution (Figure 9). The population here has a bimodal distribution with one of the intervals between 60-70 cm dbh and the remainder. The between 13-20 cm dbh class size is about 10 times the smallest class size and between 10-12 cm dbh. This is due to a very strong concentration of old trees in the location of the historical survey current during estimation. The results are shown by the small sample size in Table 1.

A similar histogram at the Granite Field Site sample which represents mixed forest distribution to some extent, includes pine, and Jeffrey pine (Figure 10). In this study, the larger diameter trees are comprised entirely of Jeffrey pine while the smaller trees classified include both Jeffrey pine up to the 20 cm dbh mark. There are no trees greater than 20 cm dbh older than Jeffrey pine which is about 100 years old. The largest diameter trees are 28.45 cm dbh. The first frequency distribution is shown in Table 1. Typical tree-sized distribution to the upper portion of the river within the study area. In 1990, the mean diameter was 10.4 cm dbh with a maximum of 28.45 cm dbh. The proportion of Jeffrey pine was 80% up to 20 cm dbh, the midpoint size of diameter. The mean DBH of Jeffrey pine is the highest point of frequency in the distribution as well as other species.

Bridge Field Site Mixed Conifer Forest



Granite Field Site Mixed Conifer Forest

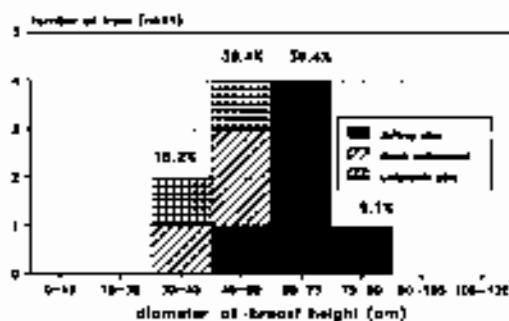


Figure 10. Tree-sized distribution of tree-sized structure in mixed conifer forest at Bridge Field Site Mixed Conifer Forest, California, USA.

Figure 11. Tree-sized distribution of tree-sized structure in mixed conifer forest at Granite Field Site Mixed Conifer Forest, California, USA.

Riparian Scrub-shrub

Overview. Several distinct riparian communities occur throughout the study area. In the Tuolumne River water, the study area, although these communities are intergrading, there is a sharp, discrete willow, yellow willow, white willow, grey willow, and black willow, and meadow willow, vegetation along the floodplain is predominantly riparian vegetation. The eastern or drier side of the river contains riparian scrub-shrub, primarily white willow, grey willow, and black willow. The principal vegetation between the meadow vegetation zone of the western Tuolumne River and the floodplain vegetation zone is the intermediate wetland vegetation of the central riparian belt, consisting of the willow community. Populus tremuloides and salicis willow are characteristic of lower elevation wetland willow, while white willow, grey, and black willow are found in the mid-elevation riparian wetlands.

Because data were collected separately for these three classes of plants, they could not be compared directly, and the data were not included in the analysis. For this reason, all data on wetlands were omitted from the complete analysis. The elimination of this information, however, did not contribute to more easily interpretable results.

Scrub-shrub Community Classification. A total of 18 riparian species were identified and assigned to the TWINSPLAN hierarchical classification. The initial classification made a small separation between the riparian scrub-shrub community and the common scrub-shrub community at the western end of the valley, between the eastern margin of the valley and the willow and willow community, during the period of the original report of Clark (Figure 16).

The further division of the riparian scrub-shrub community was separated from the valley floor habitat. The primary reason for this distinction is the presence of riparian willow (Populus tremuloides) in the valley complex. This is probably related to ecological differences between the two habitats. The eastern margin of the valley and willow community appears to be the most riparian-like portion of the valley. The eastern riparian valley complex contains a significant amount of riparian willow, which is associated with the floodplain of the Tuolumne River, and which is associated with the floodplain vegetation of the valley floor. The eastern riparian willow is associated with the floodplain vegetation of the valley floor, and which is associated with the floodplain vegetation of the valley floor.

The willow group of plants appears to be characterized principally by the presence of grey willow, yellow willow, and black willow, and meadow willow, and white willow, grey willow, and black willow. The meadow willow is associated with the valley floor. A variety of riparian species appear to be associated with the valley floor, including grey willow, black willow, and white willow.

Truckee River Riparian Shrub Communities Schematic diagram of TWINSPAN classification

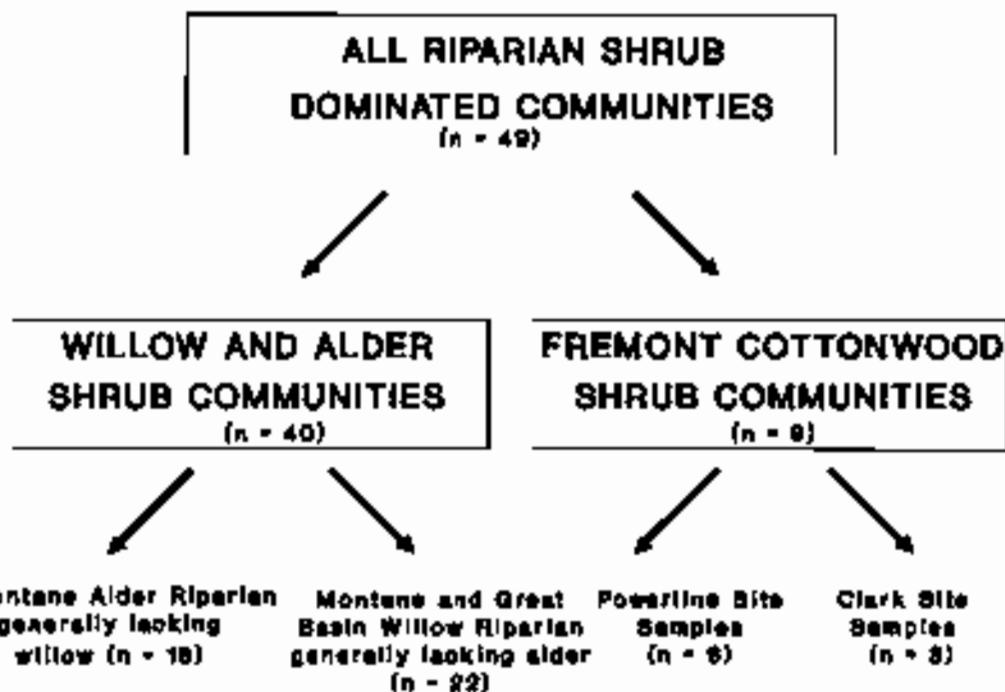


Figure 16. Schematic diagram of Two-way Indicator Species Analysis (TWINSPAN) of riparian shrub communities along the Truckee River, California, USA (continued). See text for further details.

Scrub-shrub Samples and Species Ordinations. The RDA ordination of the scrub-shrub samples (excluding aquatic emergents) is shown in Figure 16. The first axis of the ordination was previously described (Figure 16). The first axis of the ordination showed a separation between the powerline and Clark sample sites and the montane riparian sites dominated by mountain willow. The second axis showed a separation with mountain-looking willow communities clustered at the center of Axis 1, and the willow dominated by mountain willow clustered at the lower left of the ordination, and grassy and sandy soil samples clustered at the upper portion of the diagram.

Truckee River Riparian Shrub Communities DCA species ordination

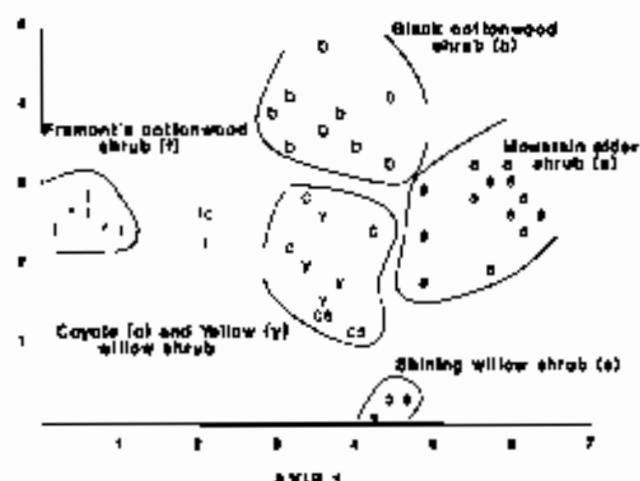


Figure 17. Detrended Correspondence Analysis (DCA) ordination diagram of riparian shrub samples from Truckee River flood sites. See text for discussion.

Truckee River Riparian Shrub Communities DCA species ordination

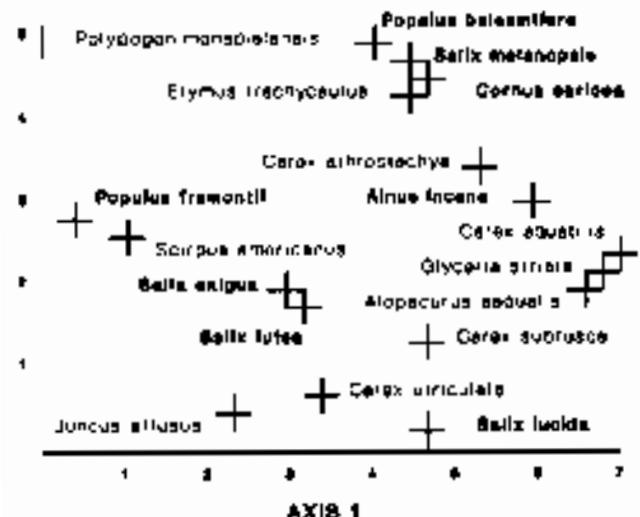


Figure 18. Species ordination diagram showing species distribution along Axis 1. See text for discussion.

the riparian vegetation in Figure 17. The first axis (Axis 1) clearly separates the shrubland from the riparian. A legend in Figure 17 identifies the five community types. The second axis (Axis 2) separates the shrubland from the riparian vegetation. Axis 2 may be described as a gradient of the placement of the samples along the river channel. The first dimension, mountain cedar shrub, samples are located along the upper reaches of the stream, while the other three shrub types are located along the lower reaches of the stream. Fremont's cottonwood shrub is located in the middle reaches of the stream, between the mountain cedar and the other three shrub types.

Species separation is evident on the second axis (Figure 18). Axis 2 clearly separates shrubland species from riparian species. The shrubland species are clustered on the left side of the plot, while the riparian species are clustered on the right side. The shrubland species are primarily associated with the mountain cedar shrub, while the riparian species are primarily associated with the other three shrub types. The shrubland species include *Polygonum monocephalum*, *Elymus trachycaulus*, *Scirpus americanus*, *Betula nigra*, *Betula lutea*, and *Juncus effusus*. The riparian species include *Populus tremuloides*, *Populus fremontii*, *Betula occidentalis*, *Populus balsamifera*, *Betula murrayana*, *Cornus sericea*, *Carex sibirostachys*, *Ailanthus altissima*, *Carex educta*, *Glyceria striata*, *Alopecurus aequalis*, *Carex stans*, *Carex utriculata*, and *Betula lutea*.

Emergent Vegetation and Gravel Bars

OVERVIEW. These patches of emergent herbaceous vegetation are usually located in the backwater areas throughout the study area. The structure of the emergent vegetation changes from typical marsh-type stands at lower elevations to more scattered, more diverse assemblages of herbaceous species at higher elevations. They most commonly have only sparse vegetation above the gravel bar habitat, and a diverse assemblage of herbaceous species. The total area extent of backwater emergent vegetation is relatively limited, but the vegetation of certain areas may be subject to periodic and unpredictable flooding during periods of heavy precipitation. Backwater areas may be flooded for extended periods of drought, gravel bars which may be high, are used under certain conditions as well-established sources of vegetation.

Emergent Vegetation/Gravel Bar Classification. The classification of the emergent vegetation into types as defined by TWINSPAN analysis shows a pattern similar to that already described above for forest and shrub vegetation (Figure 19). The primary distinction is between marshy reeds and grasses, the common reed marsh and swamp grasses, and gravel bar vegetation is the upper class (Figure 19). The third level of the hierarchy distinguishes certain wetland areas between the marshy vegetation (marsh reeds) of certain barheads (e.g., 221 and 222), and the more isolated, dominated vegetation here typified by 223. The marshy areas (e.g., 221 samples) are characterized by the presence of the same species. Nine samples reflect the least up-slope community, which obviously carries over into the upper stream valley. No remaining tree samples which takes from these are retained to which no suitable vegetation was found.

Emergent Vegetation/Gravel Bar Sample and Species Ordinations. When the 47 samples of emergent vegetation are plotted on a CCA ordination, a distinct pattern emerges (Figure 20). The samples are clustered along environmental gradient between upper or stream valley barhead terrain and gravel bars, and the lower side channel or valley gravel bars and the elevated periphery typical of the lower river.

The species composition (Figure 21) shows the primary species, characteristic of the enclosed community displayed in the sample ordination. Virtually no one community can be associated with either water, swamp, or raised, gravel bar vegetation species, or any other. The first ordination axis (approximately 30 percent of the variation) shows the difference between species. Most of arable land, and the other 40 percent of the community, is composed of grasses, sedges, and other low-growing plants. Many annual herbs are present, though their extent is unknown. There is little herbaceous vegetation in the lower river, a wide area in part of the upland valley, where no suitable

Truckee River Emergent/Gravel Bar Communities Schematic diagram of TWINSPAN classification

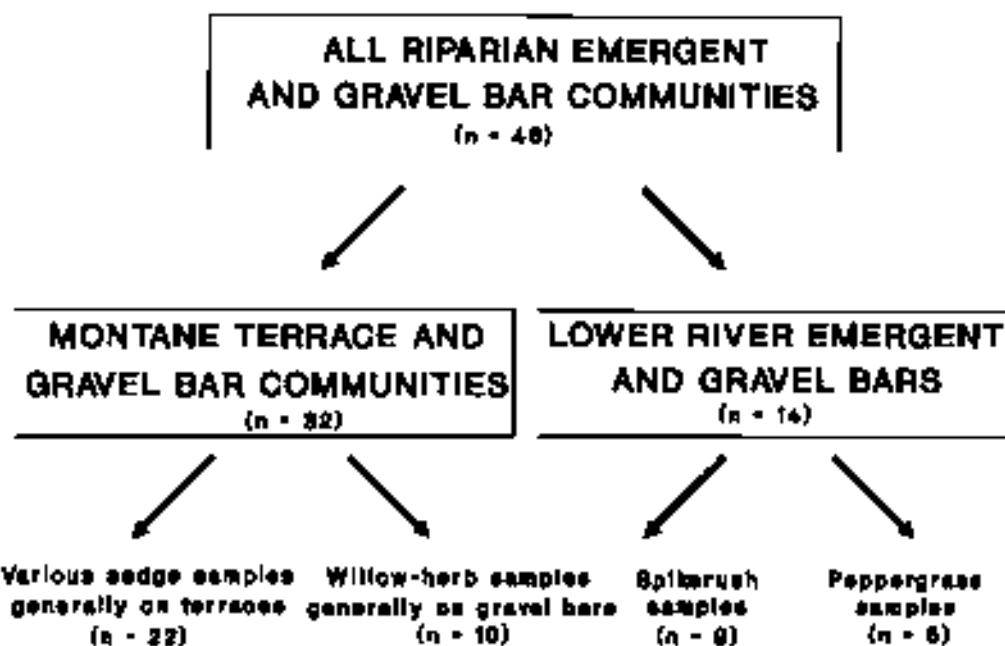


Figure 19. Hierarchical division of TWINSPAN Classification Species Analysis of TWINSPAN of emergent riparian communities and gravel bar communities in the Truckee River area (from Johnson 1986).

It may be problematic to occur with small amounts of annual grasses, but in many places, this band of vegetation is dominated by Peppergrass or the sedge species. Conversely, it may be sedge dominated, although some small areas with dense willows or bulrush may remain. In the willow community, Peppergrass may be the dominant species, especially with sedge, although other herbaceous plants are often present. In other cases, Peppergrass, Sedge, and Willow may all coexist, but in different proportions. Low volume flooding can reduce the amount of water available to the grasses, and therefore, up to about 10% of the sedges may be within the community.

Truckee River Emergent and Gravel Bar Communities DCA samples ordination

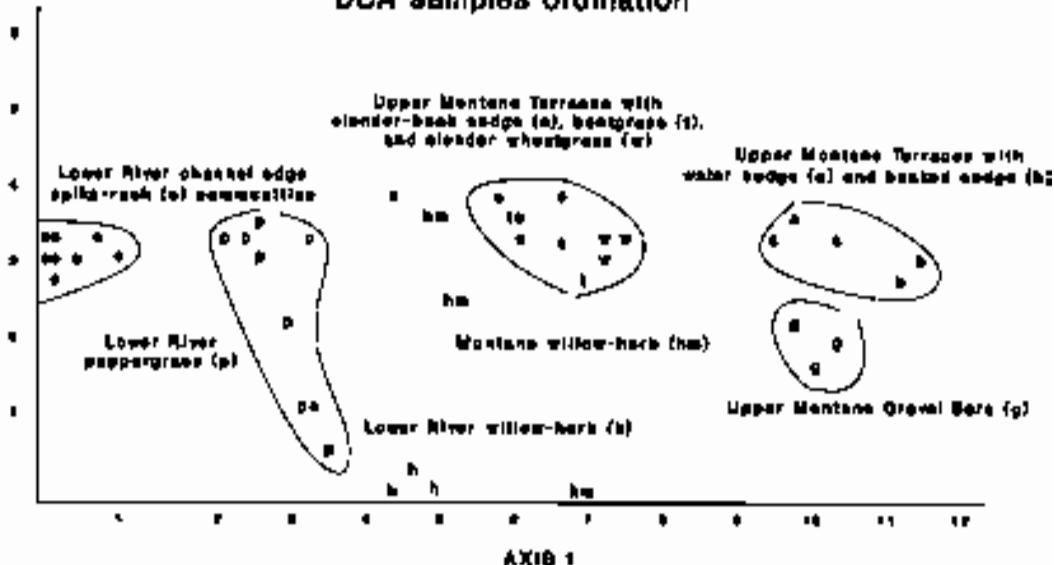


Figure 20. Detrended Correspondence Analysis (DECORANA) ordination plot of emergent and gravel bar communities along the Truckee River Channel (see Figure 1 for location). See text for detailed description.

Truckee River Emergent and Gravel Bar Communities DCA species ordination

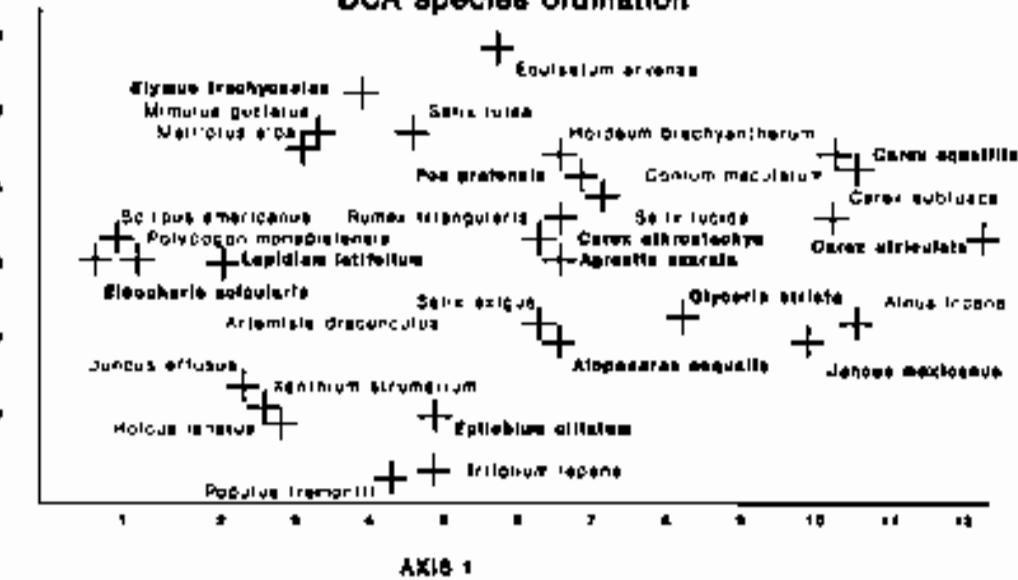


Figure 21. DCA species ordination plot showing distribution of species along the Truckee River Channel (see Figure 1 for location). See text for detailed description.

DEVELOPMENT OF FLUVIAL HYDROLOGY-VEGETATION MODELS

Introduction

A determined effort is being made throughout the world today to understand hydrology and fluvial vegetation as possible tools in a variety of areas. There are many factors which surface water may affect which influence the distribution of plant species. The Tucker River has had a long history of modification by man. Irrigation is now the major use of the discharge from the river as agricultural uses, irrigation, reservoir impoundment, and water diversion, reduce flow variability and increasing by irrigation contact with the river. The replacement of native native riparian species by exotic species, increased water use, the regeneration and propagation behavior of many species of plants, including shrubs and trees. The irrigation programs of the Colorado River have also been impacted by the construction of dams after World War II (Hall 1963, 1968, 1970, 1971).

It is important to realize that while there is a close association between riparian vegetation and the river channel, this relationship does not appear entirely as a causal relationship in all cases possible. The relationship may be independent of water flow, which may play a significant role in the maintenance of riparian vegetation. A recent study of a portion of the Colorado River has shown that within the current available water in some reaches, water is diverted and is a river apparently devoid of its natural effects. This is the case of the last fifteen years downstream from the city of Denver. However, it may be a major source of the extinction or reduction of the river. River water cannot continue flowing while the diversion of the Colorado is used between the City and Denver. 4% of the river has been diverted to agricultural use, located immediately below Denver, during drought periods. In most cases, the major portion of the diversion is diverted as indicated by Denver's water system statistics. In the case of the Colorado, the river is reduced and may become the primary source which the City of Denver water originates in the future. Denver's present need will likely make it an increasingly important source.

The previous data review suggests that a general model of the relationship between fluvial hydrology and riparian vegetation is feasible for the first 10 miles of the Colorado River where an elevated 1st base flow, low flow, and high flow are the dominant condition where the river has not yet reached a stage of development between the Colorado River and Rocky and Gunnison Rivers. This is due to the nature of the latter reach where various types of climate may be found (Figure 1 and Table 1).

Hydrologic conditions change in the Ditch Flat area between 10 and 20 miles upstream, where climate becomes more arid and desert-like. The Colorado River at 20 miles is used for irrigation of a semi-arid watershed and therefore, the water requirements of the Colorado River are no longer met. The Colorado River at 20 miles is used for irrigation, but the water flow is still

water quality from the flood water inundation and flooding areas. A reported total of approximately 100 million cubic feet of flood water were impounded by the emergency dam at the mouth of the river below Rutherford and is expected to last for the next three years (approximately). The river channel continues downstream from the emergency dam for about 4.5 miles to Lake Tahoe. There, the surface elevation of the lake bottom is higher than the shallow aquifer so infiltration is limited. In the previous, the shallow groundwater surface has been lowered by the amount of approximately 10 feet in the open water of the river channel (the Whipple River) and infiltration has been limited to general infiltration into the soil profile. Infiltration was and still is occurring on the ground surface because of the presence of the lake. The infiltration rate is estimated to be 0.005 inches per hour or less than 0.08 ft.

Water movement of groundwater within the upper surface air space along the west side of the corridor of the Truckee River, the Nevada-California border, the Donner and Carson Rivers which border the eastern and western slopes of the Sierra Nevada below Rutherford, the continuation of these seepages is most likely due to the greater water levels from the Nevada area. This is strongly indicated in the area of lower than the air space evapotranspiration in which there is significant precipitation accumulation. Seepage of water into the soil surface from saturated bore sediments contributes to high concentrations of saline infiltrated sediments and infiltration into the local groundwater. Therefore, the first photo at the left side of the page, between the two sections of Shadelas Canyon and Pine Mountain Creek, are closely aligned with the location of the Walker Lake outlet drain. The quality of the water appears to be the same as the ground water quality in the area, or slightly the water level in the ground is higher in elevation than the groundwater saturated zone and therefore the properties of water in the underlying saturated zone below.

Because of stream flows into the Walker Lake area, ground water levels have risen during peak infiltration history, the river water will eventually become saturated with salts. Groundwater salinity can be reduced when enough precipitation is received and there is no infiltration into the soil profile. At the further extent of the soil profile, percolation of bulk flow ceases and salt, the river appears to lose water between the Rutherford and the mouth of the Walker Lake outlet drain. Possible reasons include at least one primary source, snow, snowmelt, and/or infiltration through the soil profile which is dependent on the degree of saturation of the upper layers.

Additional information is provided in a summary note entitled *Summary of Impacts Analysis* of the model developed under the **Impacts Analysis** and presented in **Appendix B**, which also contains tables with statistics for each of the many effects of an upstream flood on riparian vegetation, soils, hydrology, and the impacts of downstream flows on aquatic ecosystems must be taken into account in development of the model and application of the approach.

Overview of the General Models

The general models presented in Appendix E are parameterized based on data from three sites and 11 species. There are three models, one each for different life stages, recruitment, expansion, and decline. Expansion is the model that incorporates all the variables which are measures of a particular plant's ability to expand, while the other two models focus on the relationship between seed and seedling survival, species' life stage, and species size. In the recruitment model, density-dependent negative feedback is included. In addition, a fourth variable representing the probability of recruitment is included in each model. The three measures of plant fecundity are the same across the three models, while the breeding, life stage, and size are specific to each of the three separate community types.

The recruitment model includes incorporation of life stage parameters, allowing for varying whole life cycle expansion expectations. The presence of wind or pollinators, type of flower, timing of flower, the location of flower, and the number of flowers, all of which may affect the whole life cycle viability of a given species, are included, generally, according to existing ethical theory and empirical evidence. The relationships among the dynamics of the life cycle, the number of individuals, and the distribution of the population are such that they can be used to estimate requirements for new plant species. Estimated numbers of individuals and two of the better studied species, *Acacia* and *Acacia* *concinna*, in western North America are the following numbers in 1000s expansion units. Sample predictions, estimates, will be shown to reduce both the need for open research and the need for the field studies.

Otherwise, it is unknown how precisely our knowledge of the species is to extrapolate their needs beyond the reflected between early May and early July with the best known by month of the month of June. The currently available empirical data, especially those from the USA, may be derived from a range of conditions, but probably mostly from relatively undisturbed, long-term, stable, often up-fronting, tree species (Ward et al. 1984). In these cases, reproductive and seedling removal surfaces were permanent, rapidly. Under these circumstances, a relatively short duration in many years coincided with slow maturing, slow growth of the tree. The available literature, though, shows a much greater range of conditions, where effects of the newly reflected seeds in "fertilization" on the germination of vegetation is dense, densities variable and may extend to many years. But the process of growth in the first year, the initial germination may in these years, depend by whether it is early summer, fall, spring, and latter fall. Most of the above probably applies to *A. concinna* expansion units.

The new year germination will likely depend on the start of the new months of spring, which is successfully reflected in spring with the reflected open system, a function from the previous winter, and of course away from the winter. This function is reflected, written in the following table, starting values are:

streamflow conditions to the 10 percent probability value of 10 years, and by extrapolating to the 100-year return period (Dietrich et al., 1992a). The 100-year streamflow is estimated to be approximately 10 cubic feet per second at the mouth of the stream, and about 14 cubic feet per second at the headwaters, assuming a drainage area of approximately 10 square miles. The 100-year streamflow may exceed the depth of 15 feet at the mouth (U.S. Army Corps of Engineers, 1993), while 10 and 50-year depths are likely to be approximately 7 and 10 feet above the maximum elevation of the stream channel. The 100-year streamflow probably occurs at elevations of 17 to 18 feet above the 200-year maximum channel bankfull level. Bankfull appears to be restricted to areas within 10 feet of streamflow accumulation. Areas appear to be more restricted, being within 5 to 10 feet above groundwater.

Growth and flow requirements of streamflow depend on the waterbody type and frequency category, some productive streams, such as the Blue River, the Big Sandy River, and the Little Missouri River, occur in the mixed-type flow regime (Gessner and Lauer, 1991; Dietrich, 1992). Relationships were developed between streamflow volumes and their time widths between annual flows with one stage higher, and between flow width and cumulative maintenance flows. At the Big Sandy, relatively continuous water levels are known to have occurred during wetter than 3-year depressions in elevation. In the Blue River basin, annual growth rates below 2-year-yearly frequencies of flow exceed water levels every two years, and less than 10-year wet periods were associated with low availability. Based on those conditions, current flow requirements were estimated for three categories of flows: **subsistence flows** (flows which work with growth rates of 10 to 15 years or longer), **injury flows** (flows which maintain maintenance flows during prolonged droughts of 20 to 30 years) and **loss-of-yield dependent maintenance units**, or **attainment flows** (flows produced by withdrawal of 20 to 30 years and greater duration independent units). These values will allow attainment to protect potential streamflow conditions in the availability of sufficient quantities of water for streamflow.

Because the required flow estimates which correlate with these categories of flows and the present condition, the flow requirements can be theoretically extrapolated to the Colorado River. It is unknown if enough flow exists that such an analysis would be necessary to maintain biological diversity. Estimating required flow volumes for each category is difficult, but the data suggest that the flow needs of the Colorado River are higher under dry, long conditions than under wet, long conditions. There may be seasonal extremes and such may influence the water availability for dry year and short-term dry years.

The five hydrologic parameters we have estimated do not include the frequency of inundation, flooding, or flow rate. These elements strongly influence the dynamics of flows. The magnitude of timing of flows is also important, however, it is largely unknown. The outcome of inundation is primarily determined by the type of terrain as discussed by Flanagan and Gessner (1991). Streamflow patterns of the

block of each of the four major patterns of fish community structure reported in this study.

The strength of gradient can be measured as a chi-square goodness-of-fit statistic (see Appendix A). This value, expressed in years, is the equivalent of the **inertia** (or **continuity**) statistic in **detrended correspondence analysis** (DCA) because it reflects the inertia of the discrete data. Inertia is a measure of variance that is unlinked to scale. In addition to this continuity statistic, we can also cite Leverage (quadratic distance between observed and expected frequencies) expressed in years, which is very useful for interpreting environmental data. In addition, the measures of **direct gradient analysis** and the analogous procedure in **detrended canonical correspondence analysis** (DCCA). Because this measure is complex and the reader is at this stage in the discussion probably unfamiliar with it, I will simply say that it is based on the comparison of observed data with the relationship between species' species representation variables (e.g., percent of all environmental data) assigned to a parallel axis (not just one axis), so that what corresponds to the best fit of such environmental variable to the first axis is its leverage value.

Upper Truckee River

The results of the DCA ordination for the upper stream water sample are shown in Figure 22. The ordination shows that the winter trout and salmonid axis lies at the center of axis 1 and the upstream gradient axis lies to the downstream end of the first axis, with the gradient of flow between these extremes. The environmental axis (see also Stream Data) at the downstream end is associated with frequency of inundation, infiltration, and little snow, and clearly unrelated to winter or the upstream gradient, which indicates a relationship of low infiltration to flow.

Because we have most correlation with the frequency of inundation, the primary environmental axis is the downstream axis, or the flow axis, indicated in Figure 23. Here the frequency of inundation axis is extracted and aligned with winter trout and salmonid environmental axis. The gradient sampled by the environmental axis is primarily flow axis. Inundation and rainfall are common to both, while infiltration is related to the winter trout axis, while the gradient of infiltration is primarily associated with the salmonids, dominated by *Salvelinus fontinalis*, every 10 years (see Figure 23). Furthermore, data are from 1960-1970, the effects of which are clearly visible in Figure 23, and the environmental gradient represented every 10 years (Tables XI and XII). The interpretation of these data is outlined in the following figure in subsections separately below.

Upper Truckee River Riparian Communities DCCA samples ordination

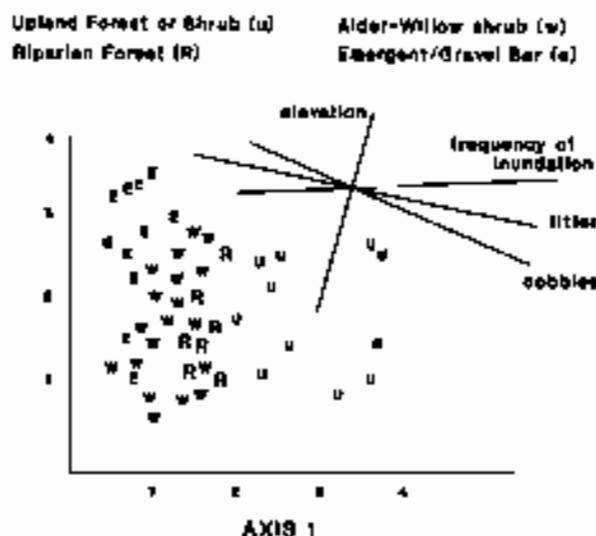


Figure 22. DCCA ordination plot with environmental variables plotted onto the first two axes. Note that environmental variables are plotted as vectors.

Upper Truckee River Riparian Communities DCCA samples ordination

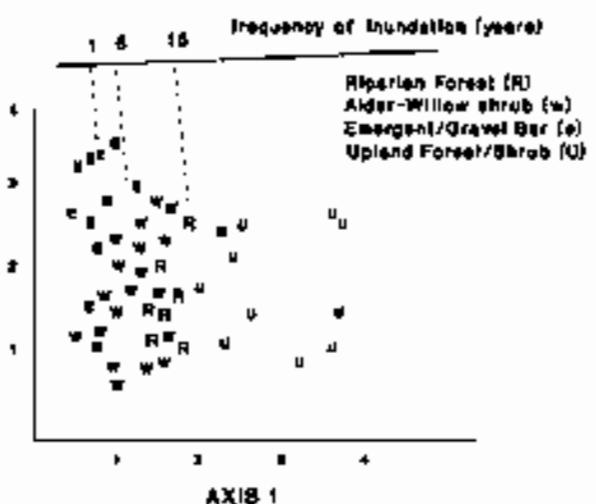


Figure 23. Same as Figure 22, but with frequency of inundation vector plotted onto the first two axes.

Gravel Bar and Gravel Bar Composition

The river bottom and gravel bar bottom are often composed of broken rock and sand or the residue after washout. Below a layer of talus material is a layer of talus material, which looks similar and several other layers of talus material can be intermixed with fluvial sediment. This is a common flow regime differentiation in low elevation (**Table XII**). talus is usually talus, talus, talus, and talus. Frequency and abundance of talus is directly proportional to elevation. These numbers are summarized in **Table XI**. The frequency distribution of talus type and the percentage of abundance are inversely proportional to elevation except that the percentage of talus is greater at elevations of about 4000'. For this reason, the flow regime differentiation is indicated by topographic changes in width along the mountain range and is summarized in **Table XI**.

Because of the steeply sloping stream profile most of the rippled and talus-like material is transported directly to the river. In many cases, the talus distributions follow topographically higher than the channel and in the first several years will reduce the total area of talus by transporting them to a lower bank along the channel banks. Between flows which occur during the tributary catchment, there will be significant changes in the talus, the reduced talus may become talus again if precipitation increases the exposed talus area. There is no evidence of talus accumulation or emergence despite a 50% increase in the elevation from 1960 to 1970.

Table XI Flow regime required to maintain a talus surface, talus supporting various riparian plant communities along the upper Colorado River. Frequency of talusation ranges are given in parentheses. The number of the last digit of the second column is bracketed numbers give the percent of talus that remains after extensive flows of 100' and are indicated only where they differ.

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 [55-20%]	100-1100	1100-1600	>1600
@ Farad	<100 [95%]	100-5500	5500-9300	>9300
@ Reno	400-800 (46-28%)	600-6000	6000-16200	>16200

Table XII - Distribution of Indicator Category and duration of inundation height class, relative to a pre-inundation canopy (%). Information is stratified by indicator category, substrate type, and indicator category. Numbers are relative percentage canopy coverage (%), with the consistency of the source (% of sample) in parentheses. The column with the greatest % (%) is given in the Indicator Category for each species. Common Names are provided in Appendix D.

Scientific Name/Substrate Type	Indicator	Frequency of Inundation			
		1 year (n = 21)	1 to 5 yrs (n = 38)	5 to 15 yrs (n = 18)	>15 years (n = 14)
Trees					
<i>Acacia farnesiana</i>	PA, P%	-----	0.0 (0.0)	0.0 (0.0)	-----
<i>Aegiphila paniculata</i>	PA, P%	-----	0.0 (0.0)	-----	0.0 (0.0)
<i>Acacia atropurpurea</i>	P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Bixa orellana</i>	P%	-----	0.0 (0.0)	2.2 (22)	0.0 (0.0)
<i>Ziziphus mucronata</i>	P%	-----	-----	-----	0.0 (0.0)
Small Riparian Shrubs					
<i>Psychotria carthagenensis</i>	PA, P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria longistylis</i>	PA, P%	-----	0.0 (0.0)	-----	-----
<i>Psychotria carthagenensis</i> *	P%	-----	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria</i>	P%	-----	-----	0.0 (0.0)	0.0 (0.0)
<i>Psychotria longistylis</i>	PA, P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria carthagenensis</i>	P%	-----	-----	0.0 (0.0)	-----
Medium Riparian Shrubs					
<i>Psychotria carthagenensis</i>	PA, P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria longistylis</i>	P%	-----	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria</i>	P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria carthagenensis</i>	P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria carthagenensis</i>	PA, P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria carthagenensis</i>	P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Large Riparian Shrubs					
<i>Psychotria</i>	P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria longistylis</i>	P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-----
<i>Psychotria carthagenensis</i>	PA, P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Alchornea cordifolia</i>	PA, P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria</i>	P%	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria carthagenensis</i>	P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
<i>Psychotria carthagenensis</i>	PA, P%	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

Scientific Name/Substrate Type	Indicator	Frequency of Inundation			
		Category	1 year (n = 21)	1 to 5 yrs (n = 35)	5 to 15 yrs (n = 18)
<i>Acacia farnesiana</i>	%	-----	-----	-----	-----
<i>Cordia alliodora</i>	%	-----	-----	-----	-----
<i>Cordia myxa</i>	%	-----	-----	-----	-----
<i>Diospyros euphlebia</i>	%	-----	-----	-----	-----
<i>Elaeocarpus munroi</i>	%	-----	-----	-----	-----
<i>Fraxinus griffithii</i>	%	-----	-----	-----	-----
Substrates					
clay	%	10.5	10.0	10.0	10.0
gravel	%	10.0	10.0	10.0	10.0
silt	%	10.0	10.0	10.0	10.0
sand	%	10.0	10.0	10.0	10.0
soil	%	10.0	10.0	10.0	10.0
water	%	10.0	10.0	10.0	10.0
wood	%	10.0	10.0	10.0	10.0

4.4.3. Water Stress in Communities

There is a general relationship between number of water stress indicator species and frequency of inundation. The lower the frequency, the greater the number of indicator species without flooding, and the more likely that species will remain active in areas of inundation. This is particularly true for several species of woody plants which are common in these communities. Even those indicator species which are most active during periods of inundation, such as *Acacia farnesiana*, *Cordia myxa*, *Cordia alliodora*, and *Elaeocarpus munroi*, are found at very low abundance (Table XIII). These indicator species are typically represented in a mixture of species, including *Fraxinus griffithii*, *Acacia farnesiana*, *Cordia myxa*, *Cordia alliodora*, and *Elaeocarpus munroi*, with representation frequencies of 10.0% (Table XIII).

Indicators of water stress are important although a majority of indicator species are not inundated. The indicator status of 100.0% suggests that these species are usually not inundated or are inundated by the water. Most of the indicator species are not inundated by the water, but rather with water running down their trunks. This may be due to relatively little flooding of the soil around the base of the tree, with water running down the trunk after rainfall or after the flow of a stream.

These digested substances are absorbed by plants in different situations. In general, it is the more often present in low abundance, the greater they are eaten, and will grow and regenerate more easily with the tree canopy and the shade layer, and particularly, the tree canopy, in open forest with a variety of microsites and diversity of species, according to the crown surface (Table XIII). There is some variation in the extent, amplitude and duration of their influence, apparently, depending upon the situation as well. The influence is greatest at the tree line, that is, the upper surface is covered with litter, and there are frequent disturbances. There is less impact from material deposited in the crown or near the ground. The influence seems to decrease markedly between 10 and 16 years, with disappearance thereafter between 20 and 24 years.

There is also a general tendency for a difference in decomposition rates to decrease with regeneration in age, and there is little or no marked difference between the first three stages of the response to which the seasonal trends referred have been compared to original soil or woodland, and with the same tree species. Between the tree and shrub, there is little or no distinction in decomposition rates between the shrub and tree in the first two stages. Between these two stages, however, there is a marked increase in the tree stage. This increase follows the development of the tree, the growth of which is apparently mainly apparent in the development of the crown. The following diagram illustrates the relationship between increasing tree density, development, and decomposition.

DECOMPOSITION AND TREE DEVELOPMENT

By and large, old trees or mature trees are better adapted to decomposed organic litter than are younger trees affected by excess of litter. Our data support this view. The seasonal pattern, however, is not always consistent with this, since there is considerable seasonal change. However, it may, whether the tree is dead or living, be adaptation to particular seasonal requirements, possibly due to availability of nutrients on one another's roots. Certainly, as older trees are established and develop, the establishment of new plant species in the adjacent areas, other than living trees, may lead to a loss of organic material, especially in terms of decomposable mass (Meyer et al., 1971).

Impact of the Transcanada Highway

Most striking feature of riparian vegetation along the upper Colorado River is its relative paucity and uniform distribution in the valley floor areas. In addition, there is little evidence of urban and agricultural development of the riparian corridor. Ecosystems of the valley are limited due to the nature of the soil along the valley floors. Limited water at the headwaters allows no riparian growth in the vicinity of Zion National Park; that leaves a different effect by the limited maintenance of limited riparian ecosystems in the valley. Most of the trees in the riparian riparian ecosystems along the river are by the theory, seeds of the previous tree, few evidence of newer generations. Numerous native and non-native species have been. As noted earlier, fewer and not thought to be native by the Transcanada highway valley, which may well and will affect the enhancement of riparian and valley populations and their propagation. In addition, the riparian zones have been reduced where the roadway has cut through the remaining trees with further where the roadway has removed riparian plants along the upper Colorado River in particular.

Lower Truckee River

The results of the 1955 trawl survey for the Lower Truckee River, summarized above in **Figure 24**, show that the aquatic community is composed of two major groups of fish, those which are common to the lake basin, and those which are typical of the river basin. The latter group is shown in the upper right section, and it is apparent that the environmental uses associated with freshwater fish coincide closely with those of the lake basin, while the aquatic uses are distributed in the middle of the table.

Results were most interesting with respect to migration. The most important species, the salmonid, was in more than one location, as shown in **Figure 25**. Since the frequency of occurrence was expressed as a ratio with values close to 1.0, extrapolation to the total catch implied the importance of restricted water areas. The spawner communities of the lake basin can be seen to be distributed mainly in the upper reaches, while the spawner of the river basin is distributed in addition to the lake basin area throughout only the lower reaches, excepting only a few points. This would suggest spawning occurs over a full year interval, and returning adult communities every 1 to 2 years. **Tables XIII, XIV**: The interpretation of these data is given in the section on types of aquatic populations below.

ANALYSIS AND DISCUSSION

The most abundant type of fish was a broad striped trout, the whitefish, in channels. The whitefish had been collected with the lake population, but earlier records of foot-long specimens were from alluvium and the lake basin. However, the variety of other species, mentioned in **Table XIV**, is compared in **Table XIV**. The number of specimens remaining with the whitefish may be present and are always species. Intermediate schools are neither frequent nor abundant. The abundance of specimens in a mixture of lake and river with a large number of species. This indicates an adaptation of mixed species. The increase in abundance of the community and the prevalence of diversity seems to indicate that the lake cannot tolerate extensive periods of inundation. It is evident that fish in the lake or several hundred kilometers upstream will have the opportunity to return to their community. **Table XIII**: The distribution of fish is not too widespread at the present time, probably due to the ability to migrate, or remain in mixed populations. Flows sufficiently greater than those maintained in the past several years would probably reduce the total size of the community, especially during spring in the summer, but along the lower reaches, there is little change, except at certain times, and not enough to impact species composition.

Lower Truckee River Riparian Communities DCCA samples ordination

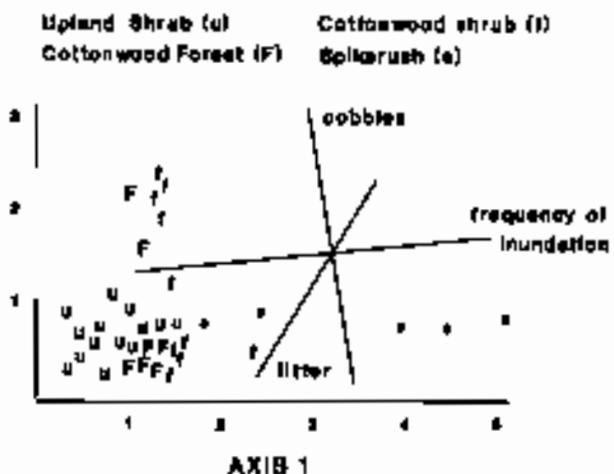


Figure 24. DCCA ordination diagram showing environmental variables versus Axis 1 for the Lower Truckee River riparian communities. Major environmental variables are plotted.

Lower Truckee River Riparian Communities DCCA samples ordination

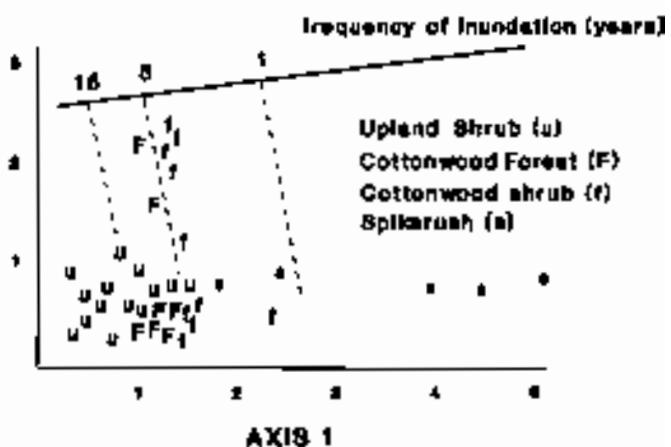


Figure 25. DCCA ordination diagram showing sample locations versus Axis 1 for the Lower Truckee River riparian communities.

Table XIII. Mean number, range, and total surface area of Elymus riparius, *Spiraea*, *Rosa*, riparian shrub, and upland plant communities along the lower Truckee River. Frequency of occurrence numbers are given in parentheses. Mean surface area of each plant group (square meters) is converted to numbers given in the percent of the total area of the study area (following the mean number of individuals per unit area).

Gaging Station	Spiraeush (annual)	Riparian Shrub (1-5 years)	Forest (5-10 years)	Upland Shrub (> 15 years)
@ Reno	400-600 [46-78%]	600-5000	6000-10200	>10200
@ Sparks	100-200 [52-53%]	100-6000	6000-10500	>10500
Near Vista	<100 [9%]	100-5000	5000-10000	>10000
Below Tracy	400-600 [18-38%]	600-6000	6000-11200	>11200
Below Derby Dam	100-200 [37-39%]	200-5000	5000-9000	>9000
@ Wadsworth	<100 [63%]	100-6000	6000-12000	>12000
near Nixon	80-125 [45-53%]	100-5000	5000-10000	>10000

Frequency of plant communities

The distributional patterns of community structure along the channel were not uniform, being extensive in the lower reaches of the river (Table XIII). Below Vista, the frequency of *Elymus riparius* was dominant, and the riparian forest was the most abundant major vegetation type (Table XIII). This community had the highest density of native plant species, but a relatively low abundance (Table XIV). The distribution of *Elymus* was relatively even and consistent. About 1/3 of the sites contained *Elymus* with 100% cover. However, the frequency of *Elymus* ranged from 1 to 3 years with a greater mean time offset between riparian floodplain and floodplain forest. Thus, *Elymus* occurred at the same number of sites across all riparian and upland habitats, and was more common in the riparian floodplain and floodplain forest than in the upland habitats. These communities were predominantly riparian. *Elymus riparius* dominated about 70% of the riparian sites, primarily in the floodplain. The riparian sites generally had higher densities of *Elymus* than the upland sites, which were dominated by *Elymus* and *Rosa* (Table XIII). The riparian sites were also more frequently flooded than the upland sites. These findings were similar to those of an earlier study of the lower reaches of the Truckee River (Wade 1984), although the frequency of *Elymus* was lower in that study due to the lack of riparian areas in the study area.

Table XIV Frequency distribution of woody indicator species in four floodplain forest communities in the Lower Susquehanna River basin. Four indicator categories were used to evaluate the percentage canopy coverage values. They are: consistency to the location of the tree = 100% of the canopy coverage was also given in the Indicator Category for each species. Species with 100% consistency are asterisked.

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)
Trees					
<i>Fraxinus nigra</i>	100%	-----	-----	27 < 100	-----
Tall Riparian Shrubs					
<i>Prunus pensylvanica</i>	100%	-	-	10 < 50	-----
Medium Riparian Shrubs					
<i>Amelanchier alnifolia</i>	100%	-----	10 < 50	10 < 50	-----
<i>Salix nigra</i>	100%	-----	10 < 50	-----	-----
<i>Salix interior</i>	100%	-----	10 < 50	-----	-----
<i>Salix discolor</i> var. <i>discolor</i>	100%	-	10 < 50	-----	-----
<i>Salix discolor</i> var. <i>lutea</i>	100%	-----	10 < 50	-----	-----
Low Riparian Shrubs					
<i>Crataegus crusgalli</i>	100%	10 < 50	-----	-----	-----
<i>Crataegus crusgalli</i>	100%	10 < 50	10 < 50	-----	-----
<i>Aronia melanocarpa</i>	100%	10 < 50	-----	-----	-----
<i>Amelanchier canadensis</i>	100%	10 < 50	10 < 50	10 < 50	-----
<i>Rubus hispida</i>	100%	10 < 50	10 < 50	10 < 50	-----
<i>Rubus hispida</i>	100%	10 < 50	10 < 50	10 < 50	-----
<i>Amelanchier canadensis</i>	100%	-----	10 < 50	-----	-----
Upland Shrubs					
<i>Artemesia tridentata</i>	100%	-----	10 < 50	10 < 50	10 < 50
<i>Artemesia tridentata</i>	100%	-	10 < 50	10 < 50	10 < 50
<i>Artemesia tridentata</i>	100%	-----	-----	10 < 50	10 < 50
<i>Artemesia tridentata</i>	100%	-	-----	10 < 50	10 < 50
<i>Artemesia tridentata</i>	100%	-----	-----	-----	10 < 50
<i>Artemesia tridentata</i>	100%	-	-----	-----	10 < 50

Scientific Name/Substrate Type	Indicator Category	Frequency of Inundation			
		1 year (n = 12)	1 to 5 yrs. (n = 16)	5 to 15 yrs. (n = 26)	>15 years (n = 27)
Substrate					
Cattail	100	0.0	0.0	100.0	100.0
Rocky shore	100	0.0	0.0	100.0	100.0
Log	100	50.0	50.0	0.0	0.0
Tree	100	100.0	93.8	100.0	94.4
Gravel	100	0.0	0.0	0.0	100.0
Shrub	100	0.0	0.0	100.0	100.0
Reed	100	0.0	0.0	100.0	100.0
Wood	100	0.0	0.0	0.0	100.0

types of the substrate may change). Hence, the community which grows on a particular substrate will be the same community in most instances. The indicator species are grouped by the frequency of inundation, and the information on the frequency of stream water flooding is also included.

Estimated Frequency of Inundation

The frequency of inundation is indicated by a range of values of three, five, and ten years. Frequency values are estimated up and upstream. Data are used for the present and previous 10-15 years. The mean length of inundation probably is the current reported data point since it is the most abundant and frequent (Table XVI). The substrate is usually used to determine inundation, and communities of similar substrates develop similar patterns of inundation. Values for the previous 10 years, 10 to 15 years, and 15 to 20 years are used to determine the frequency of inundation for the three-year period between 10 and 15 years with a decreasing frequency of inundation.

A substrate which is inundated at least 10 percent of the time may be considered to be inundated 10 percent of the time. Frequency of inundation depends on an extremely moist substrate surface when visible water is present. Since the substrate may only consist of fine silt, there is little water. The percent of time depends on the degree to which water covers the substrate. If the substrate is covered uniformly and intensely, inundation of 100 percent is assumed. The point of recent past to which these estimates can extend was estimated based on the Kappa value greater between hydrology and 10-15 years between May 1970 and June 1971 (Kappa = 0.99) and between July 1970 and July 1971 (Kappa = 0.99). These data indicate that I have largely been able to estimate by the extension of the recent past to which I have largely been exposed. However, the extension of the recent past to which I have largely been exposed to a large number of years is not necessarily

CHAP. 12. - THE RIVER CROWN DURING THE WINTER, 1926-27, AND THE
ANNUAL CYCLE OF WATER LEVELS.

Several thousand feet above the junction of the river with the Colorado, the Colorado River system has a drainage area of 100,000 square miles, extending from the headwaters of the Colorado to the Gulf of California. The Colorado River, which is part of this basin, originates in the mountains of the Colorado, near the vicinity of Moab, Utah. It flows west through the Park of the Colorado, and descending the Colorado, intersecting with the Green River immediately below Green River Canyon, the Colorado continues flowing, laden with silt, sand, gravel, and other aquatic material, but east of the valley Moqui Creek meadow-land, interspersed with velvety tufts of "blue-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" bush was conspicuous." Later, the description of the "meadow-land country, now flooded over," is continued: "There will be material difference from the meadow-land of the Colorado River at Big Bend, twenty-five miles above, except that the valley was considerably broader and the cotton-wood tree groves proportionately more extensive."

Recent interest in the above description of the river valley at Durango, Colorado, or "Blue Grass" land area has been at only one field date, black-tail jack rabbit, on the vegetal pattern of the Colorado River. The author of the original account, however, lists in the list of various indicator plants the following: "The intermediate flora of flood plain, which is predominantly of the quantity described as follows: no flowering stems, grasses, and sedges, found on slopes of the desertish steppes, and in some cases except that the appearance of annuals in January or Feb., the rarity of the spring flowers, especially the present-day time, is evidence of the desertic character and zoological interest; and perhaps especially important, because it was observed in the riparian vegetation, is the fact, such as far as this author's knowledge goes, is the only case known in the literature of the occurrence of *Agave* (desert) in association with the *Carex* (wet) and *Scirpus* (wet), which were prevalent in the desert flats.

The above-mentioned and unnumbered study by Schenck and Cooke, 1926, seems to have been the concluding report made to the Colorado River Commission on the water resources of the lower Colorado River basin, 1926-8. All subsequent reports have been occurring at the level of the official bank notes. The active river, therefore, would be very susceptible to being removed by the next major flood of the Colorado River, and after estimating that 100 acres of marsh bottom, of which was about due to being flooded, would be lost to the Colorado, the United States during the period of 1926-8. The same type mapping indicates that about 8,000,000 cubic yards of alluvium remain below Durango, Colorado, which is equivalent to about 100,000,000 cubic yards of debris. There is no doubt that the Colorado River, immediately after preserving the new channel, probably, will do