Candidates

Oncorhynchus kisutch - coho salmon, Lower Columbia R./SW Washington ESU
Oncorhynchus mykiss - steelhead, Oregon coast ESU
Rana luteiventris - Columbia spotted frog
Rana pretiosa - Oregon spotted frog
Spermophilus washingtoni - Washington ground squirrel
Polites mardon - Mardon skipper (butterfly)

Fish Species of Concern

Acipenser medirostris - green sturgeon
Catostomus occidentalis lacusanserinus - Goose Lake sucker
Catostomus rimiculus - Jenny Creek sucker
Catostomus snyderi - Klamath largescale sucker
Cottus bendirei - Malheur mottled sculpin
Cottus marginatus - margined sculpin
Cottus tenuis - slender sculpin
Gila alvordensis - Alvord chub
Gila bicolor ssp. - Catlow tui chub
Gila bicolor ssp. - Summer Basin tui chub
Gila bicolor eurysoma - Sheldon tui chub
Gila bicolor oregonensis - Oregon Lakes tui chub
Lampetra ayresi - river lamprey
Lampetra minima - Miller Lake lamprey
Lampetra tridentata - Pacific lamprey
Lampetra tridentata ssp. - Goose Lake lamprey
Lavinia (Hesperoleucus) symmetricus mitrulus - California roach
Oncorhynchus clarki clarki - coastal cutthroat trout
Oncorhynchus clarki lewisi - westslope cutthroat trout
Oncorhynchus mykiss ssp. - inland/interior redband trout
Oncorhynchus mykiss ssp. - Catlow Valley redband trout
Oncorhynchus mykiss ssp. - Goose Lake redband trout
Oncorhynchus mykiss ssp. - Warner Valley redband trout
Oregonichthys kalawatseti - Umpqua chub
Rhinichthys cataractae ssp. - Millicoma dace

Amphibian Species of Concern

Ascaphus truei - tailed frog
Batrachoseps wrighti - Oregon slender salamander
Plethodon elongatus - Del Norte salamander
Plethodon larselli - Larch Mountain salamander
Plethodon stormi - Siskiyou Mountains salamander
Rana aurora aurora - northern red-legged frog
Rana boylii - foothill yellow-legged frog
Rana cascadae - Cascades frog
Rhyacotriton variegatus - southern torrent salamander

Reptile Species of Concern

Clemmys marmorata marmorata - northwestern pond turtle
Lampropeltis getula - common kingsnake
Lampropeltis zonata - California mountain kingsnake
Sceloporus graciosus graciosus - northern sagebrush lizard

Bird Species of Concern

Accipiter gentilis - northern goshawk
Agelaius tricolor - tricolored blackbird
Athene cunicularia hypugaea - western burrowing owl
Bartramia longicauda - upland sandpiper
Buteo regalis - ferruginous hawk
Centrocercus urophasianus - greater sage-grouse
Chlidonias niger - black tern
Coccyzus americanus - yellow-billed cuckoo
Columba fasciata - band-tailed pigeon
Contopus cooperi (=borealis) - olive-sided flycatcher
Coturnicops noveboracensis - yellow rail
Empidonax traillii adastus - willow flycatcher
Eremophila alpestris strigata - streaked horned lark
Histrionicus histrionicus - harlequin duck
Icteria virens - yellow-breasted chat
Ixobrychus exilis hesperis - western least bittern
Melanerpes formicivorus - acorn woodpecker
Melanerpes lewis - Lewis's woodpecker
Oreortyx pictus - mountain quail
Picoides albolarvatus - white-headed woodpecker
Plegadis chihi - white-faced ibis
Pooecetes gramineus affinis - Oregon vesper sparrow
Progne subis - purple martin
Tympanuchus phasianellus columbianus - Columbian sharp-tailed grouse

Mammal Species of Concern

Antrozous pallidus pacificus - Pacific pallid bat
Arborimus (=Phenacomys) albipes - white-footed vole
Arborimus (=Phenacomys) longicaudus - red tree vole
Brachylagus idahoensis - pygmy rabbit
Corynorhinus (=Plecotus) townsendii pallescens - Pale western big-eared bat
Corynorhinus (=Plecotus) townsendii townsendii - Pacific western big-eared bat
Euderma maculatum - spotted bat
Gulo gulo luteus - California wolverine
Lasionycteris noctivagans - silver-haired bat
Martes pennanti pacifica - Pacific fisher
Myotis ciliolabrum - western small-footed myotis (bat)
Myotis evotis - long-eared myotis (bat)
Myotis thysanodes - fringed myotis (bat)
Myotis volans - long-legged myotis (bat)
Myotis yumanensis - Yuma myotis (bat)
Ovis canadensis californiana - California bighorn sheep
Sorex preblei - Preble's shrew
Thomomys bulbivorus - Camas pocket gopher
Thomomys mazama helleri - Gold Beach W. pocket gopher
Thomomys umbrinus (=bottae) detumidus - Pistol R. pocket gopher

Invertebrate Species of Concern

Acetropis americana - American grass bug
Agapetus denningi - Denning's agapetus caddisfly
Agonum belleri - Beller's ground beetle
Algamorda newcombiana - Newcomb's littorine snail
Allomyia scotti - Scott's apatanian caddisfly
Anodonta californiensis - California floater (mussel)
Apatania (=Radema) tavala - Cascades apatanian caddisfly
Apochthonius malheuri - Malheur pseudoscorpion
Bombus franklini - Franklin's bumblebee
Chloealtis aspasma - Siskiyou short-horned grasshopper
Discus shimekii - striate disc (snail)
Driloleirus (=Megascolides) macelfreshi - OR giant earthworm
Eobrachycentrus gelidae - Mt. Hood brachycentrid caddisfly
Euphydryas editha taylori - Taylor's checkerspot (butterfly)
Farula constricta - a farulan caddisfly (no common name)
Farula davisi - Green Springs Mountain farulan caddisfly
Farula jewetti - Mt. Hood farulan caddisfly
Farula reapiri - Tombstone Prairie farulan caddisfly
Fluminicola fuscus (=columbianus) - Columbia pebblesnail

FEDERAL ANIMAL CANDIDATES AND SPECIES OF CONCERN (continued)

Goeracea oregona - Sagehen Creek goeracean caddisfly
Gomphus lynnae - Lynn's clubtail dragonfly
Homoplectra schuhi - Schuh's homoplectran caddisfly
Kenkia rhynchida - planarian (no common name)
Lepania cascada - a caddisfly (no common name)
Monadenia fidelis minor - Oregon snail (Dalles sideband)
Moselyana comosa - a caddisfly (no common name)
Namamyia plutonis - a caddisfly (no common name)
Nebria gebleri siskiyouensis - Siskiyou gazelle beetle
Neothremma andersoni - Columbia Gorge neothremman caddisfly
Oligophlebodes mostbento - Tombstone Prairie caddisfly
Pisidium ultramontanum - montane peaclam
Plebejus saepiolus littoralis (=insulanus) - insular blue butterfly
Pterostichus rothi - Roth's blind ground beetle
Rhyacophila chandleri - a caddisfly (no common name)
Rhyacophila colonus - Obrien rhyacophilan caddisfly
Rhyacophila haddocki - Haddock's rhyacophilan caddisfly
Rhyacophila leechi - a caddisfly (no common name)
Rhyacophila unipunctata - one-spot rhyacophilan caddisfly
Stygobromus hubbsi - Malheur Cave amphipod
Zapada wahkeena - Wahkeena Falls flightless stonefly

ODFW SENSITIVE ANIMAL SPECIES LIST

Fish

Catostomus occidentalis lacusanserinus - Goose Lake sucker (C)
Catostomus rimiculus - Jenny Creek sucker (P)
Catostomus tahoensis - Tahoe sucker (P)
Cottus bendirei - Malheur mottled sculpin (C)
Cottus marginatus - margined sculpin (V)
Cottus pitensis - Pit sculpin (P)
Gila alvordensis - Alvord chub (V)
Gila bicolor ssp. - Catlow tui chub (V)
Gila bicolor ssp. - Summer Basin tui chub (C)
Gila bicolor ssp. - Warner Basin tui chub (P)
Gila bicolor eurysoma - Sheldon tui chub (C)
Gila bicolor oregonensis - Oregon Lakes tui chub (V)
Gila bicolor thalassina - Goose Lake tui chub (P)
Lampetra tridentata - Pacific lamprey (V)
Lampetra tridentata ssp. - Goose Lake lamprey (C)
Lavinia (Hesperoleucus) symmetricus mitrulus - California (pit) roach (P)
Oncorhynchus clarki clarki - coastal cutthroat trout, Lower Columbia River anadromous form (C)
Oncorhynchus clarki clarki - coastal cutthroat trout, coast-wide below natural impassable barriers (V)
Oncorhynchus clarki lewisi - westslope cutthroat trout (V)
Oncorhynchus keta - chum salmon (C)
Oncorhynchus kisutch - coho salmon, Oregon Coast ESU (C)
Oncorhynchus kisutch - coho salmon, S. Oregon/N. California Coasts ESU (C)
Oncorhynchus mykiss - steelhead, Oregon Coast ESU (V)
Oncorhynchus mykiss - steelhead, Southwest Washington ESU (winter run) (C)
Oncorhynchus mykiss - steelhead, Lower Columbia River ESU (C)
Oncorhynchus mykiss - steelhead, Upper Willamette River ESU (winter run) (C)
Oncorhynchus mykiss - steelhead, Klamath Mtns. Prov. ESU (V)
Oncorhynchus mykiss - steelhead, Middle Columbia R. ESU (C/V)
Oncorhynchus mykiss - steelhead, Snake River Basin ESU (V)
Oncorhynchus mykiss - inland steelhead/redband trout; all groups east of Cascades (V)
Oncorhynchus tshawytscha - chinook salmon, Lower Columbia River ESU (C)
Oncorhynchus tshawytscha - chinook salmon, S. Oregon and N. California Coastal ESU (fall run) (C)
Oregonichthys crameri - Oregon chub (C)
Oregonichthys kalawatseti - Umpqua chub (V)
Rhinichthys cataractae ssp. - Millicoma dace (P)
Richardsonius egregius - Lahontan redside shiner (P)
Salvelinus confluentus - bull trout (C)

Amphibians

Ambystoma mavortium melanostictum - blotched tiger salamander (U)
Aneides ferreus - clouded salamander (U)
Aneides flavipunctatus - black salamander (P)
Ascaphus truei - tailed frog (V)
Batrachoseps attenuatus - California slender salamander (P)
Batrachoseps wrighti - Oregon slender salamander (U)
Bufo boreas - western toad (V)
Bufo woodhousii - Woodhouse's toad (P)
Dicamptodon copei - Cope's giant salamander (U)
Plethodon elongatus - Del Norte salamander (V)
Plethodon larselli - Larch Mountain salamander (V)
Plethodon stormi - Siskiyou Mountains salamander (V)
Rana aurora - red-legged frog (V-WV; U-CR, KM, WC)
Rana boylii - foothill yellow-legged frog (V)
Rana cascadae - Cascades frog (V)
Rana luteiventris - Columbia spotted frog (U)
Rana pipiens - northern leopard frog (C)
Rana pretiosa - Oregon spotted frog (C)
Rhyacotriton cascadae - Cascade torrent salamander (V)
Rhyacotriton kezeri - Columbia torrent salamander (C)
Rhyacotriton variegatus - southern torrent salamander (V)

Reptiles

Chrysemys picta - painted turtle (C)
Clemmys marmorata - western pond turtle (C)
Contia tenuis - sharptail snake (V)
Crotalus viridus - western rattlesnake (V-WV)
Crotaphytus bicinctores (=insularis) - desert-collared lizard (V)
Gambelia wislizenii - long-nose leopard lizerd (U)
Lampropeltis getula - common kingsnake (V)
Lampropeltis zonata - California mountain kingsnake (V)
Phrynosoma platyrhinos - desert horned lizard (V)
Sceloporus graciosus graciosus - sagebrush lizard (V-CB)
Sonora semiannulata - western ground snake (P)

Birds

Accipiter gentilis - northern goshawk (C)
Aegolius funereus - boreal owl (U)
Agelaius tricolor - tricolored blackbird (P)
Ammodramus savannarum - grasshopper sparrow (V-CB; P-WV)
Amphispiza belli - sage sparrow (C-CB)
Amphispiza bilineata - black-throated sparrow (P)
Athene (=Speotyto) cunicularia - burrowing owl (C-WV, KM, CB, HP, BM)
Bartramia longicauda - upland sandpiper (C)
Bucephala albeola - bufflehead (breeding) (U)
Bucephala islandica - Barrow's goldeneye (breeding) (U)
Buteo regalis - ferruginous hawk (C)
Buteo swainsoni - Swainson's hawk (V)
Centrocercus urophasianus - greater sage-grouse (V-EC, CB, BM)
Chordeiles minor - common nighthawk (C-WV)
Coccyzus americanus - yellow-billed cuckoo (C)
Contopus cooperi (=borealis) - olive-sided flycatcher (V)
Coturnicops noveboracensis - yellow rail (C)
Cypseloides niger - black swift (P)
Dolichonyx oryzivorus - bobolink (V)
Dryocopus pileatus - pileated woodpecker (V)
Egretta thula - snowy egret (breeding) (V)
Empidonax traillii adastus - willow flycatcher (U)
Empidonax traillii brewsteri - little willow flycatcher (V)
Eremophila alpestris strigata - streaked horned lark (C)
Falcipennis (=Dendragapus) canadensis - spruce grouse (U)
Glaucidium gnoma - northern pygmy owl (C-BM)
Grus canadensis tabida - greater sandhill crane (V)
Histrionicus histrionicus - harlequin duck (breeding) (U)
Icteria virens - yellow-breasted chat (C-WV)
Ixobrychus exilis - least bittern (P)
Lanius ludovicianus - loggerhead shrike (V-CB, HP)
Larus pipixcan - Franklin's gull (P)
Leucosticte atrata - black rosy finch (P)
Melanerpes lewis - Lewis woodpecker (C-WV, KM, WC, EC, CB)
Numenius americanus - long-billed curlew (V-CB)
Oceanodroma furcata - fork-tailed storm-petrel (breeding) (V)
Oreortyx pictus - mountain quail (U-EC, HP, BM)
Otus flammeolus - flammulated owl (C)
Pelecanus erythrorhynchos - Amer. white pelican (breeding) (V)
Picoides albolarvatus - white-headed woodpecker (C)
Picoides arcticus - black-backed woodpecker (C)
Picoides tridactylus - three-toed woodpecker (C)
Podiceps auritus - horned grebe (breeding) (P)
Podiceps grisegena - red-necked grebe (breeding) (C)
Pooecetes gramineus affinis - Oregon vesper sparrow (C)
Progne subis - purple martin (C)
Riparia riparia - bank swallow (U)
Sialia mexicana - western bluebird (western Oregon) (V)
Sitta pygmaea - pygmy nuthatch (C-BM; V-KM, EC, HP)
Sphyrapicus thyroideus - Williamson's sapsucker (U)
Strix nebulosa - great gray owl (V)
Sturnella neglecta - western meadowlark (C-WV)

Mammals

Ammospermophilus leucurus - white-tailed antelope squirrel (U)
Antrozous pallidus - pallid bat (V)
Arborimus (=Phenacomys) albipes - white-footed vole (U)
Bassariscus astutus - ringtail (U)
Brachylagus idahoensis - pygmy rabbit (V)
Corynorhinus (=Plecotus) townsendii - Townsend's big-eared bat (C)
Eumetopias jubatus - northern (Steller) sea lion (V)
Lasionycteris noctivagans - silver-haired bat (U)
Lepus townsendii - white-tailed jackrabbit (U)
Martes americana - American marten (V)
Martes pennanti - fisher (C)
Myotis ciliolabrum - western small-footed myotis (bat) (U)
Myotis evotis - long-eared myotis (bat) (U)
Myotis thysanodes - fringed myotis (bat) (V)
Myotis volans - long-legged myotis (bat) (U)
Odocoileus virginianus leucurus - Columbian white-tailed deer (V-CR)
Sciurus griseus - western gray squirrel (U)

C = Critical   V = Vulnerable   P = Peripheral or Naturally Rare   U = Undetermined Status

BM = Blue Mountains   BR = Basin and Range   CB = Columbia Basin   CR = Coast Range   EC = East Cascades
HP = High Lava Plains   KM = Klamath Mountains   OU = Owyhee Uplands   WC = West Cascades   WV = Willamette Valley

(for further explanation of status, see pages 6 and 7. The Ecoregional map is on page 3)

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Rana aurora aurora northern red-legged frog (SV in WV ecoregion, SU elsewhere)	CR, WV, KM, WC; CA, WA + Bent, Clac, Clat, Colu, Coos, Curr, Doug, Hood, Jack, Jose, Klam, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wasc, Wash, Yamh	G4T4 S3	SoC	SV/SU	2
Rana boylii foothill yellow-legged frog	CR, WV, KM, WC; CA Coos, Curr, Doug, Jack, Jose, Klam, Lane, Linn, Mari	G3 S2	SoC	SV	2
Rana cascadae Cascades frog	KM, WC, EC; CA, WA Clac, Desc, Doug, Hood, Jack, Jeff, Klam, Lane, Linn, Mari, Mult, Wasc	G4 S3	SoC	SV	2
Rana luteiventris Columbia spotted frog	BM, BR, HP, OU, CB; ID, NV, WA + Bake, Croo, Gran, Harn, Jeff, Lake, Malh, Umat, Unio, Wall, Whee	G4 S2?	C	SU	2
Rana pipiens northern leopard frog	KM, EC, CB, BM, OU; CA, ID, NV, WA + Bake, Croo, Gill, Gran, Hood, Jack, Jeff, Klam, Malh, Morr, Sher, Umat, Wasc	G5 S2?	--	SC	2
Rana pretiosa Oregon spotted frog	WV, WC, EC; CA, WA Bent, Clac, Colu, Croo, Desc, Hood, Jack, Jeff, Klam, Lane, Linn, Mari, Mult, Polk, Wasc, Wash, Yamh	G2G3 S2	C	SC	1
Rhyacotriton cascadae Cascade torrent salamander	WC; WA Clac, Hood, Lane, Linn, Mari, Mult	G3 S3	--	SV	2
Rhyacotriton kezeri Columbia torrent salamander	CR; WA Clat, Colu, Polk, Till, Wash, Yamh	G3 S3	--	SC	2
Rhyacotriton variegatus southern torrent salamander	CR, WV, KM, WC; CA Bent, Coos, Curr, Doug, Jose, Lane, Linc, Polk, Till, Yamh	G3 S3	SoC	SV	4
Taricha granulosa mazamae Crater Lake newt	EC Klam	G5T1Q S1	--	--	1

Reptiles

Chrysemys picta painted turtle	WV, WC, BM, HP, CB; ID, WA + Bake, Bent, Clac, Colu, Grant, Hood, Lane, Linn, Mari, Morr, Mult, Polk, Sher, Umat, Unio, Wall, Wasc, Wash, Yamh	G5 S2	--	SC	2
Clemmys marmorata marmorata northwestern pond turtle	CR, WV, KM, WC, EC; CA, NV, WA Bent, Clac, Colu, Coos, Curr, Doug, Hood, Jack, Jose, Klam, Lane, Linn, Mari, Mult, Polk, Till, Wasc, Wash, Yamh	G3T3 S2	SoC	SC	1
Contia tenuis sharptail snake	CR, WV, KM, WC, EC, CB; CA, WA Bent, Curr, Doug, Hood, Jack, Jose, Lane, Linc, Linn, Mari, Polk, Sher, Till, Wasc, Wash, Yamh	G5 S3	--	SV	4
Crotalus viridis western rattlesnake (SV in WV ecoregion only)	ALL; CA, ID, NV, WA + Bake, Bent, Coos, Croo, Curr, Desc, Doug, Gill, Gran, Harn, Hood, Jack, Jeff, Jose, Klam, Lake, Lane, Linn, Malh, Mari, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5 S4	--	SV	4
Crotaphytus bicinctores Mojave black-collared lizard	BR, OU; CA, ID, NV + Harn, Malh	G5 S2	--	SV	4
Gambelia wislizenii long-nose leopard lizard	BR, OU; CA, ID, NV+ Bake, Harn, Lake, Malh	G5 S4	--	SU	4
Lampropeltis getula common kingsnake	KM, WC; CA, NV + Curr, Doug, Jack, Jose	G5 S2	SoC	SV	2
Lampropeltis zonata California mountain kingsnake	CR, KM, WC, EC; CA, WA Coos, Curr, Doug, Jack, Jose, Klam, Wasc	G4 S3	SoC	SV	3 *

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Phrynosoma platyrhinos desert horned lizard	BM, BR, OU; CA, ID, NV + Bake, Harn, Lake, Malh	G5 S3	–	SV	4
Sceloporus graciosus graciosus northern sagebrush lizard (SV in CB ecoregion only)	CR, KM, WC, EC, BM, BR, HP, OU, CB; CA, ID, NV, WA; Bake, Coos, Croo, Curr, Desc, Doug, Gill, Gran, Harn, Jack, Jeff, Jose, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wasc, Whee	G5T5 S5?	SoC	SV	4
Sonora semiannulata western ground snake	BR, OU; CA, ID, NV + Harn, Malh	G5 S2	–	SP	2

Birds

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Accipiter gentilis northern goshawk	CR, KM, WC, EC, BM, BR, HP; CA, ID, NV, WA + Bake, Clac, Coos, Croo, Curr, Desc, Doug, Gran, Harn, Hood, Jack, Jeff, Jose, Klam, Lake, Lane, Linn, Malh, Mari, Morr, Mult, Umat, Unio, Wall, Wasc, Whee	G5 S3	SoC	SC	2
Aegolius funereus boreal owl	WC, EC, BM; ID, WA + Bake, Clac, Croo, Desc, Gran, Hood, Jeff, Klam, Lane, Linn, Mari, Umat, Unio, Wall, Wasc, Whee	G5 S3?	–	SU	3
Agelaius tricolor tricolored blackbird	WV, KM, EC, HP, CB; CA Jack, Klam, Lake, Mult, Umat, Wasc, Whee	G3 S2B	SoC	SP	2
Ammodramus savannarum grasshopper sparrow (SV in CB ecoregion; SP in WV)	WV, KM, BM, BR, CB; CA, ID, NV, WA + Bake, Doug, Gill, Harn, Jack, Lane, Linn, Morr, Polk, Sher, Umat, Wall	G5 S2?B	–	SV/SP	2
Amphispiza belli sage sparrow (SC in CB ecoregion only)	CB, HP, BM, BR, OU; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Harn, Lake, Malh, Morr, Unio	G5 S4	–	SC	4
Amphispiza bilineata black-throated sparrow	EC, CB, HP, BR, OU; CA, ID, NV, WA + Croo, Desc, Harn, Klam, Lake, Malh, Morr, Whee	G5 S2?B	–	SP	2
Ardea alba (great egret) - Considered but rejected, too common					
Athene cunicularia hypugaea western burrowing owl (SC excludes EC, BR, and OU ecoregions)	WV, KM, EC, CB, HP, BM, BR, OU; CA, ID, NV, WA+ Bake, Croo, Desc, Gill, Gran, Harn, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G4TU S2?B	SoC	SC	2
Bartramia longicauda upland sandpiper	EC, BM; ID, WA + Croo, Gran, Klam, Lake, Umat, Unio	G5 S1B	SoC	SC	2
Brachyramphus marmoratus marbled murrelet	CR, KM; CA, WA + Bent, Clat, Coos, Curr, Doug, Jose, Lane, Linc, Polk, Till, Yamh	G3G4 S2	LT	LT	2
Branta canadensis leucopareia Aleutian Canada goose (wintering)	CR, WV, KM; AK, CA, WA, BC Bent, Colu, Coos, Curr, Mari, Mult, Polk, Till, Wash, Yamh	G5T3 S2N	LT	LE	1
Branta canadensis occidentalis dusky Canada goose	CR, WV; WA + Bent, Colu, Lane, Linn, Mari, Mult, Polk, Till, Yamh, Wash	G5T2T3 S2N	–	–	4
Bucephala albeola bufflehead	WC, EC; CA, ID, WA + Desc, Doug, Jeff, Klam, Lane, Linn, Mari	G5 S2B,S5N	–	SU	4
Bucephala islandica Barrow's goldeneye	WC, EC; CA, ID, WA + Clac, Desc, Doug, Jeff, Hood, Klam, Lane, Linn, Mari	G5 S3B,S3N	–	SU	4
Buteo regalis ferruginous hawk	BM, BR, HP, OU, CB; CA, ID, NV, WA + Bake, Croo, Desc, Gran, Gill, Harn, Jeff, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G4 S3B	SoC	SC	2

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Buteo swainsoni Swainson's hawk	BM, BR, HP, OU, CB; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Harn, Jeff, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5 S3B	--	SV	4
Centrocercus urophasianus phaios western greater sage-grouse (SV in EC, CB, BM ecoregions only)	EC, CB, HP, BM, BR, OU; CA, NV, WA Bake, Croo, Desc, Gill, Gran, Harn, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wasc, Whee	G4T3Q S3	SoC	SV	1
Centrocercus urophasianus urophasianus eastern greater sage-grouse	BR, OU; CA, ID, NV + Harn, Malh	G4TU S2	SoC	--	2
Cerorhinca monocerata rhinoceros auklet	CR; CA, WA + Clat, Coos, Curr, Lane, Linc, Till	G5 S2B	--	--	2
Charadrius alexandrinus nivosus western snowy plover (coastal pops.)	CR; CA, WA, Mexico Clat, Coos, Curr, Doug, Lane, Linc, Till	G4T3 S2	LT	LT	1
Charadrius alexandrinus nivosus western snowy plover (interior pops.)	EC, BR; CA, NV + Harn, Klam, Lake	G4T3 S2	--	LT	2
Chlidonias niger black tern	WV, EC, HP, BM, BR, OU; CA, ID, NV, WA + Bent, Croo, Desc, Gran, Harn, Klam, Lake, Lane, Malh, Unio	G4 S3B	SoC	--	4
Chordeiles minor common nighthawk (SC in WV ecoregion only)	ALL; CA, ID, NV, WA + all	G5 S5	--	SC	4
Coccyzus americanus yellow-billed cuckoo	WV, WC, EC, BM, BR, HP, OU; CA, ID, NV, WA + Bake, Clac, Desc, Gran, Harn, Klam, Lake, Linn, Malh, Mult, Umat, Unio, Wall	G5 S1B	SoC	SC	2
Columba fasciata band-tailed pigeon	CR, WV, KM, WC, EC; CA, ID, NV, WA + Bent, Clac, Clat, Colu, Coos, Curr, Doug, Hood, Jack, Jose, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wasc, Wash, Yamh	G5 S4	SoC	--	4
Contopus cooperi (=borealis) olive-sided flycatcher	CR, WV, KM, WC, EC, BM; CA, ID, NV, WA + all but Gill, Sher	G5 S4	SoC	SV	4
Coturnicops noveboracensis yellow rail	EC; CA + Klam, Lake	G4 S1B	SoC	SC	2
Cypseloides niger black swift	WC; CA, ID, WA + Lane	G4 S1B, S3?N	--	SP	2
Dendragapus canadensis - see *Falcipennis canadensis*					
Dolichonyx oryzivorus bobolink	BM, BR, HP, OU; ID, NV, WA + Bake, Gran, Harn, Malh, Unio, Wall	G5 S2B	--	SV	4
Dryocopus pileatus pileated woodpecker	ALL; CA, ID, WA + all but Gill, Sher	G5 S4?	--	SV	4
Egretta thula snowy egret	EC, BR; CA, ID, NV, WA + Harn, Klam, Lake	G5 S2B	--	SV	4
Elanus leucurus white-tailed kite	CR, WV, KM; CA + Bent, Jack, Lane, Linn, Till	G5 S1B, S3N	--	--	2
Empidonax traillii adastus (=*E. adastus*), eastern Oregon willow flycatcher	EC, BM, BR, HP, OU, CB; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Gran, Harn, Hood, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5TU SUB	SoC	SU	4
Empidonax traillii brewsteri (=*E. brewsteri*), western Oregon little willow flycatcher	CR, WV, KM, WC; CA, WA + Bent, Clac, Clat, Colu, Coos, Curr, Doug, Hood, Jack, Jose, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wash, Yamh	G5TU SUB	--	SV	4

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Eremophila alpestris strigata streaked horned lark	CR, WV, KM; WA + Bent, Clac, Clat, Doug, Jack, Jose, Lane, Linn, Mari, Mult, Polk, Wash, Yamh	G5T2 S2?	SoC	SC	2
Falcipennis (=Dendragapus) canadensis spruce grouse	BM; ID, WA + Bake, Wall, Unio	G5 S3	--	SU	4
Falco columbarius merlin	EC, CB, BR; ID, WA + Gill, Harn, Klam, Morr	G5 S1B	--	--	2
Falco peregrinus anatum American peregrine falcon	ALL; CA, ID, NV, WA + all	G4T3 S1B	--	LE	2
Gavia immer (common loon) - Considered but rejected, non-breeder					
Glaucidium gnoma northern pygmy-owl (SC in BM ecoregion only)	CR, WV, KM, BM, WC, EC, HP; CA, ID, NV, WA + all but Gill, Sher	G5 S4?	--	SC	4
Grus canadensis tabida greater sandhill crane	WC, EC, BM, BR, HP, OU, CB; CA, ID, NV, WA + Bake, Clac, Croo, Desc, Gran, Harn, Jack, Klam, Lake, Lane, Linn, Malh, Unio, Wall, Wasc	G5T4 S3B	--	SV	4
Gymnogyps californianus California condor	CR, KM; CA	G1 SX	LE	--	1-ex
Gymnorhinus cyanocephalus (pinyon jay) - Considered but rejected, too common					
Haematopus bachmani black oystercatcher	CR; CA, WA + Clat, Coos, Curr, Lane, Linc, Till	G5 S3	--	--	4
Haliaeetus leucocephalus bald eagle	ALL; CA, ID, NV, WA + all	G4 S3B,S4N	LT	LT	2
Histrionicus histrionicus harlequin duck	WC, EC, BM; ID, WA + Clac, Desc, Doug, Hood, Jack, Jeff, Klam, Lane, Linn, Mari, Mult, Till, Unio, Wall, Wasc	G4 S2B,S3N	SoC	SU	2
Icteria virens yellow-breasted chat (SC in WV ecoregion only)	ALL; CA, ID, NV, WA + all but Clat, Linc, Till	G5 S4?	SoC	SC	4
Ixobrychus exilis hesperis western least bittern	EC, BR; CA + Harn, Klam	G5TU S1B	SoC	SP	2
Lanius ludovicianus loggerhead shrike (SV in CB and HP ecoregions only)	EC, CB, HP, BM, BR, OU; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Gran, Harn, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5 S4B,S2N	--	SV	4
Larus pipixcan Franklin's gull	BR; CA, ID + Harn	G4G5 S1B	--	SP	2
Leucosticte atrata black rosy-finch	BR; CA, ID, NV, WA + Harn	G4 S2B	--	SP	4
Leucosticte tephrocotis wallowa Wallowa rosy-finch	BM Wall	G5T2 S2B,S2?N	--	--	4
Melanerpes formicivorus acorn woodpecker	CR, WV, KM, EC; CA, WA + Bent, Clac, Coos, Curr, Doug, Jack, Jose, Klam, Lane, Linn, Mari, Polk, Wasc, Wash, Yamh	G5 S3?	SoC	--	4
Melanerpes lewis Lewis's woodpecker (SC in WV, KM WC, EC, and CB ecoregions only)	ALL; CA, ID, NV, WA + all	G5 S3B,S3N	SoC	SC	4
Numenius americanus long-billed curlew (SV in CB ecoregion only)	EC, CB, HP, BM, BR, OU; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Gran, Harn, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5 S3S4	--	SV	4

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Selasphorus sasin (Allen's hummingbird) - Considered but rejected, locally common					
Sialia mexicana western bluebird (SV in western Oregon)	CR, WV, KM, WC, EC, CB, HP, BM; CA, ID, NV, WA + all	G5 S4B,S4N	--	SV	4
Sitta pygmaea pygmy nuthatch (SC in BM ecoregion, SV in KM, EC, and HP)	KM, EC, BM; CA, ID, NV, WA + Bake, Croo, Desc, Gran, Harn, Jack, Jeff, Klam, Lake, Malh, Morr, Umat, Unio, Wall, Wasc, Whee	G5 S4?	--	SC/SV	4
Sphyrapicus thyroideus Williamson's sapsucker	WC, EC, BM, BR; CA, ID, NV, WA + Bake, Croo, Desc, Gran, Harn, Hood, Jack, Jeff, Klam, Lake, Morr, Umat, Unio, Wall, Wasc, Whee	G5 S4B,S3N	--	SU	4
Sterna forsteri (Forster's tern) - Considered but rejected, locally common					
Strix nebulosa great gray owl	KM, WC, EC, BM; CA, ID, WA +; Bake, Clac, Croo, Desc, Doug, Gran, Harn, Jack, Jeff, Klam, Lake, Lane, Linn, Mari, Morr, Umat, Unio, Wall, Wasc, Whee	G5 S3	--	SV	4
Strix occidentalis caurina northern spotted owl	CR, WV, KM, WC, EC; CA, WA, BC Bent, Clac, Clat, Colu, Coos, Curr, Desc, Doug, Hood, Jack, Jeff, Jose, Klam, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wasc, Wash, Yamh	G3T3 S3	LT	LT	1
Sturnella neglecta western meadowlark (SC in WV ecoregion only)	WV, KM, EC, CB, HP, BM, BR, OU; CA, ID, NV, WA+ Bake, Bent, Clat, Colu, Croo, Desc, Doug, Gill, Gran, Harn, Jack, Jeff, Jose, Klam, Lake, Lane, Linn, Malh, Mari, Morr, Mult, Polk, Sher, Umat, Unio, Wall, Wasc, Wash, Yamh	G5 S5	--	SC	4
Tringa melanoleuca (greater yellowlegs) - Considered but rejected, accidental breeder					
Tringa solitaria (solitary sandpiper) - Considered but rejected, accidental breeder					
Tympanuchus phasianellus columbianus Columbian sharp-tailed grouse	EC, CB, HP, BM, BR; CA, ID, MT, NV, WA, BC Bake, Croo, Desc, Gill, Gran, Harn, Hood, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G4T3 S1	SoC	--	1

Mammals

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Ammospermophilus leucurus white-tailed antelope squirrel	BR, OU; CA, ID, NV + Harn, Lake, Malh	G5 S4?	--	SU	4
Antrozous pallidus pacificus Pacific pallid bat	CR, WV, KM, WC, EC; CA Coos, Curr, Doug, Jack, Jose, Klam, Lane, Yamh	G5T3T4 S3?	SoC	SV	2
Antrozous pallidus pallidus pallid bat	EC, CB, HP, BM, BR, OU; CA, ID, NV, WA + Bake, Croo, Desc, Gill, Gran, Harn, Jeff, Klam, Lake, Malh, Morr, Sher, Umat, Unio, Wall, Wasc, Whee	G5T? S3	--	SV	3
Arborimus (=Phenacomys) albipes white-footed vole	CR, WV, KM, WC; CA Bent, Clat, Colu, Coos, Curr, Doug, Jose, Lane, Linc, Linn, Polk, Till, Wash, Yamh	G3G4 S3	SoC	SU	4
Arborimus (=Phenacomys) longicaudus red tree vole	CR, WV, KM, WC; CA? Bent, Clac, Clat, Colu, Coos, Curr, Doug, Hood, Jack, Jose, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wash, Yamh	G3G4 S3S4	SoC	--	3
Bassariscus astutus ringtail	CR, KM, WC, EC; CA, NV + Coos, Curr, Doug, Jack, Jose, Klam, Lane	G5 S3	--	SU	4
Brachylagus idahoensis pygmy rabbit	EC, BM, BR, HP, OU, CB; CA, ID, NV, WA + Bake, Croo, Desc, Gran, Harn, Jeff, Klam, Lake, Malh, Unio, Wasc, Whee	G4 S2?	SoC	SV	2
Canis lupus gray wolf	ALL; CA, ID, NV, WA + all (represents historic range)	G4 SH	LE	LE	2-ex

Scientific Name Common Name	Ecoregion; Adjacent States Oregon Counties	Heritage Rank	Federal Status	ODFW Status	ONHP List
Odocoileus virginianus leucurus Columbian white-tailed deer (SV in CR only)	CR, WV, KM; WA Clat, Colu, Doug, Lane, Mult	G5T2Q S2	LE	SV	1
Ovis canadensis californiana California bighorn sheep	EC, CB, HP, BR, OU; CA, NV Desc, Gill, Gran, Harn, Lake, Malh, Sher, Wasc, Whee	G4G5T2Q S2?	SoC	--	4
Ovis canadensis canadensis Rocky Mountain bighorn sheep	BM; ID, WA + Bake, Wall	G4G5T4Q S2	--	--	4
Plecotus townsendii pallescens - see *Corynorhinus townsendii pallescens*					
Plecotus townsendii townsendii - see Corynorhinus townsendii townsendii					
Sciurus griseus western gray squirrel	CR, WV, KM, WC, EC; CA, NV, WA Bent, Clac, Colu, Coos, Curr, Desc, Doug, Hood, Jack, Jeff, Jose, Klam, Lane, Linc, Linn, Mari, Mult, Polk, Till, Wasc, Wash, Yamh	G5 S4?	--	SU	3
Sorex preblei Preble's shrew	EC, HP, BM, BR, OU; CA, ID, NV, WA + Bake, Croo, Desc, Gran, Harn, Klam, Lake, Malh, Umat, Unio, Wall	G4 S3	SoC	--	4
Spermophilus elegans nevadensis (=*S. richardsoni nevadensis*) Wyoming ground squirrel	OU; ID, NV + Malh	G5T4 SH	--	--	2-ex
Spermophilus washingtoni Washington ground squirrel	CB; WA Gill, Morr, Umat	G2 S2	C	LE	1
Tadarida brasiliensis Brazilian free-tailed bat	WV, KM, EC; CA, NV + Doug, Jack, Jose, Klam, Lane	G5 S2	--	--	2
Thomomys bulbivorus Camas pocket gopher	WV Bent, Clac, Colu, Lane, Linn, Mari, Mult, Polk, Wash, Yamh	G3G4 S3S4	SoC	--	3
Thomomys mazama helleri (Gold Beach pocket gopher) - Considered but rejected, questionable taxon			SoC	--	--
Thomomys umbrinus (=bottae) detumidus (Pistol R. pocket gopher) - Rejected, questionable taxon			SoC	--	--
Ursus arctos grizzly bear	ALL; CA, ID, NV, WA +	G4 SX	LT	--	2-ex
Vulpes macrotis kit fox	EC, BR, OU; CA, ID, NV + Desc, Harn, Klam, Malh	G4 S1	--	LT	2

Invertebrates

Class Turbellaria - Flatworms

Order Tricladida

Kenkia rhynchida no common name (planarian)	BR Harn	G1G2 S2?	SoC	--	1

Class Bivalvia - Clams, Oysters & Mussels

Order Ostreoida

Ostrea lurida native oyster	CR; WA Linc, Till	G? S?	--	--	3

Order Unionoida

Anodonta californiensis California floater (mussel)	CR, WV, WC, EC, BM, BR; CA, ID, NV, WA + Coos, Gran, Harn, Klam, Mult, Sher, Wasc	G3 S1?	SoC	--	3 *
Anodonta wahlametensis Willamette floater (mussel)	CR, WV, WC, EC; CA, WA Wasc	G2Q S1	--	--	1

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WILDLIFE RESPONSES TO RECREATION AND ASSOCIATED VISITOR PERCEPTIONS AT ANTELOPE ISLAND STATE PARK, UTAH

Little is known about wildlife responses to hiking versus mountain biking, the area of influence of recreational activities, or the perceptions that public lands visitors have regarding their impacts on wildlife. We examined the responses of bison, mule deer, and pronghorn antelope to hikers and mountain bikers at Antelope Island State Park, Utah. Wildlife did not respond differently to biking versus hiking, but there was a negative relationship between wildlife body size and response. We determined the area of influence along trails and off-trail transects by examining animals' probability of flushing as perpendicular distance increased. Each species exhibited a 70% probability of flushing within 100 m from on-trail recreationists. Mule deer showed a 70% probability of flushing within 390 m from off-trail recreationists. We surveyed 640 trail users on Antelope Island to investigate their perceptions of the effects of recreation on wildlife. Survey respondents perceived that it was acceptable to approach wildlife more closely than our empirical data showed wildlife would allow. Recreationists also tended to blame other user groups for stress to wildlife rather than holding themselves responsible. These results have implications for the management of public lands where the coexistence of wildlife and recreation is a primary goal.

http://www.ukc.ac.uk/anthropology/dice/scb2002/abstracts/Tuesday/ecotour.html
Society for Conservation Biology annual meeting

Special Session 4. *Recreational Impacts on Wildlife in Wildlands*

Chair
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Wildlife Preservation and Recreational Use: Conflicting Goals of Wildland Management

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Introduction

Large tracts of wildland in North America have been set aside as wilderness areas and national parks. More than 200 million acres (88 million ha) of such lands have been formally designated in Canada and the United States (Eidsvik 1989). The primary goal of these designations is the preservation of undisturbed natural conditions and processes.

Although preservation is the foremost goal of these wildlands. recreational use is usually allowed and often encouraged. Recreation use data are scant, often of poor quality and subject to misinterpretation due to changes in measurement units and number of areas reporting; however, the trend is clear. Recreational use of wilderness and national parks has increased greatly over the past half-century. Recreational use of National Forest wilderness in the United States has probably increased at least tenfold since the late 1940s. to current annual use levels of more than 12 million recreation visitor days (Lucas and Stankey 1988). In addition, the popularity of wilderness recreation in relation to other types of forest recreation has steadily increased. Wilderness use grew from 1 percent of total forest recreation use in 1946 to 6 percent in 1986. In 1946, only 5 percent of forest camping occurred in wilderness:

The Wilderness Library

in 1986, 35 percent of forest camping took place in wilderness (Lucas 1989). Similar trends took place in national parks in the United States and comparable lands in Canada.

The twin goals of nature preservation and provision of recreational opportunities inevitably conflict. Recreation causes impacts to the land and the wildlife that inhabit the land. Management actions taken to mitigate these impacts frequently restrict access and recreational activities. The responsibility of the wildland manager is to determine the optimal mix of preservation and use, and to implement strategies to achieve this mix. To help the manager in this task, research on interactions between recreationists and the environment is needed.

Recreational Impact Research

The earliest study of recreational impact on natural environments, that we are aware of, examined tourist impacts on tree roots in the California redwood state parks (Meinecke 1928). By the late 1950s, a few other recreation impact studies had been conducted, including studies of the response of animals to human presence (e.g.. Altmann 1958). It was in the 1960s and 1970s, however, that an increased awareness of recreational impact problems spurred a great increase in the number of studies. Worldwide, there have been about 150 published papers on recreational impact on vegetation and soils that contain original data (Cole 1987); the number of papers with original data on recreational impacts on wildlife is somewhat higher-there were 166 papers as of 1983 (Boyle and Samson 1985).

Despite all these studies, our understanding of recreational impacts is still rudimentary. Goldsmith (1974) has commented that most recreational impact studies merely "record observations of a rather superficial nature and only a few describe specially designed experiments with detailed analysis of the resultant data." Seventeen years later, this analysis of the situation still applies. Most research continues to merely document the obvious; time frames from studies are short; theory is lacking; few studies utilize experimental designs; and few studies produce results that lead to broader generalizations.

Need for Wildlife Impact Research

There are a number of reasons for thinking that recreational impacts on wildlife may be significantly compromising wildland preservation goals. The first reason, as stated earlier, is that recreational use of these lands has increased dramatically in recent decades. Second, in contrast to impacts on vegetation and soil, which are highly localized, impacts on wildlife are likely to be more widespread. Since animals are mobile, it is possible for entire populations or entire habitats to be disrupted by recreational use.

A third reason for concern is the tendency for management to promote more even distribution of recreational use, both in space and time. In most places, recreational use is extremely unevenly distributed (Roggenbuck and Lucas 1987). Use is often confined to trail corridors, with a few select trails accounting for a majority of use. Similarly, use is often confined to seasons when weather is mild, and to weekends and holidays when most people are away from work. Managers have frequently considered this concentration of use to be undesirable because it can result in high levels of crowding and resource impacts at popular times and in popular places (Hendee et al. 1990). The common response has been to attempt to disperse use more widely. Visitors are told about alternatives to the popular places or asked to avoid crowded trails and places. The attractions of off-season travel are advertised as a contrast to the crowded conditions of the high-use season and people are advised to visit on weekdays rather than on weekends.

Recreational use is still unevenly distributed, but there is evidence that use distributions have shifted. Winter season visitation in national parks has increased greatly, as have cross-country skiing and off-trail travel in backcountry. For example, total visitation to Yellowstone National Park changed little between 1965 and 1980: however, winter visitation increased tenfold (Aune 1981). Reductions in use at popular times and in popular places have seldom been dramatic. It is the increases in use of remote places and during the off-season that have been pronounced. The proportion of an area that is never visited and the proportion of the year that visitation is negligible have shrunk greatly over the last few decades--as much in response to changes in use distribution as to increases in use. The effect on wildlife is that refuge from disturbance has decreased dramatically--if low levels of recreational use have a significant impact.

The interface between humans and wildlife, particularly in regard to nonconsumptive uses of wildlife, has recently become a topic of considerable interest. Social scientists, in particular, have been organizing meetings and writing papers on the human dimensions of wildlife (Manfredo 1989). Another topic that obviously lies at the juncture of social science and wildlife management is the impact of recreationists on wildlife. The intent of this paper and of this session is to suggest that this area deserves more attention.

Information Needs

In order to more effectively minimize conflict between recreation use and wildlife preservation goals, we need to: (1) understand the responses of wildlife to recreational activities; (2) understand the factors that influence the nature and magnitude of impacts; (3) improve research methods: and (4) develop and implement new management strategies. This session is organized around these topics.

Previous research has documented numerous cases where wildlife have responded negatively to recreational use: however, it is seldom possible to determine how significant these impacts are. An ungulate may run from an approaching skier, but does that reduce the fitness of that individual or significantly affect a population--either in the short or long term? We need more research that documents the various effects of different recreational activities on wildlife: and more attention needs to be paid to impacts other than short-term behavioral changes in individuals. Are there long-term impacts? How are behavioral responses by individuals manifested at the population or community levels? This type of research is challenging because it is difficult to distinguish between natural variability in populations and variability that results from recreational use (Boyle and Samson 1985), particularly where the effect of recreation is indirect and the response occurs far from the point of disturbance or after a time lag (Goldsmith 1974).

Managers need to understand why some types of disturbance cause pronounced impacts while others have little effect. They also must understand why the same recreational activity causes serious problems in some situations and has no effect in others. Such characteristics of the disturbance as activity type, frequency and timing can influence the severity of the response. Characteristics, of the animals being disturbed can also influence responses. There is a particular need to better understand learned behavior, such as the ability of animals to habituate to human disturbance. An understanding of the factors that influence the nature and magnitude of impacts will enable managers to develop more effective strategies for minimizing impact.

To obtain an improved understanding of recreational impacts on wildlife, new and improved research designs and methods are needed. As stated before, impacts are complex and it is often difficult to uncover cause and effect relationships. More experimentation is clearly needed, but confounding variables are usually difficult to control. Short-term, readily observable behavioral responses are easy to study, but longer-term investigations are needed to answer questions of significance.

The ultimate goal of this research is to see that management optimizes the twin goals of wildlife preservation and recreational opportunity. Beyond simply closing areas to all recreational use, impacts might be kept to acceptable levels through such strategies as spatial and temporal restrictions or even subtle alterations in human behavior. Besides managing disturbance agents, managers may also be able to reduce impact by managing the animal populations and the context in which disturbance occurs. Hopefully, there will also be opportunities to evaluate the success of management programs that are established.

Conclusion

It is our hope that this session will accomplish a number of goals. First, we hope that it will increase awareness of the need to improve our understanding of recreational impacts on wildlife. Wildlands are important to our society and undisturbed wildlife populations are a critical indicator of the quality of wildlands. Managers can only be as effective as the knowledge and information they bring to bear on problems. The current, poor level of understanding of this topic is clearly an impediment to effective management.

Second, we hope that the substance of the technical articles will be useful to scholars interested in working in the field and managers already grappling with impact problems. Papers that review the literature, describe available research methodologies and discuss available management options should help in this regard.

Third, we hope that through the opportunity to present these papers and the discussion that ensues, we will all learn from each other. New ideas will surface and new contacts will be developed. Substantial improvements in knowledge will only come if more researchers work in the field; more of these researchers commit more of their time and energy to the subject; and new ideas and methodologies are brought to bear. Will you--the wildlife conservation community--accept this challenge?

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November 5, 2002

Hi All,

I found the Colorado publication that Holly mentioned last night, and photocopied part of it for you. I did not inlcude the case histories, but you can find them online:

http://www.coloradoparks.org/home/publications/trails%20handbook%20section%20three.pdf

The above link will take you directly to that section of the document, or you can go to http://www.coloradoparks.org/home/publications.asp
and click on Trails Publications, then go to "Planning Trails With Wildlife In Mind: A Guide for Trail Planners (Section 3)"

-Elaine

Planning Trails with Wildlife in Mind

A HANDBOOK FOR TRAIL PLANNERS

TRAILS AND WILDLIFE TASK FORCE • COLORADO STATE PARKS • HELLMUND ASSOCIATES

Planning Trails with Wildlife in Mind

A HANDBOOK FOR TRAIL PLANNERS

Governor Roy Romer

Colorado Department of Natural Resources: Wade Buchanan, Executive Director

Colorado State Parks: Laurie Mathews, Director

Colorado State Trails Program: Stuart Macdonald, State Trails Coordinator

TRAILS AND WILDLIFE TASK FORCE • COLORADO STATE PARKS • HELLMUND ASSOCIATES

September 1998

CREDITS

TRAILS AND WILDLIFE TASK FORCE

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GREAT OUTDOORS COLORADO

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FOR COPIES OF THIS HANDBOOK

To obtain a single copy of this handbook, send a large, stamped (6 first-class stamps), self-addressed envelope (minimum 9"x12") to the address above or download the handbook from our website:

http://www.dnr.state.co.us/parks/

For multiple copies, please contact the Trails Program at the address above.

Welcome

Dear Trail Planner:

How can trails best be planned and managed to recognize the needs and sensitivities of wildlife and the environment? What impacts do trail development and use have on wildlife? What can we do to minimize these impacts?

These are some of the important questions that prompted Colorado State Parks—in cooperation with Great Outdoors Colorado—to convene a state-wide Trails and Wildlife Task Force.

The Task Force was comprised of key stakeholders and experts on habitat and recreation issues.

With the increasing use of trails, a growing statewide population, and Coloradans' tremendous love of both trails and wildlife, this seemed to be an ideal time to develop a handbook on wildlife issues for trail planners.

Task Force Objectives

Over a period of nine months, the Task Force and support staff have worked to identify critical issues and sources of information about trails and wildlife, to document case studies, and to present the information in a practical format.

Dynamic format that needs your contributions

In many ways this handbook can never be finished, but we can continue to learn and use the growing body of knowledge to improve our planning efforts. It is an evolving document about a subject that is just beginning to be studied and understood. We plan to update this handbook regularly and ask you to send information and suggestions through either the comment form in the back or by visiting our website:

www.dnr.state.co.us/parks/

The Colorado State Trails Program

Since it was established in 1971, the State Trails Program has been active in encouraging trail development around the state. Recreational trails are a priority of Colorado State Parks, and provide for a significant part of the outdoor activities available in Colorado.

Stuart Macdonald
Colorado State Trails
Coordinator

Contents

1. Introduction

Few things are loved more by Coloradans than trails and the outdoors. With participation in outdoor recreation at unprecedented levels, access to nature is clearly an integral part of living in our state. Too much outdoor recreation, however, can sometimes put at risk the very natural resources upon which it is based.

This handbook will help trail planners and builders balance the benefits of creating trails and being stewards of nature, especially wildlife.

Trails make many positive contributions to conserving nature. They can help:

• restore degraded stream corridors and other habitats in the process of trail building;

• guide recreationists away from sensitive wildlife habitat and into more adaptable settings;

• educate people about wildlife issues and appropriate behavior in the outdoors; and

• build broad constituencies for wildlife conservation by putting people in contact with nature.

Trails affect wildlife in a range of ways

Typically, the impacts to wildlife from trails aren't as great as those from intensive development. More and more, however, we realize that—no matter how carefully we tread and no matter how much we desire to "leave nothing but footprints and take nothing but pictures"— building trails can effect wildlife. By entering an area, we may change the ecology of a system that is complex and frequently hard to understand.

Sometimes the effects of building and using a trail are minor and fleeting. Other times they may be more substantial and long-lasting.

Trails can be effective wildlife management tools

Let's take a typical situation. Land managers intentionally choose not to build a trail to a particularly sensitive area, perhaps a heron rookery. People hear of the rookery and make their own paths to it. Many of the visitors are careful in how and when they approach the herons.

Before long, however, many paths braid through the trees and planners are pressured into doing something. They decide to harden one of the trails and build an observation deck at an appropriate distance from the herons. Finally, with great effort—over many years—most of the social trails are revegetated.

Rules of thumb in the face of scientific uncertainty

In situations such as the heron rookery, scientists say the specific effects of trails on wildlife are usually uncertain. These complex interactions are just beginning to be understood and few unequivocal ecological principles for trail planners are known.

Because of this uncertainty, this handbook offers **rules of thumb** rather than iron-clad principles. These rules of thumb are helpful suggestions based on practical experience, extrapolations from the sometimes sketchy scientific literature, and just plain common sense. They are experienced guesses that may prove useful even though they may not be "right" in every situation. Each could appropriately be prefaced with phrases such as, "when possible" or "in general."

Perhaps the greatest contribution of these rules of thumb is that they raise issues that trail planners might not otherwise anticipate. Also, if most relevant rules of thumb cannot be met, it may indicate a trail should not be built in that location.

Even if scientists were certain of the specific impacts of trails—something that should become better known over the coming years—that knowledge still has to be balanced with the benefits of trails. Scientific facts alone don't dictate what should be done with a specific trail. It is the larger framework of laws and community desires that determine what should—or must—be valued and protected.

Handbook purpose and organization

This handbook, which was developed as part of Colorado State Parks' Trails and Wildlife Project, is divided into six main parts:

Chapter 1: Introduction.

Chapter 2: Wildlife and Trails Primer gives an overview of important wildlife and other environmental issues and suggests a range of approaches to planning trails with wildlife in mind.

Chapter 3: Wildlife and Trail Planning Checklist is a sequence of wildlife-related questions and possible steps to consider in planning a trail.

Chapter 4: Case Studies presents specific trail projects and the wildlife-related lessons learned in the process of planning each trail.

Chapter 5: Sources of Information identifies a wide range of information sources, including websites, data bases, publications, and people.

Chapter 6: Glossary defines wildlife terms likely to be encountered in further reading.

How to use this handbook

There are many ways to use this handbook. Readers who are new to wildlife issues may choose to read the handbook from cover to cover. Others may want to turn first to the wildlife planning checklist (or its summary on the next page) to find issues for which they would like more background. Others may wish to look up a specific topic or source of assistance.

The handbook's two major sections—the primer and the checklist—are offered as distinct ways of accessing the same issues and information. Readers are free to choose the approach that best fits their circumstances.

This handbook should not be thought of as a cookbook, with a one-size-fits-all approach. Every trail project is different and the important ecological issues will vary widely with the kinds of trails, wildlife, and habitat.

The Primer introduces topics

If you have general questions about the interactions of wildlife and trails, the primer—which is organized around broad wildlife topics—is a good place to start. In addition to key concepts and rules of thumb, references are presented for each topic.

The Checklist suggests steps

The checklist focuses specifically on wildlife issues of trail planning and is designed to mirror comprehensive planning processes. This should make it easier to integrate the information into the ways trails are already being planned.

If you are beginning to plan a trail and want to find appropriate ways of including wildlife issues, the checklist may be a practical aid. It raises important questions through each step of the planning process.

Overall Handbook goals

This brief document functions best at raising issues, presenting background, offering suggestions, and providing references to other, more in-depth, sources of information. The authors hope that the handbook also will encourage more discussion and study of wildlife and trails issues.

Overview of the Wildlife and Trails Planning Checklist (See Chapter 3 for details.)

Step A. Getting the Whole Picture

1. *Include wildlife in the trail vision*

   Look at the broader landscape of the area where you are considering a trail. What opportunities or constraints are there for trails and wildlife in the broader landscape? What plans are there for other trails or wildlife across the landscape? Do you foresee any cumulative trail impacts by adding a new trail? Ask the help of a biologist and other professionals, as needed. What kinds of goals and activities do you foresee for the trail? What are your wildlife goals for the trail project?

2. *Organize & communicate*

   Share your ideas and findings with other community members, including trails and wildlife enthusiasts and property owners and managers. Find ways, such as community meetings, field trips, or a web site to discuss ideas and issues related to the possible trail. What opportunities are there for both recreation and wildlife protection in the corridor? Do the ideas seem to complement or conflict?

3. *Research and inventory*

   Find information about local wildlife habitats. Conduct an inventory of the area's sensitive plants, animals, and critical habitat. Note any special opportunities for wildlife education. To the degree possible, understand the existing impacts to wildlife in the area.

Step B. Considering Alternatives

1. *Prepare and evaluate alternative concept plans*

   Looking across the broader landscape, identify and evaluate several distinct alternative alignments for a trail. (Where an existing trail is to be upgraded, alternatives might include different management strategies.) Use this handbook's rules of thumb and other information to guide the design, to help maximize the opportunities, and to minimize the constraints for wildlife. Get professional trail planning help, as needed. Are there opportunities to use the trail as a catalyst to restore degraded habitats and preserve pristine areas? Review the alternatives with the community and appropriate land managers and select a preferred plan to refine.

2. *Design the trail*

   Develop designs, budgets, time tables, and management strategies for the preferred plan. Review and refine the plan with the help of a wildlife biologist.

Step C. Building & Managing

1. *Part 1: Acquire and construct the trail*

   If land is to be acquired for the trail, look for additional areas that can be set aside at the same time for wildlife conservation. Implement the plan, being careful to impact wildlife as little as possible during construction.

2. *Part 2: Manage and monitor the trail*

   Have a clear plan to manage the trail corridor and activities within it. Monitor the effects of the trail on plants and wildlife and adjust management plans as appropriate. Look for ways to involve the public and to provide educational opportunities.

The Colorado State Parks Trails Program will be updating this handbook periodically and invites your comments and suggestions. (Colorado State Parks—Trails Program, 1313 Sherman Street, Room 618, Denver, CO 80203 or e-mail: MacTrail@aol.com)

Additional current information about wildlife issues in trails planning may be found in the Trails section of the Colorado State Parks website: http://www.dnr.state.co.us/parks/

Some overall observations

In creating this handbook, we found a number of overarching themes:

• When planned with wildlife in mind, trails can be effective management tools that help reduce the impacts of people on wildlife.

• A trail is more than a thin line traversing the landscape. To respect wildlife, a trail must be planned in conjunction with its zone of influence.

• In building a trail, we may choose to impact wildlife and habitats, but we should do so with an understanding of the implications.

• In many cases, scientific knowledge alone can't determine whether wildlife impacts are great enough to preclude a trail. The decision also should be based on community values, including the benefits the trail will offer the public.

• Wildlife don't necessarily see the landscape the way we do. What may appear to a person to be a minor change may be perceived quite differently by wildlife.

• If we learn to see the landscape more as wildlife do, we can find trail alignments that will have less impact on their surroundings.

• Understanding both the existing and potential impacts of a trail to wildlife can help set more realistic goals for a trail project.

• Native biological diversity is much more than a count of the species found in an area. Instead, it is a broader concept that includes all facets of our natural living heritage.

• The best strategy in planning trails is always to avoid impacts to wildlife. The next best is to minimize the impacts. The last resort is to mitigate for impacts.

• Plan and manage a trail in ways that help make users more predictable to wildlife so they can acclimate to people.

COLORADO'S WILDLIFE ARE VARIED AND INTERESTING

When planning trails with wildlife in mind, it may be helpful to think of specific wildlife species as part of your trail users group, along with recreationists. There are several good introductions to our state's wildlife, including:

Armstrong, David Michael; James P. Fitzgerald, Carron A. Meaney 1994. *Mammals of Colorado.* University Press of Colorado, Boulder, Colorado.

Benedict, Audrey DeLella 1991. *Sierra Club Naturalist's Guide to the Southern Rockies*. Sierra Club Books, San Francisco.

Emerick, John C.; Cornelia Fleisher Mutel 1992. *From Grassland to Glacier: The Natural History of Colorado.* Johnson Publishing Co., Boulder, Colorado.

Kruger, Frances Alley; John Fielder; Carron A. Meaney, Denver Museum 1995. *Explore Colorado: From Plains to Peaks.* Westcliffe Publishers, Englewood, Colorado.

Rennicke, Jeff 1996. *Colorado Wildlife*. Falcon Press, Helena, Montana.

Whitaker, John O., Jr. 1996. *National Audubon Society Field Guide to North American Mammals.* Alfred A. Knopf, Inc. New York, New York.

2. Wildlife and Trails Primer

Knowing how wildlife respond to recreationists and their trails is a vital part of planning trails. This section of the handbook gives an overview of the major wildlife issues relevant to trail planners and provides references for more in-depth study. The topics presented here are some of the most important for incorporating wildlife concerns into trail planning

Key Concepts and Rules of Thumb

Key concepts are presented as an introduction to each Primer topic. To make the concepts practical, rules of thumb are also given with each topic. The rules of thumb are intended as helpful advice for wildlife situations that are generally too complex for ironclad, universal principles.

For more detailed discussions

References for further reading are given with each Primer topic. These books are general in nature, and readily available in bookstores. More detailed information—on how individual species relate to trails, for example—may be available through the Colorado Trails and Wildlife Bibliographic Data Base. (See Chapter 5: Sources of information.)

A RULE OF THUMB IS:

1 : a method of procedure based on experience and common sense.

2 : a general principle regarded as roughly correct but not intended to be scientifically exact.

Practical advice is offered in each of these volumes. For example, in each chapter, Knight and Gutzwiller offer "management options for coexistence," Smith and Hellmund include planning guidelines, and Dramstad and colleagues offer useful principles of landscape ecology.

Full citations for the most common references are given below.

Dramstad, W., J. Olson, and R. Forman, 1996. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*, Island Press, Washington D.C.

Forman, R. 1995. *Land Mosaic: The Ecology of Landscapes and Regions.* Cambridge University Press, Cambridge.

Forman R. and M. Godron, 1986. *Landscape Ecology.* John Wiley and Sons, New York.

Knight, R. and K. Gutzwiller, eds., 1995. *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press, Washington, D.C.

Noss, R. and A. Cooperrider, 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press, Washington, D.C.

Smith, D. and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn.

A. Trails and their zones of influence

Key Concepts

As with anything we build in the landscape, **a trail changes its surroundings**. Some of these changes are minor and temporary—such as when a deer moves away from an approaching hiker, to return to browse once the hiker has gone. Other changes have wider ramifications and duration—such as when aggressive bird species follow trails, expanding their habitat, displacing sensitive species, and preying on songbirds and other sensitive neotropical birds.

These changes to a trail's surroundings may extend for hundreds or even thousands of feet on either side of a trail. (They are sometimes referred to as trail distance effects.)

Collectively these effects define a **zone of influence** associated with a trail. This zone is also the primary experience area for recreationists using the trail. Without wildlife in this zone, trail users would have a less diverse experience.

There is a **natural variability** to landscapes, so the width of a zone of influence varies along a trail's length.

Some of the effects characteristic of a trail's zone of influence are what biologists refer to as **edge effects**. Edges attract more **generalist species** at the expense of **more specialist species**, which have fewer options in increasingly human-dominated landscapes. (There are more and more ecological edges in the world as a result of increasing human development of all kinds.)

The specific edge effects of a trail and their associated widths depend on the **characteristics of the trail** (how wide it is and its type of users, for example) and the **surrounding landscape** (how sensitive local wildlife are).

Trailheads and other **trail facilities**, which have their own characteristics and impacts on wildlife, contribute to the extent of a trail's zone of influence and should not be forgotten in the planning process.

A trail's area of influence should be planned and managed as an integral part of the trail. This influence zone should provide recreationists with meaningful interactions with nature, without infringing on sensitive habitat.

Rules of Thumb

A.1 Always some impact. Any trail will have at least some negative impacts on wildlife. Such impacts must be weighed with the benefits of the trail.

A.2 The broader view. In considering wildlife, don't focus solely on the narrow width of the trail's treadway; also consider the wider area it may influence.

A.3 Sensitive vs. non-sensitive. Trail corridors may encourage some species of wildlife, such as jays, raccoons, and other edge-loving generalists, but these species are already increasing across the landscape and may not need encouraging.

A.4 Negative effects. Trails may negatively affect species that need conditions (such as specific vegetation or light) that are altered in trail construction.

A.5 Degraded areas. Seek out degraded areas that have the potential to be restored when aligning a trail, rather than creating another disturbed area.

A.6 Edges. Align a trail along or near an existing human-created ecological edge, rather than bisecting undisturbed areas. When this is possible, the trail will not create a totally new ecological edge.

A.7 Avoid sensitive wildlife. Keep a trail—and its zone of influence—away from specific areas of known sensitive species, populations, or communities. Where appropriate, use glimpses of these areas as opportunities for educating trail users.

A.8 Think thin. In constructing or upgrading a trail, disturb as narrow an area as possible to help minimize the zone of influence.

Radiating out from every trail is a zone of influence, the width of which varies with local conditions over the length of the trail. Planning a trail with this in mind can greatly help anticipate the future interactions of the trail and wildlife.

A.9 Screening. Locate trails and supporting facilities in areas where they can be screened and separated from sensitive wildlife by vegetation or topography. This approach is less disturbing to wildlife and reduces the amount of energy wildlife must use in reacting to recreationists.

A.10 Rewarding trails. Provide trail experiences that are diverse and interesting enough that recreationists are less inclined to create their own trails and thereby expand the zone of influence.

A.11 Predictability. The more predictable human actions are, the more adaptable wildlife may be to those actions.

Further Reading

Dramstad, W., J. Olson, and R. Forman, 1996. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*, Island Press, Washington D.C., pp. 27-29.

Noss, "Wildlife Corridors" in Smith, D. and P. Hellmund, 1993. *Ecology of Greenways*. University of Minnesota Press, Minneapolis, Minn., pp. 58-59.

Noss, R. and A. Cooperrider, 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity*. Island Press, Washington, D.C., pp. 197-203.

Forman R. and M. Godron, 1986. *Landscape Ecology*. John Wiley and Sons, New York, pp. 108-109.

Forman, R. 1995. *Land Mosaic: The Ecology of Landscapes and Regions*. Cambridge University Press, Cambridge, pp. 81-111.

Variable	*Example interactions*
VEGETATION	Some types of vegetation, such as dense forests, can visually screen trail users more than others.
WILDLIFE SPECIES	Some species are more sensitive to human activities than others.
SEASON	Certain times of the year, such as breeding season, may be more sensitive than others for wildlife. Also, during dormant periods, some plants may be less easily impacted.
TIME	During resting, feeding, or other specific times of the day, wildlife may be more susceptible to disturbance.
WEATHER	In cold weather, recreationists may have greater impact on wildlife because of the increased energy wildlife must expend to avoid the recreationists.
TRAIL/USER LOCATION	Wildlife may respond differently if trail users are above or below them, on or off a trail.
SURROUNDING LAND USE	Trail impacts may be less significant in an already disturbed area.
INTENSITY/LEVELS OF USE	More intensive or higher levels of trail use may have farther-reaching impacts.
PREDICTABILITY	The more predictable trail users are, the more likely their presence can be incorporated into the daily strategies of wildlife.
RECREATIONAL ACTIVITY	There is greater impact when recreationists bring along dogs. Also the speed of activity influences the level of disturbance

How wide an area will be influenced by a trail is determined by many variables in a complex interaction. Some of these variables and examples of their effects on the interactions of wildlife and recreationists are shown above. (Adapted from Clinton Miller, City of Boulder Open Space, 1994)

B. Avoiding large natural areas

Key Concepts

Typically as we go about building communities—and especially the infrastructure that supports them—we cut across and through streams and forests, windbreaks and prairies—the natural systems around us. This tends to leave ever-smaller areas that are even more directly impacted or influenced by humans.

This **habitat fragmentation** is considered by many biologists to be the single greatest threat to biological diversity. Some species, such as lynx and wolverine, for example, may not survive without **large, unbroken blocks** of habitat.

There is little specific knowledge of how much a trail may contribute to these factors or ultimately help degrade biological diversity. The extent of the impacts depends on a number of factors, including the **type of habitat,** the **species present**, and the **characteristics of the trail**, including how heavily it is used by people.

As mentioned above, trails have zones of influence (of variable width) associated with them. Taking this added width into account, it is easier to understand how a region criss-crossed with trails could end up with few areas not somehow influenced by humans.

In a complex series of interactions, fragmented habitats may see:

- an **influx of plant and animal species** (usually generalists) that like or tolerate the new conditions of light, wind,or human presence; and
- a **decline of species** that cannot tolerate these conditions or are adversely impacted by the species newly arriving in the trail's zone of influence.

The new species may include weeds and other exotic plant species, as well as predators that eat the eggs or young of indigenous wildlife.

These new conditions and interactions can change the trail's zone of influence in ways that **may not be obvious** to the casual observer.

The impacts of a trail on the biological diversity of a large area that has already been heavily disturbed may not be significant. For example, constructing a trail through a young, even-aged stand of lodgepole pine that has regrown after clearcutting may not change how wildlife use the area. If the stand has very low diversity of wildlife—as is often typical of this type of habitat—it is even possible wildlife diversity might increase with the creation of the trail.

Protecting large, undisturbed areas of wildlife habitat should be a priority. Deciding whether or not to build a trail that may contribute to fragmentation is a tradeoff that the local community or land manager will have to make.

Rules of Thumb

B.1 Big habitat areas. When possible, leave untouched large, undisturbed areas of wildlife habitat. They are an important—and rapidly vanishing—resource. Identify and seek to protect all such areas when aligning a trail.

B.2 Edge trails. It is better to route a trail around the edge of an area of high quality, undisturbed habitat, than through its center.

B.3 Trail density. Keep the density of trails lower within and near pristine or other high quality areas to reduce the contribution of trails to fragmentation.

B.4 Stepping-stone patches. Avoid small patches of high quality

HOW TO EXTRAPOLATE PRACTICAL INFORMATION FROM A SCIENTIFIC JOURNAL ARTICLE

There may be no existing specific studies of wildlife and the potential impacts of a trail for your particular area, but you can still get help from scientific journal articles and other sources. It may take time to get used to scientific jargon, but it is possible to cull practical information from such sources with patience.

In particular in reading an article, consider: Are the species of wildlife examined in the study the same as my project? Is the habitat type the same? Are the trail uses you anticipate similar to those studied, if any?

Through this process, you can start to develop new rules of thumb to apply to your trail project.

habitat in routing a trail. Such patches may be important stepping stones used by wildlife to move across the landscape.

B.5 Balancing needs across landscapes. It is easier to balance competing wildlife and recreation needs across a landscape or region than it is on a specific trail project within a smaller area.

Further Reading

Smith, "An Overview of Greenways" in Smith, D. and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn., pp. 2-4.

Forman, R. 1995. *Land Mosaic: The Ecology of Landscapes and Regions.* Cambridge University Press, Cambridge, pp. 405-434.

Noss, R. and A. Cooperrider, 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press, Washington, D.C., pp. 50-54.

Harris, L.D. 1984. *The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity.*

Trails should be routed away from large, undisturbed areas of sensitive wildlife habitat, such as the forest in the left of this illustration. Such areas are a valuable natural resource that is rapidly disappearing from the American landscape. With their loss go species of wildlife that cannot survive without extensive, undisturbed habitats.

C. Tools for a broader view

Key Concepts

It's only when looking at the **broader landscape over time** that one can discover how wildlife use a place and what impacts activities in one area will have in another.

Fortunately, the relatively new discipline of landscape ecology provides useful tools for describing and analyzing broad landscape patterns and functions.

Looking across a **landscape**, especially from above, you typically see a mix of **patterns**—a wetland patch here, a stream corridor there. These components of the landscape function in varying ways for wildlife.

Knowing the locations of patches, corridors, and matrices—the structural elements of the landscape—helps identify edges and habitat blocks. How these elements of the landscape are used by wildlife varies from species to species: what is an edge for one species may not be for another.

Part of understanding the broader picture is **looking at the landscape over time.** Such a perspective makes clear that how wildlife use the landscape can be very dynamic. There may be substantial changes in how wildlife use the landscape from season to season and year to year.

Looking at changes across landscapes and over time, it is easier to make a trail compatible with a larger conservation effort. Such a regional plan seeks to balance trails and wildlife goals across the region. This is one way to make certain that there is a balance between streams with roads and trails and undeveloped streams devoted to wildlife habitat.

One framework for making a plan for a landscape or region—a part of which could be a trail plan—is that developed by Noss and Cooperrider (1994). Their approach divides an area into core biological reserves that are surrounded by buffers and connected by wildlife corridors. The core areas are strictly for nature preservation. In each successive buffer more human activities are allowed.

Trails might go into the core areas only rarely but would be more common in buffer areas.

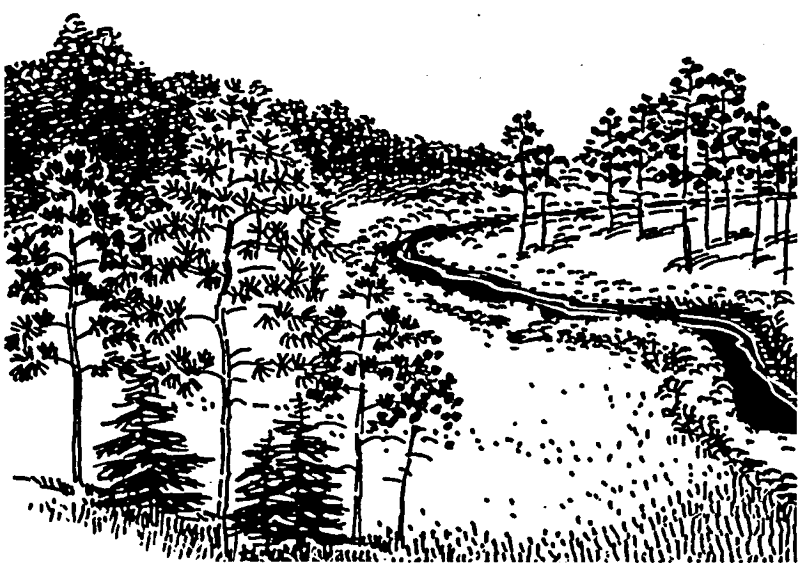
With this kind of coordinated plan there it is easier to accommodate competing objectives.

The Noss and Cooperrider approach is similar to the Forest Service's landscape assessment and planning effort.

Rules of Thumb

C.1 Regional view. Plan a trail consistent with a regional or landscape-wide plan that identifies where trails should go and which areas should be conserved for wildlife. Balance the needs of wildlife and recreationists across that larger perspective.

C.2 Already disturbed areas. Site a trail where there are already human-created disturbances or in areas of less sensitive habitat.



Landscape ecology provides many useful tools for understanding and documenting the landscapes through which trails pass. By identifying a landscape's patches (such as the stands of trees in the illustration), corridors (e.g., the stream), and surrounding matrix (e.g., grasslands), it may be easier to find the best alignment for a trail, one that fits the landscape.

C.3 Landscape structure. Analyze the landscape noting the patches, corridors, and matrix—the landscape structure—as they might be used by species of special interest.

C.4 Corridor crossings. Minimize the number of times prominent landscape corridors—such as riparian zones—are crossed by a trail. These corridors may serve as important conduits and habitat for wildlife.

C.5 Smaller, isolated patches. Avoid smaller, isolated patches when laying out a trail, but do give users an experience of the varied landscape.

C.6 Sensitive patches. Avoid patches that are habitat for threatened, endangered, or other species of concern.

C.7 Involving conservation advocates. Enlist the help of conservation advocates in planning trails. Find opportunities to integrate trails and open space planning.

Further Reading

Dramstad, W., J. Olson, and R. Forman, 1996. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning,* Island Press, Washington D.C.

Noss, R. and A. Cooperrider, 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press, Washington, D.C

Thorne, James 1993. "Landscape Ecology," in Smith, D. and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn., pp. 23-42.

Forman R. and M. Godron, 1986. *Landscape Ecology.* John Wiley and Sons, New York, pp. 83-225.

Forman, R. 1995. *Land Mosaic: The Ecology of Landscapes and Regions.* Cambridge University Press, Cambridge.

D. Habitat quality varies

Key Concepts

Not surprisingly, **types of habitat** vary widely in the number and kinds of wildlife using them. (Frequently habitat type is used as a surrogate for wildlife use because vegetation is easier to observe and map.)

For example, the 33 habitat types included in the Colorado Division of Wildlife's "Latilong" data base potentially have a range from 35 species for tundra to 302 for lowland riparian areas.

The top two ranking habitat types, in terms of overall numbers of species and the most threatened or endangered species, are riparian, which illustrates why there is so much interest in conserving such areas found near water.

None of this is to suggest the **number of species** is the only or best measure of a habitat's value to wildlife, although some habitats are used by more species of wildlife than others.

Tundra (33), for example, because of its severe climate, has a low diversity of wildlife species. Yet tundra plays a vital role in the lives of species that are important components of Colorado's biodiversity.

Lodgepole pine forests (19) tend to have a moderate to low diversity of plants and animals. Because typically they are dense forests, recreationists may not be seen or heard by wildlife from as great a distance as open areas.

An important consideration in aligning a trail is the relative **resiliency** of habitats that might be crossed.

Rules of Thumb

D.1 Variety of experience. Route a trail through varied habitat types to enrich user experiences, but avoid small patches of species-rich habitats.

D.2 Potential vs. actual species. Determine which species of interest actually occur in the area you are studying. Wildlife data bases sometimes list species that potentially occur within a given habitat type; not all of these species may actually be found there.

D.3 Screening. Consider the physical characteristics of habitat types when routing a trail. For example, trail users may be screened in some forest types.

D.4 Habitat variability. Even within a single type of habitat, some elements may be of greater importance to wildlife than others. For instance, shrubby thickets of snowberry or American plum within riparian habitat provide very important cover and food for birds and small mammals.

Further Reading

Kruger, Frances Alley; John Fielder; and Carron A. Meaney, Denver Museum 1995. *Explore Colorado: From Plains to Peaks.* Westcliffe Publishers, Englewood, Colorado.

COLORADO HABITAT TYPES	NUMBER OF SPECIES	THREATENED & ENDANGERED	SPECIAL CONCERN SPECIES
1. Riparian Lowland (below 6000 ft.)	302	5	8
2. Riparian Transition (6000-9000 ft.)	222	6	2
3. Piñon-Juniper Forest	179	1	5
4. Scrub Oak	153	2	0
5. Urban Areas	146	2	0
6. Agricultural Areas with Trees	142	1	3
7. Open Water—Lakes or Reservoirs	139	5	14
8. Marshes/Bogs	130	5	5
9. Ponderosa Pine Forest	128	4	0
10. Shortgrass Prairie	126	3	11
11. Mountain Mahagony	112	1	0
12. Greasewood/Sagebrush or Saltbush	111	0	6
13. Sagebrush/Rabbitbrush	111	1	4
14. Riparian Highland (above 9000 ft.)	111	3	1
15. Tallgrass Plains	89	1	1
16. Mountain Meadow/Parkland	89	4	3
17. Sagebrush	86	3	1
18. Spruce-Fir Forest	86	4	1
19. Lodgepole Pine Forest	81	5	1
20. Douglas Fir Forest	78	4	1
21. Mixed Grasses of Disturbed Areas	78	1	1
22. Aspen Forest	70	4	0
23. Shortgrass Semi-Desert	70	0	2
24. Wet Open Ground	69	3	3
25. Cholla Cactus Grassland	65	0	1
26. Open Water—Streams/Rivers	64	4	9
27. Shortgrass-Mountains	64	0	0
28. Limber Pine Forest	60	1	0
29. Bristlecone Pine Forest	56	0	0
30. Sand Sage Prairie	54	1	2
31. Cropland	44	2	2
32. Alpine Transition	40	1	0
33. Tundra	35	0	0

Use of habitats by wildlife varies widely. The number of wildlife species potentially found in the various types of habitat listed in the Colorado Division of Wildlife's "Latilong" data base varies widely. This ranking shows why riparian areas are so significant to Colorado's wildlife. Note: The data base includes mammals, birds, reptiles, and amphibians, but not fish. (Dave Weber, Colorado Division of Wildlife, 1998.)

E. The importance of streamside areas

Key Concepts

Riparian areas play a disproportionately large role in maintaining biodiversity, especially in Colorado and other western states. The hydrology and vegetation of riparian areas—usually starkly contrasting with surrounding habitats—create very high biological diversity. (The term **riparian** refers to the area associated with streams and other bodies of water.)

For example, of the 627 vertebrate species listed in the Colorado Division of Wildlife's "Latilong" data base as occurring in the state (including mammals, birds, reptiles, and amphibians), 458 species (73 percent) use riparian, stream, lake, or marsh habitat types for at least some part of the year. More than 80 percent of Colorado **breeding birds** are dependent on riparian areas.

Not all riparian areas are high in habitat quality. Because they are attractive to people, frequently riparian areas have seen many human uses and are degraded. Trails projects can be catalysts for restoring such areas.

Because they help concentrate human use and thereby reduce trampling, trails can reduce the impacts of people on riparian areas.

By understanding the relative quality of riparian areas, it may be possible to find places within the riparian zone for trails that will have less impact on wildlife.

Plants in riparian soils are especially vulnerable to **trampling** because compacting soils damages and limits roots, reduces aeration, decreases soil water, and destroys soil structure.

Where horses, pedestrians, and others cross streams, erosion can result which may affect fish habitat. Also if rest rooms are not available, the impacts of human waste may be considerable.

Fishing is a type of managed recreation that has direct impacts on habitat, as well as fish. Of special concern are the extensive **social trails** often created along banks by anglers, sometimes in sensitive riparian areas.

Rules of Thumb

E.1 Regional balance. Looking across the landscape or region, find a balance between the riparian areas that have trails and those devoted to wildlife conservation.

E.2 Habitat restoration. Use the process of building trails as a catalyst to restore degraded stream corridors.

E.3 Removing grazing. Whenever possible, use a trail as a catalyst to restrict cattle and other stock from good quality riparian areas.

E.4 Strategic entries into riparian zone. For both habitat and maintenance reasons, it is better to run a trail just outside the riparian area (perhaps on a topographic bench) and bring it in at strategic places, than to keep it continuously close to a riparian area.

E.5 Not encircling ponds. In routing a trail near a pond or lake, don't run it completely around the body of water. Instead, leave some shoreline without a trail to allow water birds the option of moving away from people to the far side of the pond.

E.6 Beaver ponds as attractions. Occasionally taking a trail to beaver ponds may provide an opportunity for trail users to see wildlife habitat close at hand. Beaver are not as likely to be disturbed by recreationists as other wildlife, but be careful of sensitive species that also use beaver ponds.

E.7 Stream crossings. Minimize the number of times a trail crosses a stream. However, stream crossings may be needed to avoid critical habitat areas.

E.8 Stream confluences. Avoid crossings where two or more streams come together. These are particularly important nodes for wildlife.

E.9 Stream buffers. To maintain natural processes along a stream corridor, maintain an interior or upland buffer on both sides of a stream, which is wide enough to control overland flows from the surrounding landscape, provide a conduit for upland species, and offer suitable habitat for floodplain species displaced by beaver flooding or channel migration.

E.10 Poor riparian habitat. In riparian areas of variable habitat quality, route a trail closer to a stream where habitat quality is poorer.

E.11 Approaching streams. Give trail users the opportunity to be near water or they will find ways themselves, likely with greater overall impact than if a trail is provided.

E.12 Wider conservation. Use public support of trails to protect riparian corridors.

E.13 Restoring wetlands. Restore wetlands near a trail to expand cover, food, and nesting opportunities.

Further Reading

Binford and Buchenau, "Riparian Greenways and Water Resources," in Smith, D. and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn., pp. 69-104.

Carefully consider how and where to route a trail through a streamside area. These riparian zones are rich habitat for wildlife. The illustration shows a trail alignment running primarily outside the riparian area, but moving into it at places where wildlife is less likely to be disrupted. (Left: plan view, right: sketch.)

F. Species and places of special interest

Key Concepts

While some species (such as bald eagle and Ute ladies-tresses orchids) and habitats (such as wetlands) have **legal status** that must be respected in the process of trail building, others may deserve special attention because of the **value placed on them by a local community.**

Threatened and endangered are legal designations applied to certain species of plants and animals perceived to be in danger of potentially becoming extinct, either in the world, country, or state.

For those working in Colorado, there are two lists of threatened or endangered (T&E) species. One is issued by the federal government, the other by the Colorado Division of Wildlife.

The federal T&E list includes species that are in danger of becoming extinct nationally. The Endangered Species Act, which provides some protection for these species, is administered by the U.S. Fish and Wildlife Service.

The degree to which the law protects species on the list is complicated and varies depending on the individual species. It is best to discuss specific situations with U.S. Fish and Wildlife Service (USFWS) personnel. (See website: http://www.fws.gov/pullenl/cais /tespec.html or call the Service's Colorado Field Supervisor, 303-275-2370.)

To review the Endangered Species Act see http://www.fws.gov/r9endspp/esa.html#Lnk03

If your project includes a federal action, permit, or funding and will impact a federally listed species, you must contact the USFWS for what is known as a Section 7 consultation. Even if your project has no association with the federal government, if you believe there may be an "incidental takings" of a federally listed species you must have a Section 9 consultation with the Fish and Wildlife Service.

The State of Colorado T&E list includes species that are in danger of becoming extinct in Colorado, but not necessarily in the country. Almost all species on the Federal list are on the Colorado list, but the Colorado list includes several species that are common elsewhere in the country, but rare in this state.

Colorado law gives no protection to the habitat of species on the state list, but provides for increased penalties for directly killing such animals.

The Colorado Division of Wildlife administers the law, and its personnel—either the district wildlife manager or the habitat biologist in a region—should be contacted with questions about state-listed species. (For a copy of the complete list, visit the Division of Wildlife's website: http://www. dnr.state.co.us/wildlife/T&E/list.html or request a free copy of the brochure: "Non-game Wildlife Regulations" from: Colorado Division of Wildlife, Order Fulfillment Center, 6060 Broadway, Denver, CO 80216.)

The Division of Wildlife only offers advice and does not approve or reject projects.

Some **wetlands** are protected by federal legislation. Special (404) permitting is required before they can be disturbed. (See sidebar opposite.)

Other **specially designated areas** to take note of include:

- proposed wilderness study areas
- wilderness areas
- inventoried roadless areas
- USDA Forest Service research natural areas and areas with a prescription emphasizing wildlife, flora, fauna, or ecological values
- BLM areas of critical environmental concern
- wild and scenic rivers
- Colorado State Natural Areas,
- significant archeological sites, and
- other officially protected areas.

Extra care and research should be taken when proposing a trail in any of these areas or in areas that may be of local concern.

Plans for trail construction that will affect a stream must, by Colorado law (Senate Bill 40), be approved by the Colorado Division of Wildlife, if they are being done by a state agency or with state funding.

Rules of Thumb

F.1 Avoiding sensitive areas. Generally avoid specific areas where there are known species, populations, or communities of special interest and where potential impacts of a trail are uncertain. This is especially true of breeding sites of big game and raptors.

F.2 Spur trails. When it is appropriate to provide access to a more sensitive area, use a spur (i.e., dead-end) trail instead of a through trail because spur trails tend to have lower volumes of traffic. This is because, given a choice, people tend to stay on a through path rather than take a spur.

F.3 Expert advice. Check with the U.S. Fish and Wildlife Service and the Colorado Division of Wildlife about special species and places. Check with the U.S. Army Corps of Engineers regarding impacts to wetlands.

Further Reading

In general there is considerable information available for individual species and specially designated areas.

WETLANDS PERMITS

Before you disturb a wet area to build a trail or a bridge, you should determine if you will need a wetlands permit from the U.S. Army Corps of Engineers.

The federal government defines a wetland as an area with saturated soil in low depressions, secondary stream channels, or in areas that "appear to feel wet." In most cases, wetlands created by people are subject to the same protection as naturally occurring wetlands.

Wetlands regulations include filling, draining, excavating, and flooding.

Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands.

There are two basic types of 404 permits issued by the Army Corps, individual and general. An individual permit is usually required for potentially significant impacts. However, for most discharges that will have only minimal adverse effects, the Army Corps often grants general permits. These may be issued on a nationwide, regional, or statewide basis for particular categories of activities (e.g., minor road crossings, utility line backfill and bedding) in order to expedite the permitting process.

When applying for a permit you must show that you are in compliance with the EPA §404b(1) guidelines. These include:

1) avoiding wetland impacts where practicable,

2) minimizing potential impacts to wetlands, and

3) providing compensation for any remaining unavoidable impacts through activities to restore or create wetlands.

Other permit application requirements include a §401 Water Quality Certification from the appropriate Regional Water Quality Control Board.

If threatened or endangered species may be affected by the proposed activity, the Army Corps will consult with the appropriate Federal agency (e.g., U.S. Fish and Wildlife Service) to obtain a biological opinion on the affects to the species.

For more information see the following websites:

http://www.epa.gov/owow/wetlands/
http://www.epa.gov/docs/Region4Wet/overview.html
http://ceres.ca.gov/wetlands/permitting/sec_404.html

Or call the U.S. Army Corps of Engineer.

G. A site's existing impacts

Key Concepts

It is very rare that an area proposed for a trail hasn't already seen **at least some impact** from humans. The questions then become—How disturbed is the site? What kinds of impacts to wildlife already exist there?

With this kind of **ecological evaluation,** it will be easier to set reasonable wildlife goals for a trail or to evaluate the tradeoffs between wildlife and trails. Every trail project should have wildlife goals.

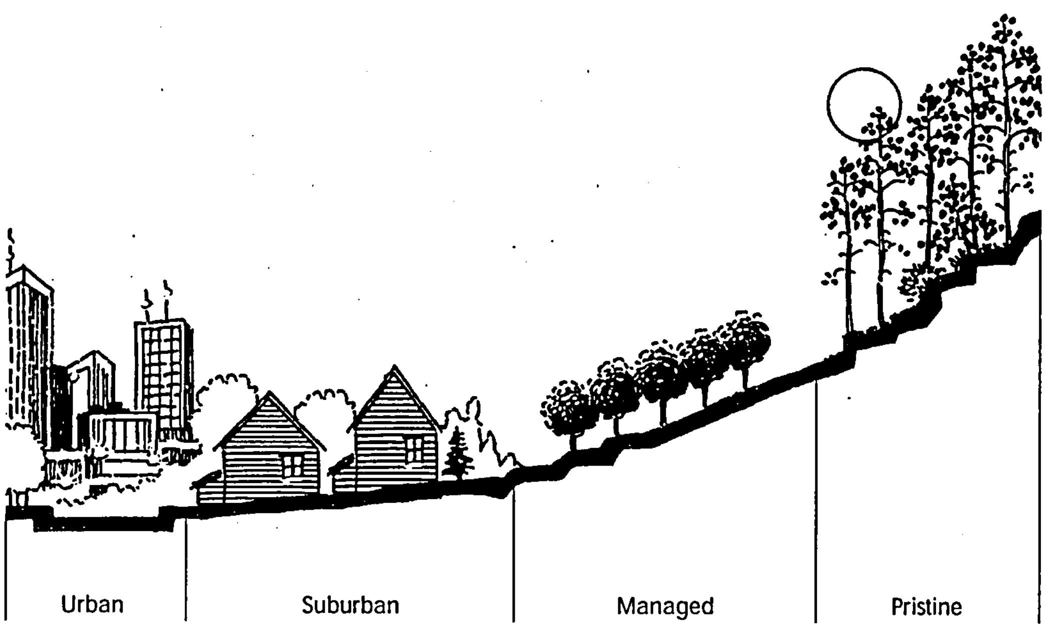
The specific wildlife goals and rules of thumb you apply will partly depend on **how disturbed a site is.** Typically, urban landscapes are heavily disturbed and restoring habitat may be the principal wildlife goal. In more pristine settings, preserving what is already there and minimizing impact may be the major concerns.

An important first step is determining where a site fits on the gradient of human modification ranging from urban (highly modified) to pristine (few modifications).

Even portions of **wilderness areas** may have had some human impacts from activities such as mining, forestry, or road building. Understanding these modifications can help guide trail alignments. For example, trails might follow **ecological edges** created by historic roads or timber cuts.

In gauging how modified an area already is, there are some practical questions to ask:

- Generally, what kind of wildlife habitat is present? What condition is it in?
- Are the plants and animals typically associated with that habitat actually present? Is the ecosystem already impoverished to some extent?
- What are and have been the human impacts to wildlife in the area?
- What are the surrounding land uses and condition of habitat? How close is any nearby development? Are there already roads bounding the area under consideration for a trail, posing obstacles to wildlife movement?
- Overall, to what extent is the site insulated from external forces?
- What opportunities are there to improve habitat on the site?



Assessing the amount of human disturbance already along a potential trail alignment can help set more realistic wildlife goals for a trail project. Trail alignments may pass through one or more of the general levels of modification along a gradient from urban to pristine.

Rules of Thumb

G.1 Patterns of disturbance. The best trail alignments work with the existing patterns of disturbance already in a landscape, rather than imposing an entirely new set.

G.2 Existing human disturbance. Before setting wildlife goals for a trail project, consider the degree to which an area has already been modified by people.

G.3 Urban limitations. In urban landscapes there are often few options for routing trails other than streetside (where there are not many ecological implications) and along streams and other drainages often already transformed for flood control.

G.4 Restoring habitat. Trail projects can aid wildlife by being catalysts for restoring habitat, creating wetlands, and planting native plant species for food, cover, and visual screening.

G.5 Seeking professional help. Without special training, it's easy to overlook or oversimplify wildlife issues. Get professional assistance whenever possible.

Further Reading

Thorne, "Landscape Ecology," in D. Smith and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn., p. 27.

Forman R. and M. Godron, 1986. *Landscape Ecology.* John Wiley and Sons, New York, pp. 286-310.

H. How wildlife respond to trails

Key Concepts

The construction of a trail **directly impacts** the habitat it displaces. Specifically, vegetation removed in the process of building a trail is no longer available for use by wildlife.

Once a trail is built, its physical presence also can change its environs. The trail may have created a new **ecological edge**, perhaps increasing the light intensity and prompting a shift in the composition of wildlife and plant species, thus **changing biological diversity.**

Impacts of a trail will depend on the **type of trail use** (e.g., hiking, snowmobiling, biking). These uses do not represent a continuum with hikers at the low-impact end and motorized recreationists at the high end; wildlife impacts are more complicated than that.

That is why, for example, some wildlife refuges allow auto tours but not walking tours because many wildlife species are less fearful of people in vehicles.

Sometimes the response of wildlife to a trail **doesn't last long,** as when a bird stops feeding as a hiker approaches, only to continue eating after the hiker has passed. With **increasing levels of use** and **changes in the type of use,** there may be sufficient disturbance along a trail that some wildlife may move away permanently. **Predictability** can be a major factor in how much disturbance a trail user causes. If trail users stay on a trail they are more likely to be perceived as acting in a predictable fashion and therefore as less of a threat.

Dogs can cause considerable disturbance (because they may chase and kill wildlife), but less so if they are on a **leash** and don't leave the trail.

Paradoxically, **bird watching** and other forms of nature viewing that intentionally seek out close encounters with wildlife may have a significant impact.

Factors affecting the **short-term impact of human disturbance** on wildlife include:

- Type of species and flushing distances;
- Type and intensity of human activity
- Time of year and time of day; and
- Type of wildlife activity (feeding, nesting, roosting, migrating).

For example, a slowly moving birdwatcher may impact the birds he approaches, but only over a more localized area than a speeding motorcycle that may have a briefer impact on any one area, but impact a broader area.

Wildlife characteristics, including type of animal, group size, age, and sex, also determine the response to a disturbance.

Disturbance by humans can cause nest abandonment, decline in parental care, shortened feeding times, increased stress, and possibly lower reproductive success.

If an animal responds to a noise as soon as it hears it, noisy vehicles may affect it at a greater distance than humans can typically be heard.

Trails often pass through areas used by hunters. **Hunting**, by design, affects wildlife. In general, even though hunting reduces animal populations annually, it is often of short duration, closely controlled, and can be used as a wildlife management tool.

In weighing impacts to wildlife, attention is often given to effects on biological diversity. **Biodiversity** is not equivalent to species diversity. It is more than just a count of how many species use an area.

"Biodiversity is the variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting" (Noss and Copperrider).

Although the presence of large numbers of exotic species may boost the count of species in an area, it would probably indicate **declining biodiversity** due to loss of native species. Exotic species frequently outcompete natives and replace them.

Rules of Thumb

H.1 Lack of wildlife knowledge. Because there isn't much detailed knowledge about the effects of human disturbance on wildlife, be cautious in planning a trail, carefully weighing the alternatives.

H.2 Make do. Use the best wildlife information available, even if it is scarce. Get the advice of a biologist.

H.3 Considerable differences. Not only do different species respond differently to trails, different populations of the same species may respond differently, based on previous encounters with people.

H.4 Concentrated use. Generally, it is better to concentrate recreational use rather than disperse it. If social trails have developed in an area, it is probably better to consolidate them into one or a few trails.

H.5 Type of trail use. Some wildlife are more alarmed by hikers than by people who stay in their vehicles, especially if the vehicles don't stop.

H.6 Dog controls. If dogs are to be allowed on a trail where there are sensitive wildlife, the dogs should be leashed or excluded seasonally to reduce conflicts.

H.7 Screening. The natural visual screening of a trail in a wooded area frequently makes most wildlife tolerate greater human disturbance than they would in open terrain. In some areas, it may be possible to plant a vegetative screen or build a screening fence to accomplish similar effects.

H.8 Impacts vs. benefits. Don't assume all wildlife impacts can be resolved through management. There may be situations where the negative impacts of a trail to wildlife outweigh the benefits to trail users and a trail should take a different alignment.

H.9 Breeding areas. Either avoid wildlife breeding areas or close trails through them at the times such wildlife are most sensitive to human disturbance.

H.10 Enforcing closures. If there won't be sufficient resources to enforce a trail closure during wildlife-sensitive seasons, consider rerouting the trail through another area.

Species	Disturbance Factor	Flight Distance*
Mule deer	Person on foot—In low disturbance area	330 m
	— In medium disturbance	250 m
	— In high disturbance	200 m
	— recommended to avoid most flight	191 m
Mule deer	person afoot in winter	200 m
Elk	person afoot in winter	200 m
	highway vehicles	77 m
Elk	cross country skiers in—high use area	15 m
	— low use area	400 m
Mountain sheep	person afoot in winter	50 m
Golden plovers	people on trail	200 m
Eider ducks	land-based disturbance—with a dog	103 m
	— without a dog	52 m
American Kestrel	winter disturbance of person afoot	75 m
Merlin	winter disturbance of person afoot	125 m
Prairie Falcon	winter disturbance of person afoot	160 m
Rough-legged hawk	winter disturbance of person afoot	210 m
Ferruginous Hawk	winter disturbance of person afoot	140 m
Golden Eagle	winter disturbance of person afoot	300 m
Bald Eagle	land activities near roost on shoreline	250 m
Great Blue Heron	land-based activities	200 m
	water-based activities	100 m

*Note: Flight distance is the measurement from the source of the disturbance to the animal when the animal physically flees to a safer location, not the distance at which the animal first responds or is aware of the disturbance.

Flight Distances for a variety of wildlife. Studies have documented a range of responses by wildlife to various forms of disturbance. (This chart was developed from a review of the published literature by Clinton Miller, City of Boulder Open Space, 1994). While these numbers don't specify how far a trail needs to be from wildlife to avoid disturbance, taken together they illustrate a variability based on the species of wildlife and types of disturbance.

Further Reading

Knight and Cole, "Wildlife Responses to Recreationists," in Knight, R. and K. Gutzwiller, eds., 1995. *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press, Washington, D.C., pp. 51-69.

Knight and Cole, "Factors that influence Wildlife Responses to Recreationists," in Knight, R. and K. Gutzwiller, eds., 1995. *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press, Washington, D.C., pp. 71-79.

Noss, R. and A. Cooperrider, 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press, Washington, D.C.

I. What happens to plants near trails

Key Concepts

The most readily **observable impact** of trail recreationists is to vegetation near trails. While these impacts tend to be very localized, they have broader implications because they alter habitat conditions and, in turn, affect wildlife. In most cases, however, these impacts to vegetation are much less than the trampling that results when there is no trail to channel people.

Of special concern should be impacts to plants that have been designated as **threatened, endangered,** or **sensitive.**

If recreationists don't stay on trails, they tend to:

- reduce the density of plants near a trail by trampling and picking;
- compact soil and contribute to erosion;
- alter the composition of species by damaging existing plants, creating bare spots that favor exotic species, the seeds of which are introduced by trail users and their pack animals; and
- in the process, change the vertical structure and spatial pattern of vegetation.

The conditions along trails also can allow weedy, **exotic plants** to invade natural areas. Weeds are a problem because frequently they are more aggressive than native species and yet don't provide the habitat that wildlife get from native species. (Typically, weeds are also less successful at inhibiting soil erosion than native plants.)

Recovery times from trampling vary widely with habitat type,with alpine ecosystems some of the slowest to recover.

In alpine ecosystems, herbaceous meadows are most quickly modified by walking, fellfields with cushion forms are less affected, and turf meadows are least affected of all. Heavy trampling will destroy a turf ecosystem in eight weeks, while a rock-desert (fellfield) will be destroyed in only two weeks.

Rules of Thumb

I.1 Keeping users on trails. In areas with sensitive vegetation, provide a well-designed trail to encourage users to stay on the trail. Use signs, educational materials, and even barriers as appropriate.

I.2 Native plants. In natural areas, use native plants in revegetating along trails because these are the plants wildlife depend upon.

I.3 Weed-free feed. Require use of weed-free feed for horses and other pack animals so they don't spread weeds along trails.

I.4 User education. Educate trail users about the results of direct impacts to vegetation and indirect impacts to wildlife.

I.5 Toilets. Provide toilets at trailheads and other key locations to reduce damage to surrounding vegetation.

I.6 Weed control. To prevent weed spread, control aggressive weeds along trails, especially at trailheads.

I.7 Trampling. Design trails with proper drainage and sustainable gradients so users are less likely to trample vegetation along alternate routes.

I.8 Wet areas. Route a trail around meadows and other wet areas and build up a dry trail in areas where seasonal water creates boggy soil.

I.9 Improving existing trails. To minimize ground disturbance and possible spread of weedy species, reconstruct an existing trail instead of rerouting it.

Further Reading

Cole and Landres. "Indirect Effects of Recreation on Wildlife,"in Knight, R. and K. Gutzwiller, eds., 1995. *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press, Washington, D.C., pp. 183-202.

Cole, "Minimizing Conflict between Recreation and Nature Conservation," in Smith, D. and P. Hellmund, 1993. *Ecology of Greenways.* University of Minnesota Press, Minneapolis, Minn., pp. 105-122.

J. Managing trails with wildlife in mind

Key Concepts

While the specific activities associated with managing a trail come after it has been built, an understanding of **how a trail will be managed** must be part of planning the trail. Management is a poor substitute for a lack of planning.

Trail management is more effective when it is **planned up front,** rather than later as a corrective for poor trail location.

Because environmental conditions change along the length of a trail, it is often useful to identify distinct **zones** along the trail, where management reflects differences in wildlife habitat and recreation use.

Adaptive management—in which the process of managing a trail can be used to learn more about impacts to wildlife—is especially appropriate for trails given the uncertainties of potential wildlife impacts.

The best laid trail plans, carefully crafted and built with wildlife in mind, can be disrupted by people who choose to make trails of their own. **Social trails** are one of the biggest challenges facing trails planners and managers, who may have worked long hours to provide trails that respect wildlife. Social trails degrade vegetation and may increase soil erosion.

Offering wildlife interpretation and environmental education to trail users can play an important role in reducing impacts to wildlife. People more readily protect what they understand and appreciate. Interpretive programs, guided tours, staff interactions, signs, brochures, maps, and videos all can be effective in communicating appropriate visitor behavior among wildlife.

Carefully **monitor** the trail corridor to detect social trails early. Then use brush, boulders, signs, or other means to dissuade use.

Monitoring and other aspects of effective trail management may seem like luxuries, but they are actually basic **stewardship** requirements. Finding the resources to accomplish this stewardship will require the same levels of creative effort as building the trail.

Volunteers can be tremendously helpful in managing trails. They can serve as trailhead hosts or trail guides who offer information about wildlife and trail regulations. They can conduct interpretative programs and help with trash pickup and other maintenance tasks. Volunteers can enforce rules and educate trail users about seasonal wildlife closures, inventory and monitor wildlife, and much more.

Trails present good opportunities for the public to understand wildlife. Whether conducted by volunteers or paid staff, offering **wildlife interpretation and environmental education** to trail users can play an important role in reducing impacts to wildlife. People more readily protect what they understand and appreciate.

Interpretive programs, guided tours, staff interactions, signs, brochures, maps, and videos can all be effective in communicating appropriate visitor behavior among wildlife.

Sound **regulations** are needed to protect wildlife, but they also need to be enforced.

Rules of Thumb

J.1 Early management planning. Plan how to manage a trail's wildlife issues before its alignment is set.

J.2 Resolving conflicts. Don't depend on management to resolve wildlife conflicts that can be avoided by careful alignment in the first place.

J.3 Increased demands on management. More careful management of resources will be required when a trail passes through or near sensitive habitat.

J.4 Predictability. Wildlife accept the more predictable disturbances of people (and dogs) on trails more readily than off trails.

J.5 Weed-free feed. Using weed-free feed for packstock will help minimize weed invasions.

J.6 Discouraging generalists. Encourage visitors not to leave food or garbage around to further support generalists species.

J.7 Multiple approaches. Use a combination of management techniques to facilitate the coexistence of recreationists and wildlife.

J.8 Volunteers. Enlist the help of trail users in monitoring wildlife use of the trail corridor and other activities.

J.9 General references. To protect wildlife, when describing points of sensitive, ecological interest near a trail—sites you want people to know about, but not visit,—don't indicate the direction or distance to the spot.

J.10 User facilities. Provide facilities, such as blinds, viewing areas, and boardwalks, for visitors to see wildlife with minimal disturbance.

J.11 Interpretation. Interpretation and environmental education are very important management tools. If people value wildlife and understand the implications of their own actions, they are less likely to behave in ways that are harmful to wildlife.

Further Reading

Larson, R., "Balancing Wildlife Viewing with Wildlife Impacts: A Case Study," in Knight, R. and K. Gutzwiller, eds., 1995. *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press, Washington, D.C., pp. 51-69.

"Agencies and Volunteers: Conducting Your Own Volunteer Projects," Volunteer for Outdoor Colorado, 1990. To order: Volunteers for Outdoor Colorado, 600 South Marion Parkway, Denver, CO 80209, (303) 715-1010.

"Organizing Outdoor Volunteers, Second Edition," Appalachian Mountain Club Books, 1992. To order: Appalachian Mountain Club Books, P.O. Box 298, Graham, NH 03581, (800) 262-4455.

K. Making informed decisions

Key Concepts

Any trail will have at least some impact on wildlife. Therefore, deciding whether the recreational value of a trail outweighs those impacts is a **community choice**, or in some cases, a **legal question.**

To conform to legal requirements it is important to check with state and federal wildlife agencies. In order to understand community values related to wildlife and trails, there needs to be a **public process** associated with a project.

There are many public **involvement techniques** and abundant sources of information about them. An important first step in understanding how a community values wildlife and trails is recognizing that there are probably many subgroups within a community—many **publics**. These groups may hold very different values and may need to be invited into the process in different ways.

It is easiest to reach **consensus** among groups with differing values when there is a common understanding of the issues at hand. That is one of the main purposes of this handbook.

More and more often today, communities are not just discussing their present needs and desires for trails and wildlife, but also ways of leaving choices for future generations. The concept of **sustainability** is about meeting the needs of the present without compromising the ability of future generations to meet their own needs. In the case of wildlife and trails, sustainability is about enjoying trails today without precluding the ability of future generations to enjoy wildlife.

A trail that is contributing to the sustainability of an area is meeting people's fundamental desire to experience nature while not compromising the ecological integrity of the area. This implies careful planning of trails so that they do not seriously degrade biodiversity.

With this kind of forward-looking perspective, it is especially appropriate to restore degraded areas for trails. Improving degraded habitat (i.e., correcting past mistakes) is better than entering undisturbed areas and it acknowledges our obligation to future generations.

Rules of Thumb

K.1 Sweeping statements. In discussing trails and wildlife, avoid sweeping generalities about wildlife impacts that may not be possible to substantiate or even be true in a specific situation.

K.2 Public values. Scientific study doesn't reveal how the public values wildlife. Various kinds of wildlife may be valued quite differently from a public and a scientific perspective.

K.3 Broader perspective. Frequently, disagreements over trails and wildlife can be resolved by balancing objectives over the broader landscape. It may be harder to balance competing interests of wildlife and trails in the same confined area.

K.4 Public process. Don't assume everyone in your community values trails or wildlife in the same ways you do. Invite broad public participation on every trail project.

L. Land ownership

Key Concepts

Many longer trails cross from one **jurisdiction** to another. This has ramifications for how the trail is planned and specifically how wildlife issues are considered. If a trail will cross **federal lands,** a more careful environmental analysis may be required.

Federal agencies, such as the USDA Forest Service and the Bureau of Land Management have their own environmental review processes in most cases. These agencies also have land management plans that identify where they believe trails should and should not go.

It is important early on in a trails project to contact the federal, state, and local agencies with jurisdiction over lands you are considering. This is not just because they manage the land and have the ultimate say as to what happens, but also because they most likely have **important wildlife information** and **knowledgeable experts.**

The **National Environmental Policy Act** (NEPA) outlines an environmental review process for reviewing projects proposed with federal lands or funds. NEPA can seem intimidating to those first encountering it. (Contact the manager of the federal property early in the process for advice.) Because the NEPA process would have been followed for an adopted federal forest or other land management plan, it may be possible that additional environmental review is not needed for a specific trail project. Often reconstruction or minor trail rerouting may be approved under existing NEPA documentation, without the need for additional review.

In general, the smaller and less intrusive the trail project on federal lands, the quicker the environmental review. The public scoping process (by which issues and concerns are identified) may be more lengthy if a trail is perceived as controversial.

For more information, see NEPAnet at: http://ceq.eh.doe.gov/nepa/nepanet.htm

As early in the trail planning process as feasible, contact the owners of private lands in the general area of your proposed trail. Out of respect for private property, it is good to communicate with these community members from the beginning of the project.

Rules of Thumb

L.1 Existing plans. Propose trails on federal lands in areas identified as suitable in existing management plans.

L.2 Additional requirements. Be prepared to follow a more formal environmental review process if you are proposing a trail on federal land. You may want to start working with the responsible agency a year in advance of proposed construction.

L.3 Practical advice. Interview a person who already has been through the NEPA process for a trail project similar to yours. (Talk with the Bureau of Land Management or U.S. Forest Service, for example.)

Further Reading

Shipley Environmental, *Applying the NEPA Process.* Telephone: 801-298-7800.

USDA FOREST SERVICE TRAIL SYSTEM ANALYSIS

Typical information needed for trail system analysis on lands managed by the USDA Forest Service includes:

1. Is there an approved plan for the area?
2. What are the general goals of the Forest Plan as they relate to the area?
3. What specific Forest Plan management objectives and prescriptions have been designated for the area? What other resource activities are likely to take place?
4. Within those prescriptions, what standards and guidelines might affect trail system design, operation,and administration?

From: http://www.fs.fed.us/ im/directives/fsh/2309.18/2309.18_1

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3. Wildlife and Trails Checklist

While the Wildlife and Trails Primer (Chapter 2) is a topical presentation of wildlife and trails issues, this chapter presents wildlife concepts in a sequence your might follow in planning a trail.

The checklist provides a broad framework for considering wildlife while planning trails. It also highlights important issues to consider at specific points in the planning process, raising questions rather than providing answers.

The checklist's organization is complementary to such trail planning processes as that developed by the Austin Metropolitan Trails Council with assistance from the Rivers, Trails, and Conservation Assistance Program of the National Park Service. (For more information, see the council's website: http://www.austin360.com/greenzone/amtc/build.htm)

Specific questions addressed

How well wildlife concerns are represented in a planning process depends on how well the following are understood:

1) the specific wildlife species and populations being affected,

2) their habitats, and

3) the proposed recreational activities affecting that population.

The steps outlined in the checklist should help trail planners become more familiar with these issues.

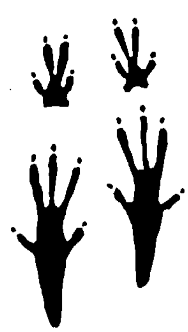
A generalized process

Every trail project is unique and not all of the detailed steps and questions in the checklist will be relevant to each project. Therefore it is important to adapt the checklist to your own situation.

For example, in an urban setting it may not be possible to identify a range of options for a trail. The only possible alignments may be along drainages or other existing corridors not attractive to most kinds of development.

Similarly, many trail projects in Colorado improve existing roads or trails, rather than create new alignments. Developing wide-ranging alternatives may not make sense in such cases.

Also, users of the checklist from states other than Colorado will need to find substitutes for the Colorado-specific resources.



Wildlife and Trails Checklist

A. Getting the whole picture	→ B. Considering alternative alignments	→ C. Building and managing the trail
1. *Including wildlife in the trail vision*	1. *Preparing and evaluating alternatives*	1. *Acquiring and constructing the trail*
2. *Organizing & communicating*	2. *Designing the trail*	2. *Monitoring and managing the trail*
3. *Researching & inventorying*		

Comments welcomed

It would be very helpful to have your comments and suggestions on the Wildlife and Trails Checklist. Please send them to:

Stuart Macdonald, Colorado State Parks—Trails Program, 1313 Sherman Street, Room 618, Denver, CO 80203 or e-mail: MacTrail@aol.com.

A. Getting the whole picture

1.
Including wildlife in the trail vision

❑ Look at the broader landscape. What opportunities or constraints are there for trails and wildlife in the broader landscape? What plans are there for other trails or wildlife across the landscape? In general, what kinds of landscapes would the trail pass through? Would any be areas that currently have no trails and little human modification? Do you foresee any cumulative trail impacts by adding a new trail?

❑ Develop preliminary goals for the project. What activities do you foresee for the trail? What are your wildlife goals for the project?

❑ Develop initial trail concepts. What destinations, users, and activities do you foresee for the trail?

❑ Keep wildlife concerns within the focus of the project vision. Are there biologists or other professionals available to advise you on wildlife and trails concerns?

❑ Look for opportunities to coordinate your trail project with conservation and other complementary projects. Are there opportunities to coordinate habitat restoration, protection, or acquisition with the trail project? Where?

2.
Organizing & communicating

❑ Create a profile of the kinds of users who are likely to use the trail. What are likely levels and seasons of use? Are there organizations that would be interested in the trail project? Would any help monitor the trail area for wildlife issues?

❑ Identify the groups interested in wildlife in your trail area. What wildlife and conservation organizations would be interested to know of your trail project? Would any help monitor the trail area for wildlife issues?

❑ Share your ideas and findings with other community members, including both trails and wildlife enthusiasts, property owners, and land managers. Who are people and organizations that would feel strongly for or against the project? How can you inform and involve them?

❑ Meet with agency planners. Are there city or county land-use planners and federal or state resource planners who understand the broader context of the area where you are considering a trail? Is there an area-wide land-use, open space, or trails plan? If the trail might cross federal land, is there an existing management plan? Is your trail concept consistent with these plans?

❑ Start a public discussion of the trail and its implications for wildlife. What are the best ways to reach the various groups interested in your trail? Community meetings, field trips, a web site? What are the wildlife issues that must be addressed in planning the trail? Do the ideas you hear seem to complement or conflict?

A. Getting the whole picture, cont.

3.
Researching and inventorying

❑ Determine the physical extent of the project. Over what area might the trail extend? What elevational ranges?

❑ Conduct a preliminary biological inventory. What are the area's sensitive plants, animals, and wildlife habitats? Are there any special opportunities for wildlife education? How impacted already are wildlife in the area? How much modified is the area—is it urban, suburban, agricultural, pristine?

❑ Determine the habitat/ecosystem types present in the area of the proposed trail and the potential species or communities of special concern. What do the Colorado Natural Diversity Information Source (available online Fall 1998) and other sources indicate are likely species or communities of special interest in the area?

❑ Draw inferences from scientific studies done in similar habitats or with similar wildlife species. Does the Colorado State Parks wildlife/trails bibliographic data base include any such relevant references?

❑ Learn from others who have completed projects with similar wildlife issues. Are there case studies in Chapter 4 of this handbook with similar wildlife issues? Does the Trails Section of the Colorado State Parks website (www.dnr.state.co.us/parks/) include trails projects through similar environments? What lessons can you draw from the experiences of others?

❑ Review data found to date and conduct a site visit with a wildlife biologist or other scientists to identify potential wildlife opportunities and constraints. Are there areas to avoid because of resource sensitivity or areas to consider because of restoration potential or lower sensitivity? Which areas would provide the most interesting route and have the least impact on wildlife? Are there special opportunities for wildlife education?

❑ Identify seasons of special concern for the important wildlife species or communities. Are there times of year, such as elk calving or eagle nesting season, that are particular sensitive to disturbance from people? Are there alternatives for the trail away from such areas? Would seasonal closures of a trail near such areas be workable?

❑ Identify important plants in the area. Are there any sensitive plant species or communities in the area? Are there ways to present these communities to trail users without disturbing sensitive species?

❑ Evaluate the extent of existing impacts to wildlife and the landscape. What are the existing impacts to wildlife? How much have humans already modified the area? Is the area primarily natural, managed, cultivated, suburban, or urban? Will the trail provide access to backcountry or areas that have never had trails before? How can you minimize the trail's contribution to habitat fragmentation?

❑ Take a step back. Given what you have learned to this point, how well do you think this project will fit into its larger ecological context?

❑ Formalize the project goals. How would you revise the preliminary project goals based on what has been learned? What do members of the public and others think of the project goals?

B. Considering alternative alignments

1.
Preparing and evaluating alternatives

❑ Create distinctive alternative plans. With this handbook's rules of thumb as a guide, develop alternative plans that maximize the opportunities and minimize the constraints for wildlife. Especially look for opportunities to coordinate the restoration of degraded habitats. Get professional help preparing and evaluating alternatives, if possible. Where an existing trail is to be improved, alternatives might include different management strategies.

❑ Consider alternatives for trailheads and other support facilities. Sites for trailheads and parking areas are sometime overlooked in evaluating wildlife impacts of trails. They need careful design and review.

❑ Evaluate the alternatives. Conduct an internal evaluation of the alternatives using the goals set earlier.

❑ Ask others to help evaluate the alternatives. Conduct an external evaluation of the alternatives with wildlife biologists or other agency personnel, public, environmental groups, landowners, land managers, and others, as appropriate. Summarize the pros and cons of each alternative.

❑ Select a preferred plan. Review the comments made during the evaluation process and select one of the alternatives or create a hybrid plan incorporating the best qualities of two or more plans.

2.
Designing the trail

❑ Refine the selected plan. Develop site designs, budgets, and timetables.

❑ Develop management strategies. Consider how the trail will be managed, maintained, and monitored.

❑ Develop an environmental education/ interpretation plan. The plan should explain how to communicate to trail users the specific wildlife issues of this trail.

❑ Develop a volunteer plan. Outline support tasks for involving volunteers in monitoring or managing wildlife.

❑ Conduct a final review of the plan and its components. Review the final plan with a wildlife biologist and other specialists to make certain all the parts went together in ways that support wildlife.

C. Building and managing the trail

1.
Acquiring and constructing the trail

☐ Look for opportunities for complementary conservation. In acquiring the land needed for the trail, look for additional areas that can be set aside for wildlife conservation at the same time and for the partners to implement such efforts.

☐ Implement the plan. Be careful to impact wildlife as little as possible during construction.

☐ Communicate to all interested parties. Share the progress about the trail and what is being learned about co-existing with wildlife.

2.
Monitoring and managing the trail

☐ Manage the trail. Implement the plan to manage the trail corridor and activities within it.

☐ Monitor. Using staff or volunteers, monitor the important plants and wildlife of the alignment, looking for impacts. Adjust management plans as appropriate.

☐ Communicate to all interested parties. Share the progress about the trail and what is being learned about co-existing with wildlife.

ABSTRACT

Avian species represent a varied collection of organisms with key roles in ecological systems. Species are not immune to overall declines in biodiversity and large-scale efforts are underway to conserve bird species. Direct and indirect impacts of human recreational activities were reviewed in the literature. Avian species reacted differently to the presence of recreationists. A continuum of responses existed with habituation at one extreme and habitat abandonment at the other. Reactions varied within a species, depending on breeding status, activity (foraging, roosting etc), species size, and group size. Birds responded to human activity by altering their behavior, spatial distribution and use of habitats. Effects on breeding birds during incubation included nest desertion and temporary nest abandonment, which resulted in exposure of the eggs to temperature extremes and predators. Disturbance during brood rearing can result in trampling of eggs or neonates, premature fledging, and separation of young from parents. Outside of the breeding season, bird activity is focused on energy gain for winter and migration. Human disturbance during this period may cause changes in foraging habits and decreased foraging efficiency. Management recommendations and guidelines were presented for species groups. Birds that were endangered, threatened, or of special concern were given special attention to assist managers in prioritizing conservation strategies.

Suggested citation for this chapter

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Management Guidelines

Frissell (1994) presented 5 general guidelines to reduce negative impacts of firewood-cutting:

1. Avoid cutting snags that already show evidence of bird use.

2. Leave all snags larger than 20 inches dbh.

3. Leave snags with broken tops.

4. Avoid cutting trees that show evidence of heart rot.

5. Avoid cutting western larch, ponderosa pine, and black cottonwood.

SONGBIRDS

There are approximately 111 species of songbirds in Montana (MBDC 1996). Birds may respond to human activity by altering their behavior, spatial distribution, and use of habitats (Knight and Cole 1995). Management of songbird habitat where recreation and travel activities occur is essential to prevent reductions in songbird carrying capacity and diversity. Travel corridors created for motorized travel and recreation may fragment songbird habitat, and human activity within songbird habitat may disrupt breeding activity and displace birds.

Forested and Forested-Riparian Habitats

Roads have contributed to forest fragmentation by dissecting large patches into smaller pieces and by converting forest interior habitat into edge habitat (Askins et al. 1987, Small and Hunter 1988, Schonewald-Cox and Buechner 1992, Askins 1994, Reed et al. 1996). Small and Hunter (1988) classified roads as an edge if they could be identified from aerial photographs or USGS topographic maps. Some researchers have considered a corridor at least 10 m in width as having a fragmenting effect (Lynch and Whigham 1984). Rich et al. (1994) recently attempted to quantify the corridor width that creates fragmentation by comparing songbird response to road and powerline corridors 8, 16 and 23 m wide. Corridor widths as narrow as 8 m produced forest fragmentation effects, in part, by attracting cowbirds and nest predators to corridors and adjacent forest interiors. Similar fragmentation effects may also occur with nature trails that are only 2-3 m wide. Hickman (1990) found that nest predators and brown-headed cowbirds (*Molothrus ater*) were attracted into trail-corridor habitat in Illinois.

Habitat fragmentation from corridors can reduce songbird carrying capacity for at least 2 reasons. If roads create significant disruptions of continuous forest habitat, the space required by forest interior species will be reduced. Road corridors 16 m in width appear to have this affect. Rich et al. (1994) found that densities of forest interior species in New Jersey were significantly reduced adjacent to 16 m-road corridors as compared to adjacent interior forest habitat. Similar effects may occur in the Northern Rockies. Hutto (1995*a*) noted that 2 interior species, the brown creeper (*Certhia americana*) and golden-crowned kinglets (*Regulus satrapa*), were twice as likely to occur on points more than 100 m from, rather than adjacent to, a road.

If roads fragment habitat, a number of other Northern Rockies species may also be affected. Hutto (1996) reported that some forest songbirds may not occur as commonly in small as in larger forest patches, including the Townsend's warbler (*Dendroica townsendii*), varied thrush (*Ixoreus naevius*), golden-crowned kinglet, chestnut-backed chickadee (*Parus rufescens*), winter wren (*Troglodytes troglodytes*), red-breasted nuthatch (*Sitta canadensis*), and Swainson's thrush (*Catharus ustulatus*). In Wyoming, Keller and Anderson (1992) found that the brown creeper, hermit thrush (*Catharus guttatus*) and red-breasted nuthatch were associated with larger forest patches.

Fragmentation of limited, high-value habitats may cause some of the most severe impacts to songbirds. Many songbird species are largely or primarily restricted to riparian habitats (Hutto 1995*a*). Fragmentation of riparian habitats with corridors (e.g., trails, roads) will create greater impacts to songbirds on a landscape perspective than fragmentation of adjacent forests.

Fragmentation of habitats may not only reduce patch size for interior species, but may separate important associations between two adjacent habitats. Riparian habitat in conjunction with upslope habitat may be more effective in meeting habitat needs of the entire songbird community in western coniferous forests. McGarigal and McComb (1992) found that while riparian forests in Oregon supported many songbird species, upslope areas were more important in contributing to the avifauna of mature, unmanaged forest stands.

When riparian areas remain only as remnant forests adjacent to cutover areas, fragmentation may be most serious. Minimum corridor widths from 75-175 m have been recommended to include at least 90% of the songbird species, including forest interior species, such as the veery (*Catharus fuscescens*) and pileated woodpecker (*Dryocopus pileatus*) (Spackman and Hughes 1995, Dickson et al. 1995). In studies of fragmented riparian corridors, Vander Haegen and DeGraaf (1996) recommended maintaining a minimum riparian corridor width of 100 m.

The breakup of continuous forest habitat with roads may increase predation rates on songbirds by increasing the ratio of edge to interior habitats. This has been observed in heavily forested areas of Connecticut and Maine (Askins et al. 1987, Small and Hunter 1988). Small fragments may be easier for predators to penetrate, while the adjacent roads will provide predators a travel corridor into forested habitat from nearby areas (Small and Hunter 1988, Askins 1994). Predation rates on eggs were also found to be significantly higher along 100 m of minor roads through otherwise continuous forests in Belize (Burkey 1993). Increases of both cowbirds and nest predators have been observed along unpaved and paved roads in New Jersey (Rich et al. 1994). Increases of cowbirds and nest predators have even been noted along 2-3 m-wide nature trails in Illinois (Hickman 1990), while in Colorado, predation of songbirds was greater closer to forested hiking trails (Miller et al. 1998).

The phenomenon of reduced songbird productivity along edges was recently reviewed by Paton (1994). Nest success varied near edges, with both depredation rates and parasitism rates increasing near edges; in addition, there was a positive relationship between nest success and patch size. The most conclusive studies suggest that edge effects usually occur within 50 m of an edge. Paton (1994) concluded that strong evidence exists that avian nest success declines near edges, and his review corresponds with management recommendations provided by Askins (1994) that if diversity of neotropical migratory songbirds is a management goal, large blocks of continuous forest should not be segmented with roads.

The creation of edge habitat may have the greatest impacts in riparian areas due to the large number of riparian and/or deciduous forest songbirds that are common to frequent hosts for cowbirds. These include the veery (*Catharus fuscescens*), willow flycatcher (*Empidonax traillii*), red-eyed vireo (*Vireo olivaceus*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), ovenbird (*Seiurus aurocapillus*), common yellowthroat (*Geothlypis trichas*), yellow-breasted chat (*Icteria virens*), rose-breasted grosbeak (*Pheuticus ludovicianus*), song sparrow (*Melospiza melodia*), Brewer's blackbird (*Euphagus cyanocephalus*), American redstart (*Setophaga ruticilla*), and American goldfinch (*Carduelis tristis*) (Ehrlich et al. 1988). More common cowbird hosts in coniferous forest habitat are more limited, and include vireos (*Vireo* s pp.), black-and-white warbler (*Mniotilta varia*), yellow-rumped warbler (*Dendroica coronata*), and chipping sparrow (*Spizella passerina*) (Ehrlich et al. 1988).

In addition to fragmentation effects, roads and trails in forests likely disrupt songbirds breeding activities and/or displace birds from the zone of disturbance. Even non-motorized activity has documented disturbance impacts to songbirds. Miller et al. (1998) studied bird species density in forest habitat in Colorado and found that generalist species were more abundant near hiking trails, whereas specialist species were less common. The zone of influence averaged about 75 m, but extended to more than 100 m some sensitive species. Similar disturbance impacts were noted for 8 of 13 songbird species along wooded trails in the Netherlands (van der Zande et al. 1984). Because of the noted sensitivity of even common songbirds to disturbance, van der Zande et al. (1984) recommended that recreational disturbance impacts be concentrated into already heavily used areas rather than dispersed.

Motorized activity along roads and trails may have an even greater disturbance and/or displacement effect on birds. One indication of reduced habitat quality along roads is an increased proportion of yearling males during the breeding season. Reijnen and Foppen (1994) found that in wooded habitat adjacent to roads in the Netherlands, the density of territorial male willow warblers was lower because of a low presence of older males. In the road zone (200 m next to the road), the proportion of successful yearling males was only half that of other zones, and overall productivity in this road zone was reduced. Reijnen and Foppen (1994) suggested that, due to source/sink dynamics and emigration, the highway reduced the population size of the entire 400-acre study area, of which 20% belonged to the road zone. For all species present, Reijnen and Foppen (1994) also found that 60% showed evidence of reduced density adjacent to roads. In another study along highways in Maine, Ferris (1979) detected no reductions in overall songbird density, but he noted that 3 interior species were displaced from the highway.

Although few data are available on the direct disturbance impacts of off-road vehicles on songbirds, such impacts will likely be greater than those created by non-motorized activities. Gutzwiller et al. (1997) intentionally disturbed breeding songbirds with scheduled hikes through their territories in a Wyoming forest. The authors were able to detect curtailments of singing activity in some species; this may have reduced breeding activity and the quality of those sites for producing young. Gutzwiller et al. (1998) found tolerance was lower for more conspicuous species, birds that were active nearer to the ground and birds in areas with few conspecifics. Riffell et al. (1996) also studied non-motorized human intrusion into songbird habitat in Colorado coniferous forests. Declines in richness and abundance observed during some years for core species indicates that intrusions have the potential to generate important problems for some or all of these species during the breeding season.

In an analysis of off-road vehicle use on desert avifauna, Luckenbach (1979) noted that in addition to habitat alteration, harassment and noise forced a parent bird to leave an active nest for long periods, thereby exposing young to thermal and water stress. Because young birds are poor thermal regulators, mortality due to abandonment would be expected to be high.

The combined on-site effects of roads and trails due to habitat fragmentation and disturbance activities likely produce notable changes in bird species composition. The implications of these changes may be highly significant when the total mileage of fragmentation/disturbance routes on a local landscape are tallied. These cumulative impacts may be further exacerbated when campgrounds are created within riparian areas to support these recreational routes. When open, campgrounds can reduce both the density and diversity of songbirds (Aitchison 1977). Species that may be most severely impacted by these riparian campgrounds may, in turn, be those that can least tolerate impacts, such as the veery, a species that is experiencing significant population declines throughout the North American continent. In Idaho cottonwood forests, Saab (1996) found that the veery required larger patches of cottonwood forest in areas disturbed by campgrounds. Loss of shrub understories in and around campgrounds reduced key habitat for many riparian species as well (Luckenbach 1979). Locations of campgrounds in riparian areas also impacted nesting of the belted kingfisher, especially when displaced from limited bank-nesting sites or key feeding areas in riffles (Davis 1982).

Grassland/Shrub and Savannah Species

Grassland-shrubland and savannah songbirds may be vulnerable to road and trail activities in manners similar to forest birds. Roads and trails create edge habitat for predators. Miller et al. (1998) found lower nest survival for grassland birds adjacent to rather than removed from hiking trails in Colorado. Johnson and Temple (1990) found that rates of nest predation and brood parasitism for 5 bird species nesting in fragments of tallgrass prairies in Minnesota were affected by the size of the prairie fragment containing the nest; rates of predation were lower for nests on large fragments. Roads and trails have reduced patch size of remaining habitat for area-sensitive species. In Idaho, Knick and Rotenberry (1995) found that fragmentation of shrubsteppe communities significantly influenced the presence of shrub-obligate species, such as the sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), and sage thrasher (*Oreoscoptes montanus*).

Although fences are rarely constructed for recreational management, it should be recognized that this activity has the potential to increase cowbird parasitism on songbirds in grassland, shrubland, and savannah habitats. Fencelines have provided perches from which cowbirds can search for host nests (Johnson and Temple 1990). Grassland and savannah species that are most vulnerable to cowbird parasitism include the vesper sparrow (*Pooecetes gramineus*), lark sparrow (*Chondestes grammacus*), clay-colored sparrow (*Spizella pallida*), spotted towhee (*Pipilo maculatus*), and chipping sparrow (Ehrlich et al. 1988).

The disturbance impacts of recreational activities along roads may even be greater in grassland/shrub habitats as opposed to forested habitats, because of the greater impacts of noise. Miller et al. (1998) found that grassland birds were more likely to nest away from rather than near hiking trails in Colorado, with a zone of influence approximating 75 m. Both Van der Zande et al. (1980) and Reijnen et al. (1996) found depressed densities of grassland birds adjacent to roadways in the Netherlands, with disturbance impacts increasing with traffic volume and noise levels. On busy roads (5,000 cars per day), the disturbance distance for some species extended up to 1,700 m; this distance increased to 3,530 m on major highways (50,000 cars per day).

Management Recommendations/Guidelines

1. Motorized activity should be limited to designated routes in forested, grassland, and shrubland habitats from early spring through fall (April-May through September) to avoid disruption of songbird courtship, breeding, nesting, and post-fledging activity.

2. The total-access-corridor density on a local landscape, whether forested, grassland, or shrubland, should be limited to control disturbance and fragmentation impacts on songbirds; corridors with increasing width and motorized use should be assigned progressively higher disturbance values and be more restricted in density.

3. No new roads, trails, or campgrounds should be established in riparian areas (600 m adjacent to the stream border) or cottonwood forests. The greater the disturbance or fragmentation value of a corridor, the higher it should be placed upslope from the riparian area.

4. Short- and long-term objectives should emphasize concentration rather than dispersal of the fragmentation/disturbance impacts of recreation and motorized access within songbird habitat. Corridor activities should be combined where feasible, and new or relocated corridors should be located in areas already fragmented, including natural edges such as breaks between forests and grasslands. Caution should be used when constructing fences along existing roads since cowbirds may benefit.

5. Long-term objectives should be established to identify and avoid disturbance or fragmentation of large blocks of forest/grassland/sagebrush habitats with recreational and travel corridors. Wildlife habitat should be zoned for maintenance of large unfragmented, undisturbed blocks of forest, grassland, and sagebrush habitat.

6. High-value wildlife areas that are currently disturbed and/or fragmented by travel/recreation corridors, particularly riparian and cliff habitats; large blocks of sagebrush; and low-elevation, old-growth forests, should be targeted for restoration.

Cliff Habitats

Cliffs are unique features in Montana's landscape because they create abrupt edges and provide habitats for a wide diversity of birds. Cliff habitats are generally inaccessible to humans and livestock and may be the least-disturbed features of a landscape (Camp and Knight 1998). During the last few decades, the sport of rock climbing has attracted an ever-increasing number of recreationists and has contributed to changes in cliff bird communities (Pyke 1997). Knight and Skagen (1988) suggested that rock climbing reduced nesting success of birds. Camp and Knight (1998) suggested that rock-climbing activities affected the diversity of species as well as species behavior. The number of observations for species, such as canyon wrens (*Catherpes mexicanus*), rock wrens (*Salpinctes obsoletus*), tree swallows (*Tachycineta bicolor*), and Lazuli buntings (*Passerina amoena*), differed depending on the frequency that cliffs were climbed. Cliff habitats may deserve special management attention, therefore, management recommendations from Camp and Knight (1988) follow.

Management Recommendations/Guidelines

1. Monitor expanded use of cliffs by climbers.

2. Implement monitoring programs to evaluate spatial and temporal fluctuations of bird species and changes in numbers of invasive species.

ABSTRACT

Semi-aquatic mammals (beaver, muskrat, river otter, and mink) inhabit waterways and associated wetland and riparian habitats throughout Montana. Because these species require aquatic and adjacent shoreline habitats, they may be impacted by both water-based and shoreline recreational activities. The impacts of motorized boating are of particular concern. The number of boats registered in Montana increased 34% from 1990 to 1998. Personal watercraft registration increased 700% from 560 to 4,470 in the same period. Impacts of recreation on semi-aquatic mammals include disturbance effects to the animals themselves and habitat effects related to water quality, bank integrity, and vegetation. Disturbance may cause stressful physiological reactions, interrupt activities, and displace semi-aquatic mammals from preferred habitats, with resultant energetic consequences. Displacement can vary from a short-term flight and return or long-term abandonment of the area. Disturbance during spring and early summer (breeding, dispersal, parturition, and post-natal periods) may be most detrimental to productivity, although disturbance at any time of the year may lower fitness, reproductive success, and survival. Cover availability and the type, frequency, predictability, location, and duration of the activity may all influence semi-aquatic mammal responses to recreational disturbance. Semi-aquatic mammals concentrate their activities along the shore. The closer the recreational activity is to the shoreline, the greater the disturbance potential. Semi-aquatic mammals may habituate to non-threatening recreational activities if they occur in predictable areas at predictable times. The type, frequency, duration, and location of the activities also May influence recreation effects on semi-aquatic mammal habitats. Substantiated impacts of motorized recreation on aquatic and shoreline habitats include shoreline erosion, pollution from boat engines, contaminant resuspension and increased turbidity, increased turbulence, and laceration of aquatic vegetation by propellers. Bank stability and shoreline vegetation are important habitat components for semi-aquatic mammals. Motorized watercrafts generate wakes that may hit the shoreline and cause bank and substrate erosion, which impacts shoreline vegetation. Loss of shoreline vegetation makes the bank even more susceptible to continued erosion by natural and boat-induced waves. Wakes may also swamp den sites, erode den entrances, erode muskrat canals, swamp river otter latrine sites, and compromise the structural integrity of bank dens, beaver lodges, beaver caches, muskrat houses, and muskrat feeding platforms. Reduced boat speeds and increased operating distances from shore can lower bank erosion rates. Motorized boats, personal watercraft, and snowmobiles operating on frozen surfaces introduce oil residue and various derivatives from the combustion process into the water. These pollutants may directly impact fish, thereby affecting the forage base of mink and river otters, and bioaccumulate in the food chain. Uptake of petroleum hydrocarbons by aquatic animals has been documented. Motor boat activity also increases sediment resuspension and turbidity, which may decrease water clarity and increase nutrient loading. The removal of riparian habitat to develop public recreational facilities, private docks, and homesites in conjunction with the proliferation of artificial bank stabilization measures pose serious threats to semi-aquatic mammals and their habitats. The cumulative effects of habitat loss and recreational activities (including trapping) on semi-aquatic mammal populations need to be considered to determine the overall impacts of recreation. Responsible management of boating and shoreline recreation is essential to the conservation of semi-aquatic mammals in Montana.

Suggested citation for this chapter

Waller, A. J., C. A. Sime, G. N. Bissell, and B. Dixon. 1999. Semi-aquatic Mammals. Pages 5.1-5.25 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society. 307pp.

ABSTRACT

It is difficult to segregate human demographic trends from trends in rural development and outdoor recreational participation in settings like the West where they appear to be interrelated. One extension of human recreation in wildlife habitats is the effect of disturbance, harassment, displacement, or direct mortality of wildlife attributable to domestic dogs that accompany recreationists. At some level, domestic dogs still maintain instincts to hunt and/or chase. Given the appropriate stimulus, those instincts can be triggered in many different settings. Even if the chase instinct is not triggered, dog presence in and of itself has been shown to disrupt many wildlife species. Authors of many wildlife disturbance studies concluded that dogs with people, dogs on-leash, or loose dogs provoked the most pronounced disturbance reactions from their study animals. During winter, concerns are primarily related to human activity on ungulate winter ranges. Dogs extend the zone of human influence when off-leash. Many ungulate species demonstrated more pronounced reactions to unanticipated disturbances, as a dog off-leash would be until within very close range. In addition, dogs can force movement by ungulates (avoidance or evasion during pursuit), which is in direct conflict with overwinter survival strategies which promote energy conservation. During summer, concerns are primarily related to the birth and rearing of young for all wildlife species. Dogs are noted predators for various wildlife species in all seasons. Domestic dogs can potentially introduce diseases (distemper, parvovirus, and rabies) and transport parasites into wildlife habitats. While dog impacts to wildlife likely occur at the individual scale, the results may still have important implications for wildlife populations. For most wildlife species, if a "red flag" is raised by pedestrian-based recreational disturbance, there could also be problems associated with the presence of domestic dogs. Managers may consider the following when evaluating recreational impacts of dogs in wildlife habitats: species biology, reproductive potential, abundance, density, distribution, degree of habitat specificity or reliance on certain habitat components, and predisposition and sensitivity to disturbance by other agents. This information is intended to increase awareness among natural resource professionals and the public about the potential implications of uncontrolled domestic dogs in wildlife habitats and to encourage responsible outdoor recreation ethics.

__Suggested citation for this chapter__

Sime, C. A. 1999. Domestic Dogs in Wildlife Habitats. Pages 8.1-8.17 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

ECOLOGICAL IMPACTS OF RECREATIONAL USE OF TRAILS: A LITERATURE REVIEW

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May 4, 2000

SUMMARY: Recreation such as hiking, jogging, horseback riding, and photography can cause negative ecological impacts to ecosystems, plants and wildlife including trampling, soil compaction, erosion, disturbance (due to noise & motion), pollution, nutrient loading, and introduction of non-native invasive plant species. Corridors such as trails and roads also cause habitat fragmentation and edge effects which may impact some plant and animal species. Thirty references are cited.

SOURCES OF INFORMATION & SUBJECTS: This document is based on references obtained from online data base searches, journal articles, information from internet searches, and personal communications. I found many articles on the impact of backcountry camping and horse packing in the western US (which I did not pursue or include in this review), quite a few articles on impacts of recreational use on birds, and one review paper on effects recreation on mammals, birds and herps. I found very few references on possible introduction of invasive non-native plants by hikers or horses, and almost nothing on bicycles or ATVs. Although the primary emphasis of this review is on recreational impacts from trail use, I have also included some articles on powerlines and small roads since they may cause habitat fragmentation and edge effects similar to those caused by trails, although on a somewhat larger scale.

TYPES OF RECREATIONAL TRAIL USE (possible sources of stress/threats)
Horseback riding
Hiking, jogging, bird watching, photography
Bicycling
ATV use (all-terrain vehicles)

STRESSES (all somewhat inter-related)
Trampling
Habitat disturbance or modification (noise & motion of recreational users, erosion, soil compaction etc.)
Competition (from introduced exotics)
Habitat fragmentation/edge effects (microclimatic change, reduced dispersal/migration, increased predation)
Nutrient loading (horse and hiker manure & urine)
Pollution (food waste, dangerous litter such as fishing line, plastic six-pack tops)

TARGETS POTENTIALLY AFFECTED
Ecological communities
Plant species
Birds
Amphibians? Others?

Trampling: Effect of trampling is fairly limited, extending only about one meter from the trail's edge (Dale & Weaver 1974, Dawson et al. 1974). Trampling causes compaction of leaf litter and soil; compaction by horses is greater than by hikers (Dawson et al. 1974, Whittaker 1978). Some plant species decrease near trails, especially woody plants since they are brittle (like low shrubs or tree seedlings; Tonnesen and Ebersole 1997) but also more delicate herbaceous plants. Grasses and sedges are most tolerant of trampling (Dale & Weaver 1974, Douglas et al. 1975). Horses destroyed eight times as much cover and created an order of magnitude more bare ground than hikers (Nagy & Scotter 1974).

Habitat disturbance (Trail width and depth): Width increases linearly with logarithmic increase in number of users (width doubles with 10-fold increase in use). Trails in meadows are a little wider than trails in forests. "Trails with both horse and foot traffic are similar in width or slightly narrower than those receiving foot traffic alone" [NOT what we've observed in T. Roosevelt Co Park on Long Island]. .. Trails used by horses and people are deeper than those used by people alone" [agrees with Long Island observations] (Dale & Weaver 1974).

Habitat disturbance (noise & motion): Based on an extensive review of recreation effects on birds, Bennett and Zuelke (1999) concluded that disturbance from recreation clearly has at least temporary effects on behavior and movement of birds. Direct approaches caused greater disturbance than tangential approaches, rapid movement by joggers was more disturbing than slower hikers, children and photographers were especially disturbing to birds, horses did not seem to disturb birds, and passing or stopping vehicles were less disturbing than people on foot. No studies specifically addressing bicycles were found. Road noise has been shown to negatively affect birds (reduced nesting, etc.) at distances of up to 1,000 m (Forman 1998 ESA talk), so noise from trail users might also affect birds but presumably over shorter distances. Boyle and Samson (1985) reviewed 166 articles containing original data and found negative impacts reported in 81% of them.

Competition (from introduced exotics): Few references are available on introduction of exotics by hikers and horses, and is an area in need of more research (Williams & Conway-Durver 1998). Dale & Weaver (1974) studied hiking and horse trails in the Northern Rocky Mountains, and reported that some plant species appeared only at trail sides (invaders) and several of these were non-native. He speculated that these species may be favored by microclimatic edge effects and nutrient enrichment from horse urine and manure. Benninger (1989) reported that horse manure contained viable seeds of at least eight exotic species, and she presumed that horse scat may be a dispersal mechanism for some exotic species. In her study of forested areas in Rocky Mountain National Park she found significantly less plant cover, and more exotic plant species near trail edges; exotic species tended to be more abundant on more heavily used trails; and total species richness (but not exotic richness) was significantly negatively correlated with distance from trailheads (Benninger-Truax et al. 1992). They inferred that trail corridors were serving as conduits for movement of species (Benninger-Truax et al. 1992). Exotic species richness in Montana grasslands was highest near road edges and steadily declined out to 100 m, the most distant sampling position (Tyser and Worley 1992). However, the gradient for three back-country trails was much less pronounced due to high numbers of exotic species at 100 m distant. They believed the widespread distribution of exotic grasses was due to past pasturing of concession horses. The two most abundant exotic species near both roads and trails were timothy (*Phleum pratense*) and bluegrass (*Poa pratensis*), species that had been included in past roadside seeding (and are common in pastures and hay).

Timothy is an aggressive exotic at Yellowstone (Meyers-Rice pers. comm.). Other grasses common in pastures and hay that can be weedy are Lolium multiflorum and Lolium perenne (rye grass); common wildland weeds closely related to cultivated oats are Avena fatua and A. barbata (Meyers-Rice pers. comm.). In addition to spreading weeds in their manure, horses may collect and spread weed seeds via their tails (Meyers-Rice pers. comm.).

In T Roosevelt Co Park, Montauk LI, NY, several exotic grasses appear more abundant along the sides of horse trails including velvet grass (Holcus lanatus), bluegrass, fescue, orchard grass and timothy (Jordan, unpub. obs.). These grasses are common in pastures and hay, and probably have been introduced by the horseback riding concession. Bentgrass (Agrostis alba/tenuis), is found throughout the park and in essentially all grasslands on Long Island. Bentgrass likely was an early introduction by European settlers.

Lespedeza cuneata (Chinese lespedeza) occurs along a trailside in pine barrens forest in the Peconic River Headwaters, LI, NY near but outside of a DEC "food plot" where this invasive exotic had been planted (cover for released pen-reared game birds)(M. Jordan unpub. obs). The vector for seed movement is unknown.

It is not possible to tell from reports of weeds along trail sides if the weedy species were actually out-competing native species, or if they were just "filling in" ecological space opened up by reduction of native species due to unfavorable environmental change (due to trampling, microclimate change, etc.). Some of both probably may occur, depending on circumstances. It is also not possible to tell how the weeds got there, although hikers could conceivably carry weed seeds on their clothes and shoes and move them to new areas (potential research study - stop hikers at trail heads and scrape their boots! Measure weed abundance relative to distance from trailheads). A correlation analysis of literature from 184 studies from around the world found that the number of exotic species in nature reserves increased with the number of visitors, but no conclusions could be drawn about roles of dispersal and disturbance since other variables were involved (Lonsdale 1999).

Habitat fragmentation/edge effects: Microclimatic changes (increased sunlight, increased rainfall due to reduced canopy interception, increased wind, decreased humidity, altered temperature regime, etc.) have been documented within the edges of forests adjacent to clearings (Chen et al. 1999, Saunders et al 1991, Wildove et al. 1986) and similar effects probably could occur along a forest trail wide enough to open up the canopy (Cole, N. 1978, Dale and Weaver 1974). These microclimatic alterations could result in plant species changes and might also affect wildlife. Several references document negative impacts on breeding bids of recreational trails as narrow as 1-3m wide in forest and grasslands (Miller et al. 1998, Hickman 1990), as well as by dirt roads and powerlines (Kroodsma 1982, Askins 1994). The negative impacts included decreased nesting near trails, altered bird species composition near trails, and increased nests predation by cowbirds, skunks, racoons and foxes using the clearings as corridors. These effects are possible even if the forest canopy is not opened by the trail (Hickman 1990).

Trails also might impede movement and dispersal of some animals that are reluctant to cross openings, especially those with exposed bare soil.

Nutrient enrichment: Nutrient enrichment from horse manure and urine is a likely factor that could favor invasion of weedy species along horse trails. Research has shown that experimentally fertilized grasslands undergo a dramatic species change resulting in increased abundance of non-native grasses, decline of native grasses and decreased diversity (Wedin & Tilman 1996).

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APPENDIX D

PUBLIC ACCESS AND WILDLIFE COMPATIBILITY SURVEY

Results

August, 2000

Prepared as part of the Public Access and Wildlife Compatibility Policy Development Project

SAN FRANCISCO BAY
CONSERVATION AND
DEVELOPMENT COMMISSION

CONTENTS

FIGURES

TABLES

Chapter 1
Introduction

Background

The San Francisco Bay Conservation and Development Commission (BCDC) is charged with both protecting the Bay and its wildlife resources, and providing for maximum feasible public access to and along the Bay. Federal and state resource agencies and nonprofit environmental groups, such as local chapters of the National Audubon Society, the Sierra Club and Save San Francisco Bay Association, have sometimes objected to the public access provisions of projects approved by BCDC, contending that public access is incompatible with wildlife. Moreover, federal and state resource agencies, such as the U.S. Fish and Wildlife Service and the California Department of Fish and Game, also periodically object to the public access provisions required by BCDC as a condition of obtaining a BCDC permit. Often the groups conflict in their independent view of whether public access is appropriate at a particular site and the appropriate scale and intensity of the access.

Over the last 30 or so years, BCDC's policies on public access have evolved from the fundamental goal of public access creation and expansion, to more complex policies that recognize the necessity of balancing development of public access with parallel goals of wildlife and habitat protection and enhancement. BCDC's permitting process has reflected the increasing attempt to balance public access opportunities with wildlife needs. However, in the years since BCDC most recently updated its public access policies, available information on the effects of public access on wildlife has increased and concern over this issue has grown. BCDC is now endeavoring to further revise its policies to better address the complex issue of public access and wildlife compatibility.

The San Francisco Bay Public Access and Wildlife Compatibility Project

BCDC received funding from the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resources Management, to address this fundamental coastal management issue. BCDC has initiated, in partnership with the Association of Bay Area Government's Bay Trail Project (Bay Trail Project), the San Francisco Bay Public Access and Wildlife Compatibility Policy Development Project. This two-year study will generate improved information on public access impacts on wildlife and ways to address these impacts to facilitate better informed policy decisions.

Formation of the Policy Advisory Committee

BCDC formed a Policy Advisory Committee (PAC) to function as a forum for public input and debate and to help facilitate a consensus among regional public agencies and non-profit organizations on the development of revisions to existing public access policies. The PAC is comprised of fourteen individuals representing a wide range of professional fields, geographic areas and public interests to assist BCDC in developing achievable, effective consensus-based policies that may be implemented throughout the region. The represented disciplines include biologists (consultant, academic and agency), resource managers, regional park district employees, environmental planners, landscape architects, and non-governmental agency activists (including both recreation and wildlife protection advocates).

Distribution of National Survey

With assistance from the PAC, BCDC conducted a survey of land managers from coastal and Great Lake states nationwide. The goals of the survey are to gather further observational information on recreational impacts on wildlife, and to document on-site experiences with specific design and management strategies and how those strategies have or have not been an effective tool in avoiding or reducing impact on wildlife from human activities. Results from the survey will be incorporated with other information on human impacts on wildlife and design and management tools to avoid or minimize impacts. The cumulative analysis of all available information will be presented in a BCDC staff background report, which will include preliminary findings and recommended policies that will be presented for Commission consideration.

Chapter 2
Methodology

The Public Access and Wildlife Compatibility Survey was developed over several months by BCDC staff and the Policy Advisory Committee. Additional survey development assistance was provided by statisticians from the California Department of Fish and Game and the social science department of the National Park Service. The survey was pretested with representatives from local, state, and federal sites.

The survey was mailed to 362 land managers from coastal and Great Lake states around the country. The selected participants manage local, state and federal reserves, parks, refuges, open spaces, recreation areas, and wildlife management areas. The sites managed by survey participants contain sensitive habitat areas, such as wetlands or sandy beach, and allow public access for recreational activities.

Significant interest in this topic nationwide and a vigorous follow up effort resulted in164 surveys returned, for an excellent response rate of 45 percent. However, seven of those surveys were returned too late for inclusion in the analysis. This report is therefor an analysis of 157 surveys.

Responses to the survey were tabulated, where possible. Many of the survey questions were open-ended and generated a variety of qualitative responses. Responses to open-ended questions were reviewed, categorized, and summarized to the greatest extent possible. Answers have not been correlated or queried for causal relationships. Not all respondents answered all questions.

Chapter 3
Survey Results

Background

Survey respondents provided background information on themselves and the sites they managed. A total of 157 surveys were returned from coastal and Great Lake states (Table A). The returned surveys represent a wide national distribution, with 62 responses from the Eastern Seaboard, 27 from Gulf Coast States, 61 from West Coast states, and 8 from the Great Lakes.

Table A. Breakdown of Survey Responses by State

STATE	# Sent	# Received	STATE	# Sent	# Received
Alabama	6	4	Mississippi	6	3
Alaska	18	9	New Hampshire	2	0
Arkansas	5	3	New Jersey	2	1
California	42	23	New York	2	0
Delaware	9	1	North Carolina	11	6
Florida	46	18	Ohio	1	0
Georgia	7	5	Oregon	29	10
Hawaii	4	0	Puerto Rico	2	1
Louisiana	11	6	Rhode Island	0	0
Maine	17	8	South Carolina	8	2
Maryland	25	19	Texas	6	1
Massachusetts	20	7	Virginia	13	4
Michigan	1	1	Washington	55	18
Minnesota	11	5	Wisconsin	2	2

The returned surveys also represent a wide distribution among various types of federal, state and local managed areas (Table B).

Table B. Breakdown of Respondents by Site Type

FEDERAL			
National Wildlife Refuge	National Estuarine Research Reserve	National Seashore (NPS)	Wetland Management District (USFWS)
60	10	5	2
STATE			
Park	Recreation Area	Wildlife Management Area	Preserve/Reserve
47	5	4	5
Natural Resource Management Area	Wildlife Park	Wildlife Sanctuary	
1	1	3	
REGIONAL			
Park	Preserve	Marine Reserve (park)	
6	2	1	
COUNTY			
Park	Wetlands Sanctuary (park)	Marine Reserve (park)	
2	1	1	
CITY			
Refuge			
1			

The majority of the respondents answering for the sites were the Managers, Assistant Managers, Directors, or Supervisors of the site. Figures 1 and 2 show the respondents' titles and the respondents' training/background, if provided.

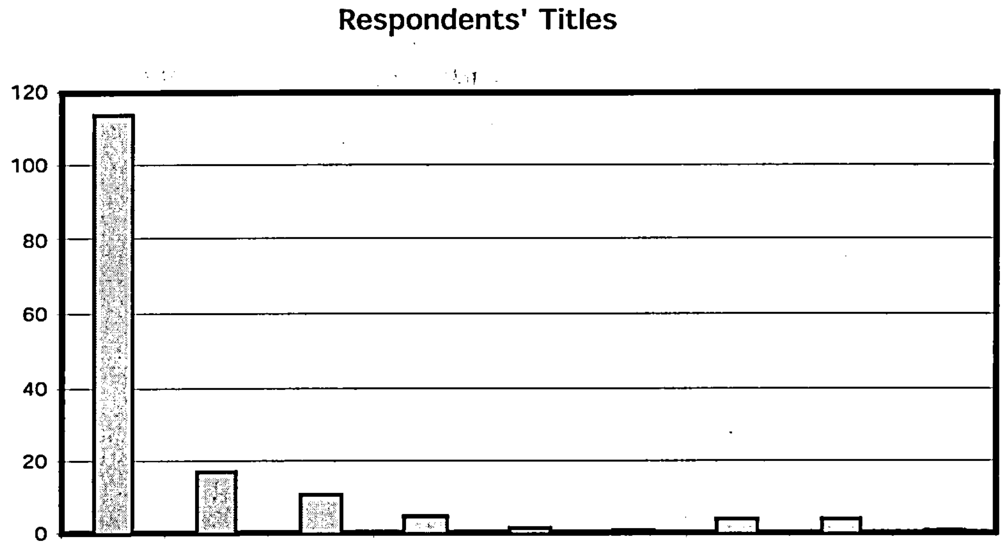

Figure 1. Titles of Respondents

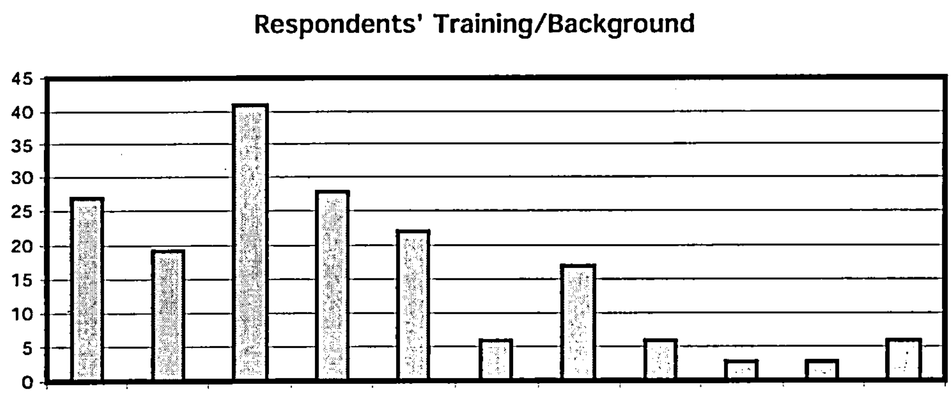

Figure 2. Background/Training of Respondents

Figure 3 shows the varying lengths of time the sites have been open to the public, and Figure 4 shows the varying lengths of time the respondents' have been involved with the sites they provided information for. Most sites had been open at least ten years and most respondents had been associated with the site for five or more years.

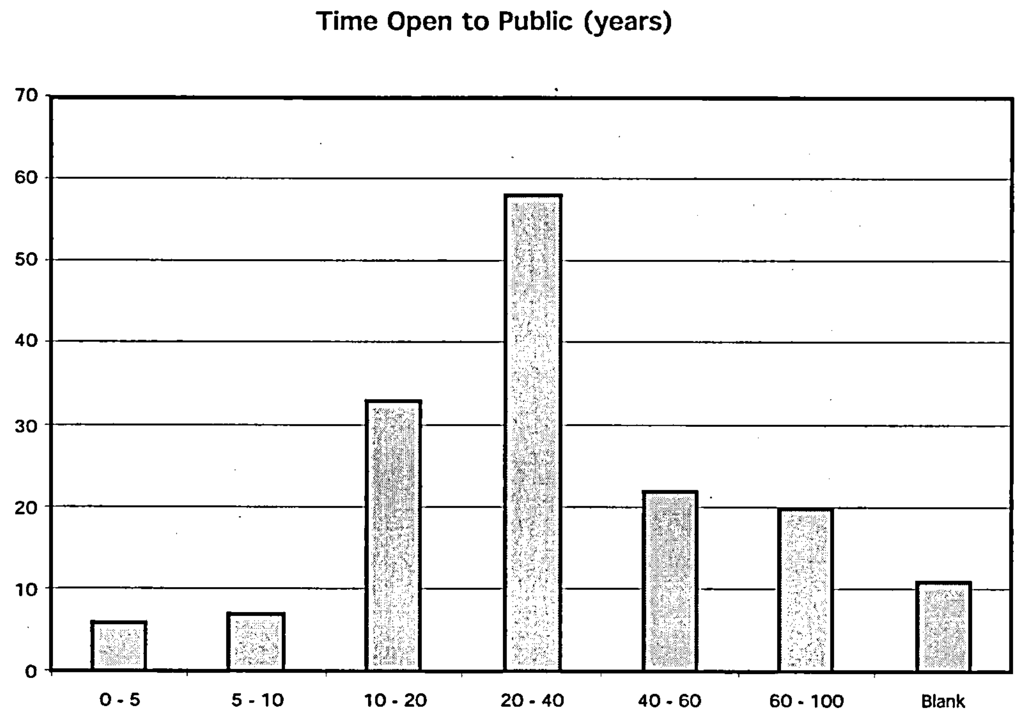

Figure 3. Length of Time Responding Sites Open to Public (in years)

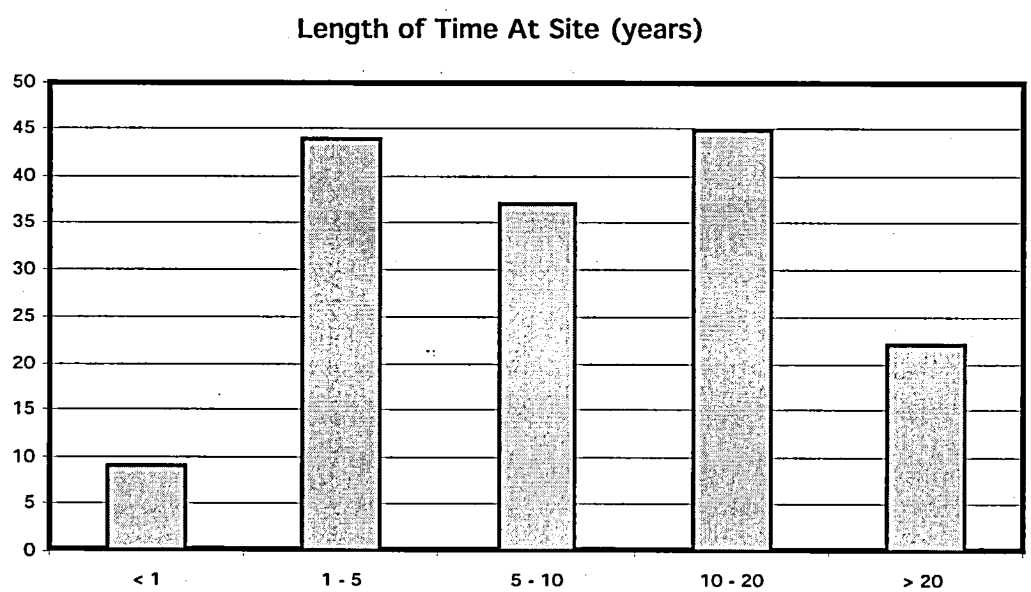

Figure 4. Length of Time Respondents' Involved with Site (in years)

Site Characterization

Respondents were asked a series of background questions regarding the sites they were providing information for. The responding sites were of various sizes as shown in Figure 5, with 33% of the sites 1000 acres or less in size.

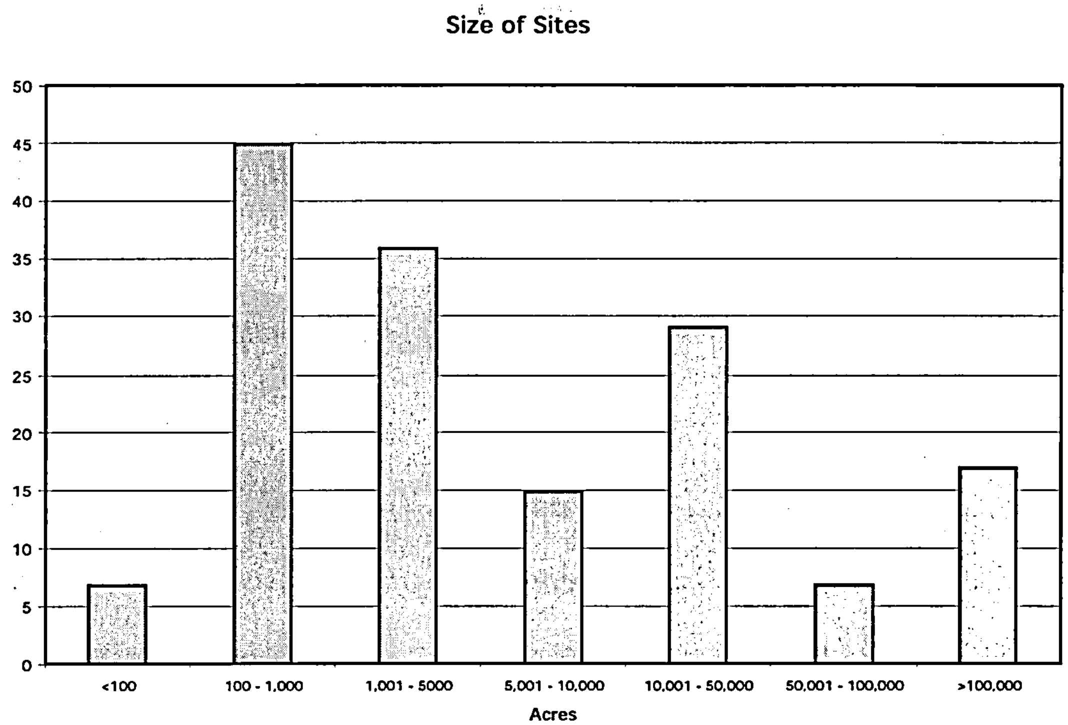

Figure 5. Size of Responding Sites

The sites contained a variety of habitat types, as shown in Figure 6. Types of land uses identified under "other" included agriculture (the most commonly identified other habitat type) tundra, glaciers, levees, agriculture, beach, rocky shore, coastal scrub, oak scrub, rock outcrop, pasture, mangroves, peat bog, and willow shrub.

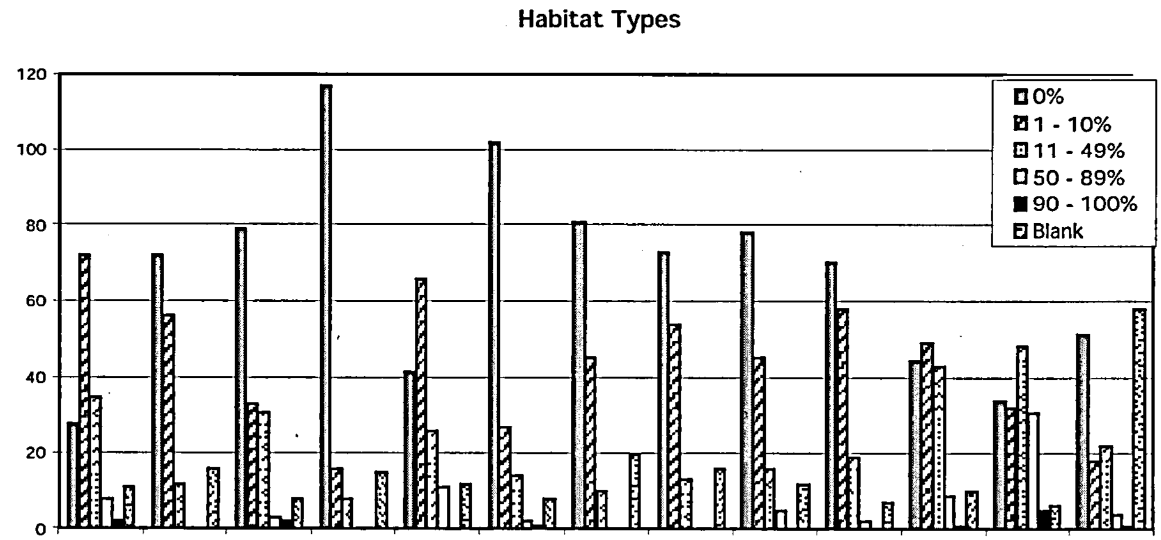

Figure 6. Percentage of Habitat Types at Responding Sites

Respondents were asked to indicate, to the best of their ability, the types of wildlife present at their sites (Figure 7a and 7b).

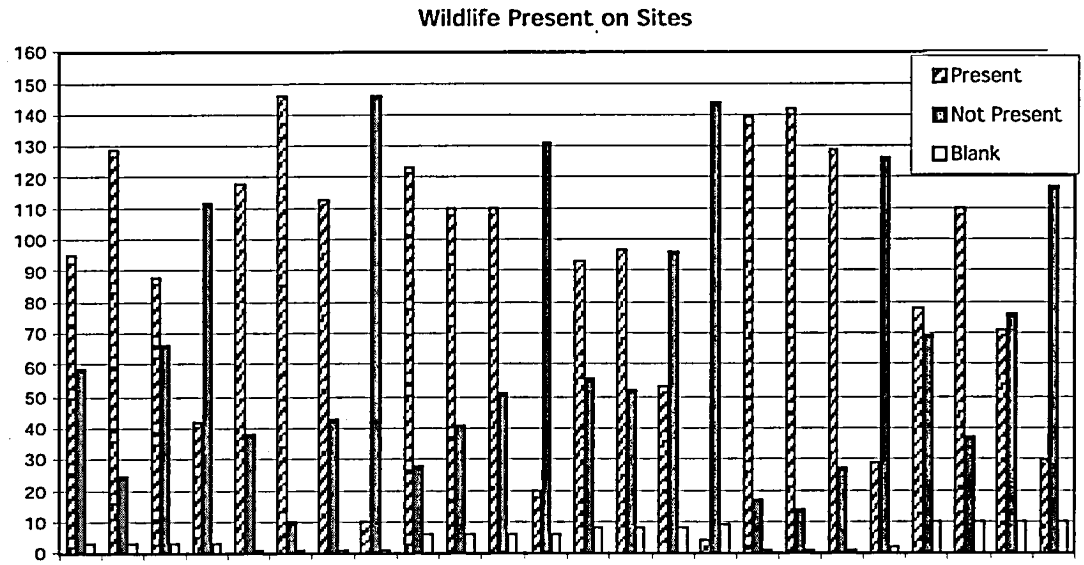

Figure 7a. Types of Wildlife at Responding Sites

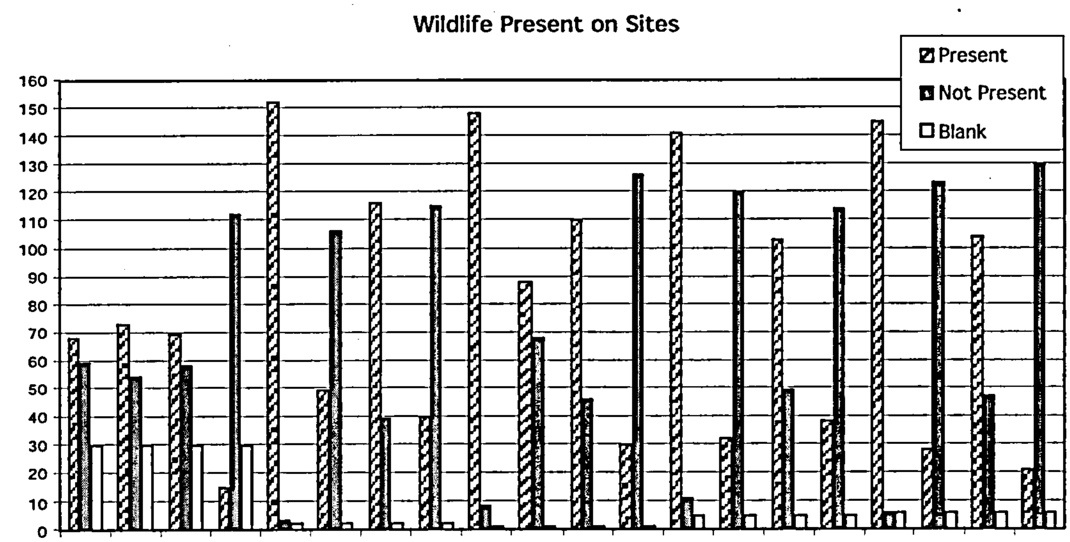

Figure 7b. Types of Wildlife at Responding Sites, Cont.

Respondents were then asked to identify the most common wildlife type(s) at their sites (Figure 8). The most common wildlife type identified were waterfowl, followed by passerines, then mammals.

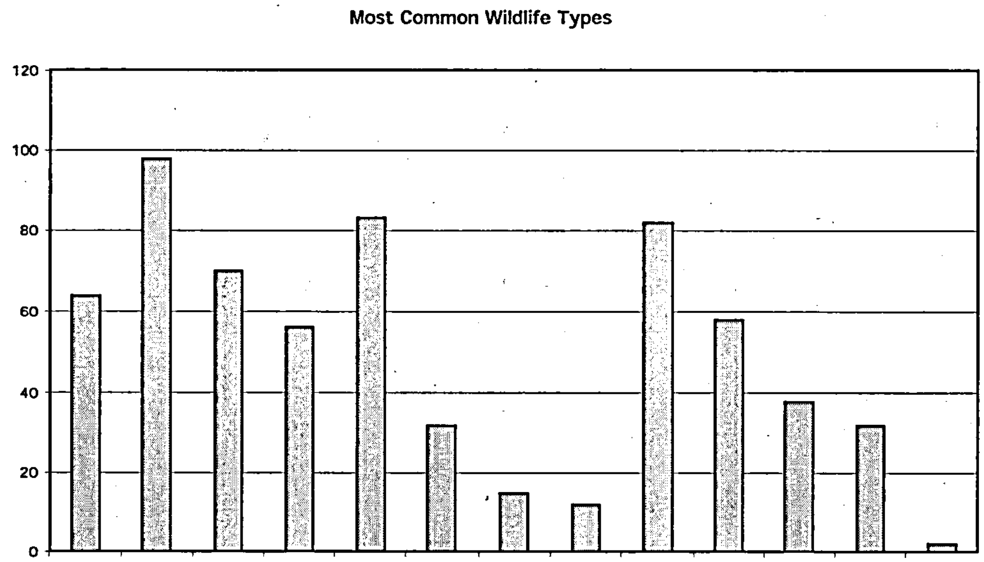

Figure 8. Most Common Wildlife Types Identified at Responding Sites

The responding sites also contained various amounts of trails open to the public, as shown in Figure 9, with the majority of sites containing between 1 and 10 miles of trails open to the public.

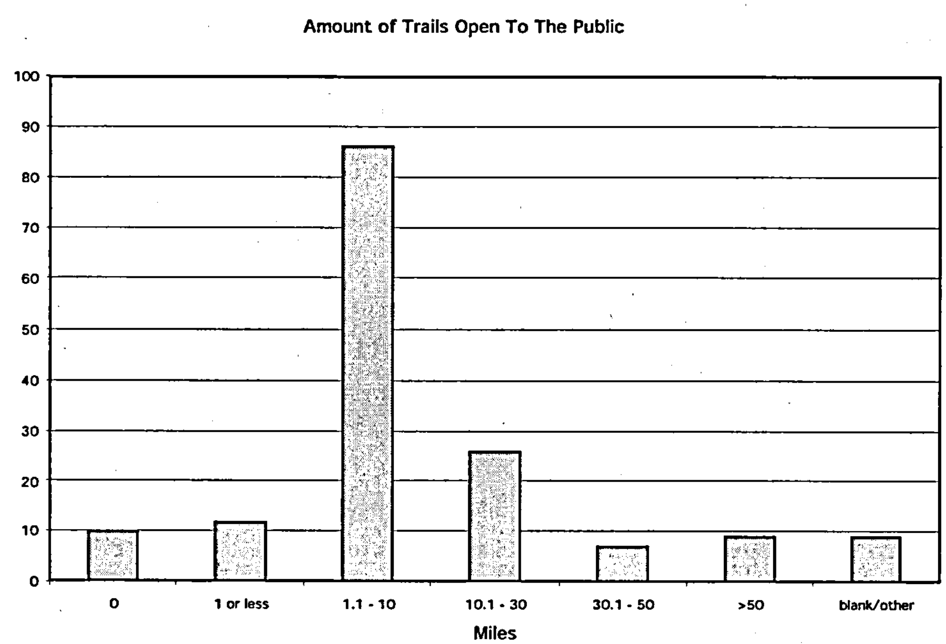

Figure 9. Amount of Trails Open to Public at Responding Sites

Finally, the responding sites had various types of adjacent land uses as shown in Figure 10. The most common types of adjacent land uses were open space, residential rural, and agricultural. Types of adjacent land uses identified under "other" included mining, timber harvest, hunt clubs, native villages, golf course, roads, open water, dump site/landfill, silviculture, government/military, oil/gas, and residential suburban.

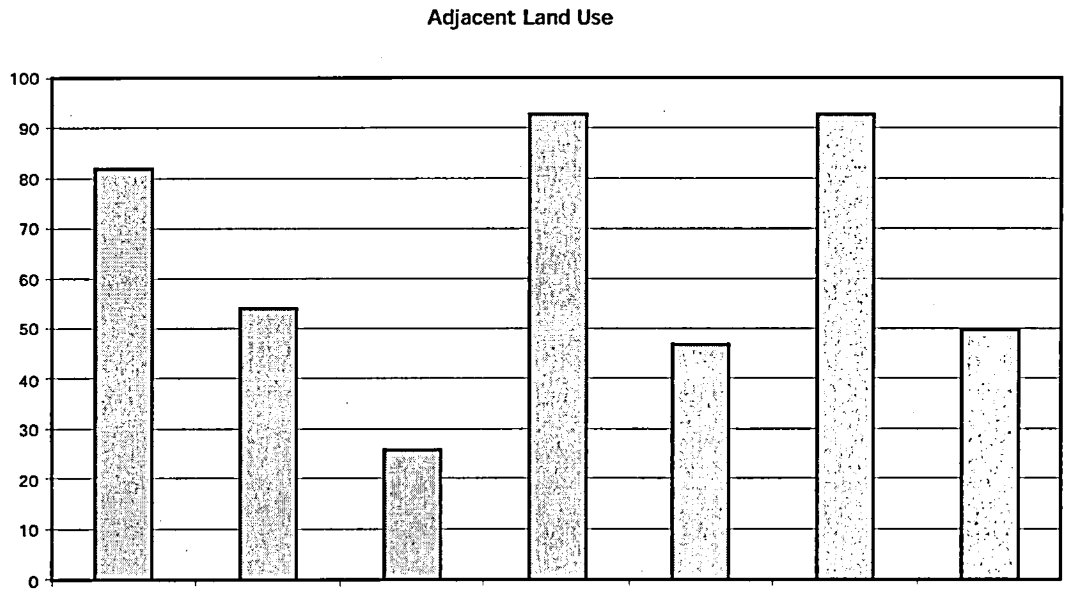

Figure 10. Types of Land Use Adjacent to Responding Sites

Human Interaction with Wildlife

Respondents were asked a series of questions regarding human interaction with wildlife at their sites.

The number of visitors at the sites ranged from 100 to five million (Figure 11). Most of the sites had a high degree of visitor use, between 100,000 and 1 million visitors in the last calendar year.

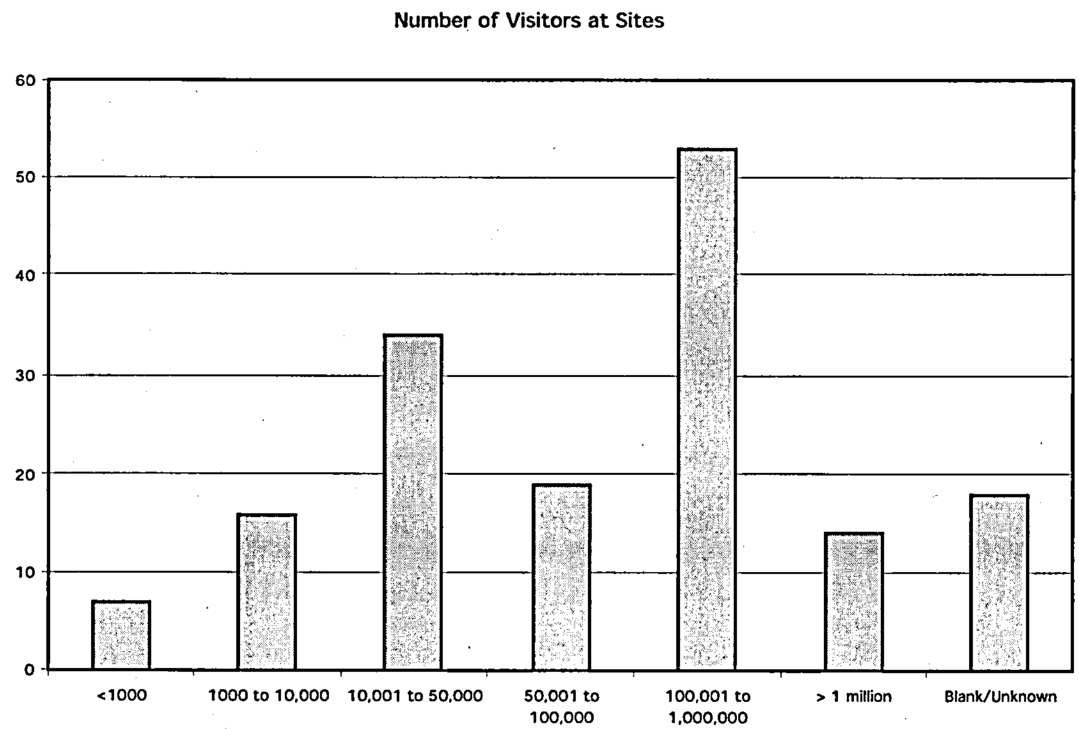

Figure 11. Number of Visitors to Responding Sites During Last Calendar Year

Respondents were asked how, if at all, they monitor impacts on wildlife from recreational activities at their sites (Figure 12). The vast majority of the respondents indicated they had informal, anecdotal, or observational monitoring and/or some degree of formal monitoring or surveys at their site (often species specific). The blank/other category includes answers that were unclear as well as blank answers.

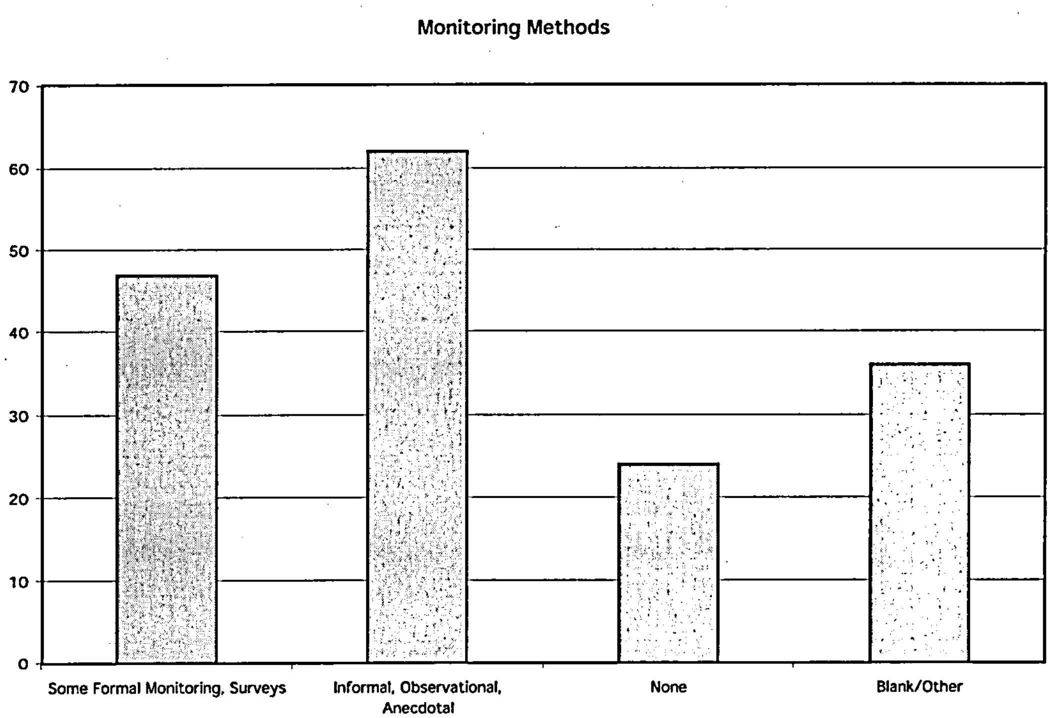

Figure 12. **Methods of Monitoring Impacts on Wildlife From Recreational Activities on Responding Sites**

Respondents were asked to identify all observed or documented effects on wildlife by activity type. Respondents were asked to identify both immediate effects (such as alarm calling, nest abandonment, flushing, reduced feeding due to increased vigilance, site abandonment, or fatality) and long-term effects (such as decreased reproductive success, site abandonment, decreased population within species, or decreased number of total species). Respondents were not asked to specify whether observed or documented effects were positive or negative. Figures 13a and 13b show results for those activities present ("activity not present" or blank answers are not included in results).

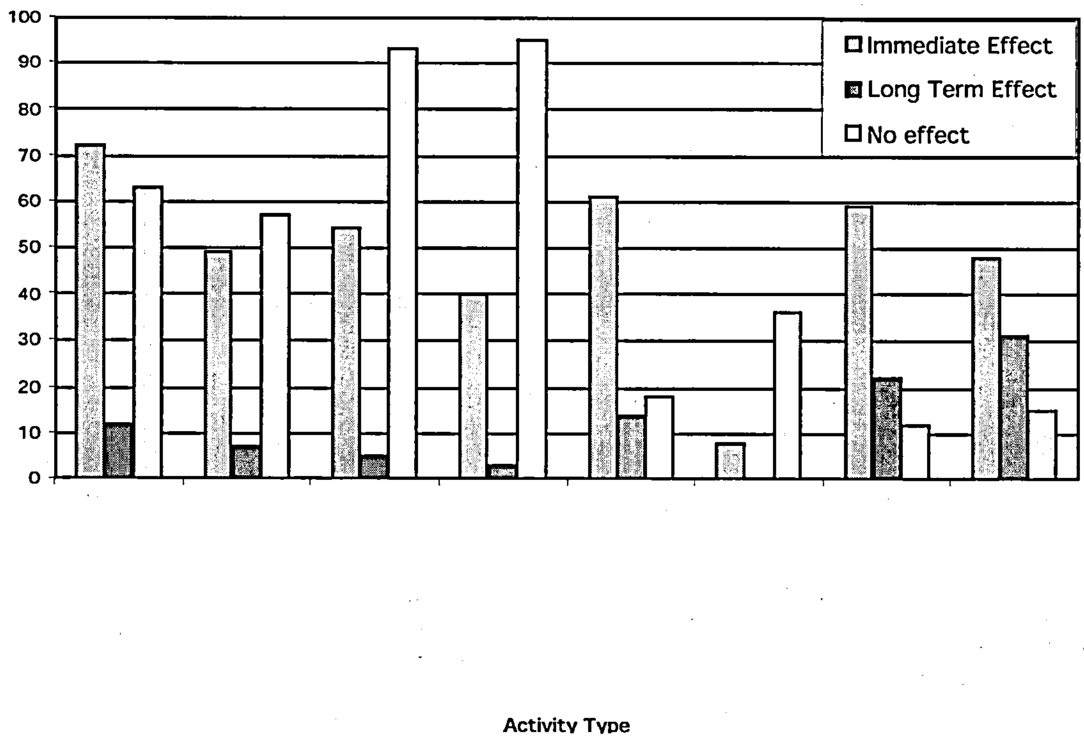

Figure 13a. Reported Observed or Documented Effects on Wildlife at Respondents' Sites

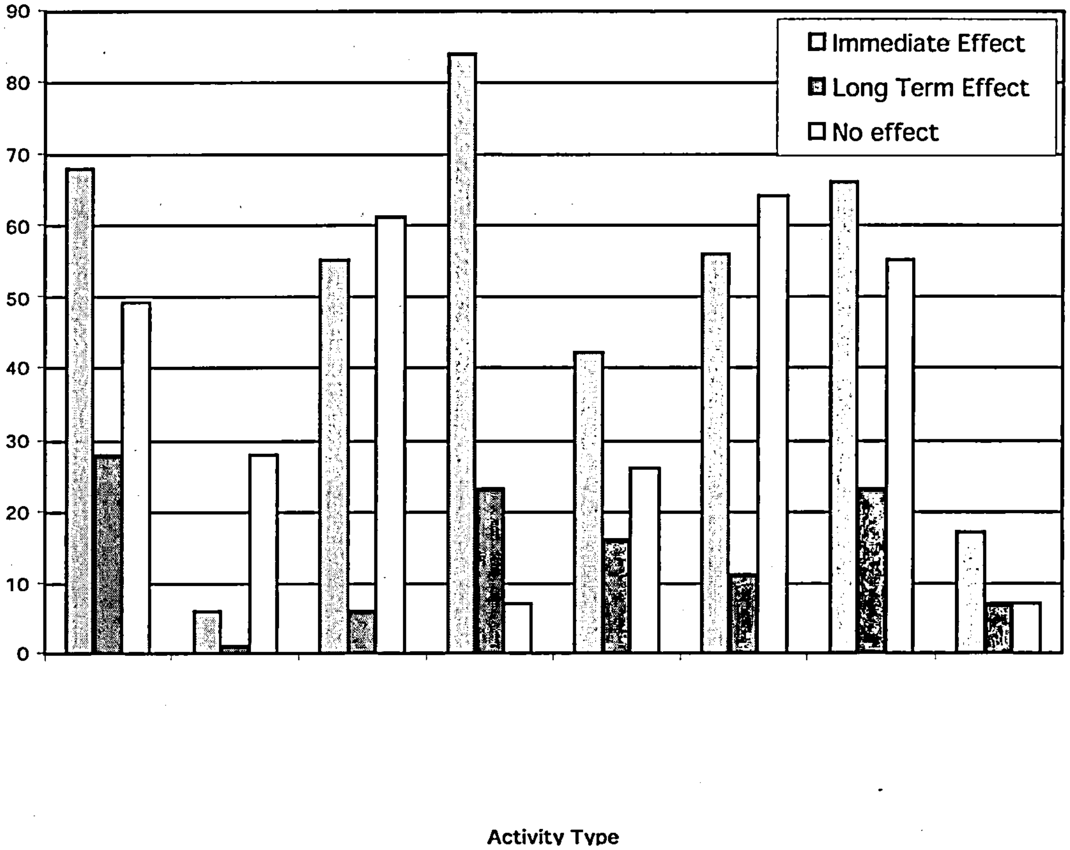

Figure 13b. Reported Observed or Documented Effects on Wildlife at Respondents' Sites, Cont.

It is important to note that respondents were not asked to correlate observed or documented effects on their sites with any other factors such as intensity of human use or management and design strategies employed at the sites. For example, seven respondents specified very low visitation at their sites (1000 or less visitors in the last calendar year) which may have affected their answers about observed or documented effects (i.e., no effect due to low intensity of human use). Similarly, the perceived effectiveness of various management strategies may have also affected responses regarding observed or documented effects of human activities (i.e., effects may have been avoided or minimized due to specific design and/or management strategies).

Finally, respondents were asked to provide any additional information that may help understand the effects of human activities on wildlife at their site. As expected, responses to this open-ended question varied, with 89 respondents answering. Many respondents mentioned specific conflict areas on their sites (i.e., Bear/people interactions, poaching, foot traffic on dunes, effects of light on sea turtles, vehicle/wildlife conflicts, photography, illegal uses, etc.).

Two respondents stated that effects were species specific. Three respondents indicated generally that shorebirds are easily disturbed by human activities, and one respondent cited observed movement of shorebirds away from trails. One respondent stated they had observed birds temporarily flushing at the site from every activity. Two respondents indicated location, seasonal modifications, and/or environmental factors as important modifiers of degree of impact of recreational use. Two respondents indicated wildlife habituation as a reason for low/no impact at their site. One respondent observed that pedestrian traffic appeared to cause more disturbance to wildlife than vehicular traffic and one respondent observed no apparent conflicts between resting bald eagles and park visitors.

Many respondents discussed degree of use on their site. Fifteen respondents mentioned low human use of their site. Nine respondents mentioned use restrictions or discussed how access is controlled or limited at the site to limit impact. Two respondents felt that a high concentration of people negatively impacted wildlife at their site. One respondent stated it would be "misleading" to claim that any human activity has no effect. Four respondents discussed educational programs at their site. One respondent specified no observed impacts with multiple users on site. One respondent felt that activities on site resulted in a mostly "incidental" disturbance to wildlife.

Design And Management Strategies

Respondents were asked a series of questions regarding siting, design and management strategies on their sites. All of the respondents employed one or more strategy(ies). Figure 14 shows the number of respondents who employed each type of design and management strategy. The vast majority of all respondents felt that their design and management strategies were at least somewhat effective in avoiding or reducing impacts on wildlife from human activities.

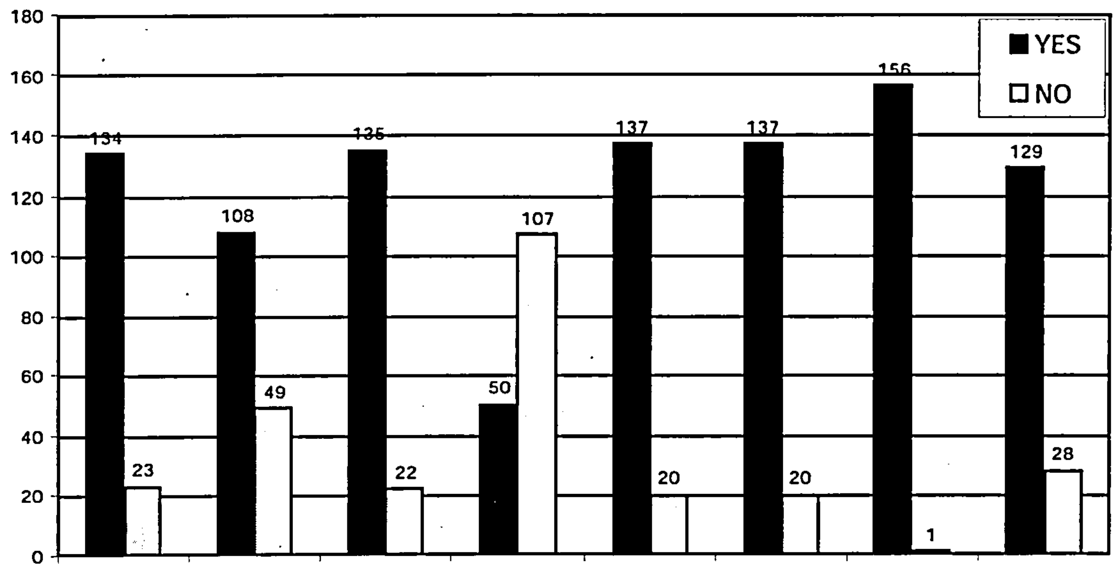

Figure 14. Design and Management Strategies Employed at Responding Sites

The following sections describe responses to design and management questions in more detail.

1. Trail Siting and Buffer Design

Trail Types and Separation Features. Respondents were asked to identify what trail types and features are present on their sites and of those trail types and features, which they felt are effective at avoiding or reducing recreational impacts on wildlife and why.

Loop trails were the most common trail type present at the sites (Figure 15), and vegetative buffers were the most common separation feature at the sites (Figure 16).

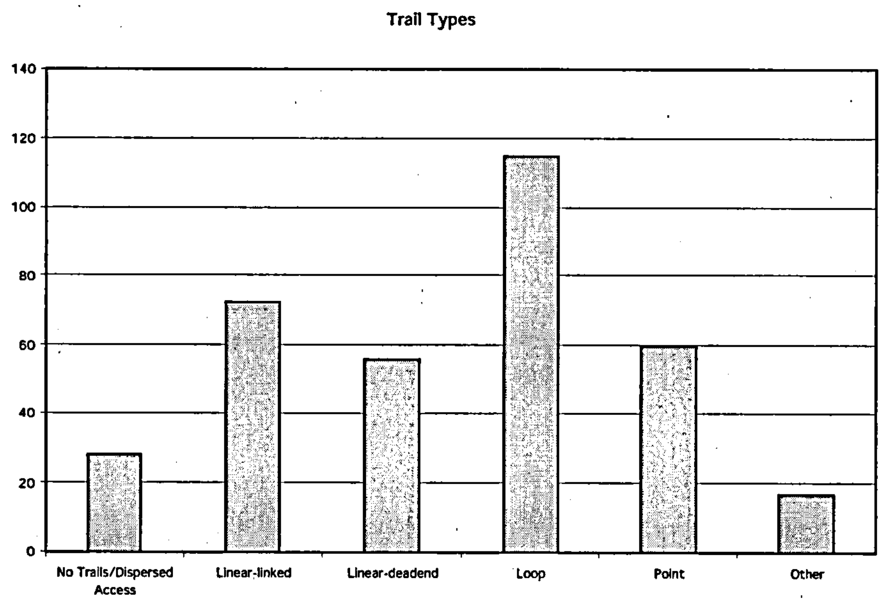

Figure 15. Types of Trails Present at Responding Sites

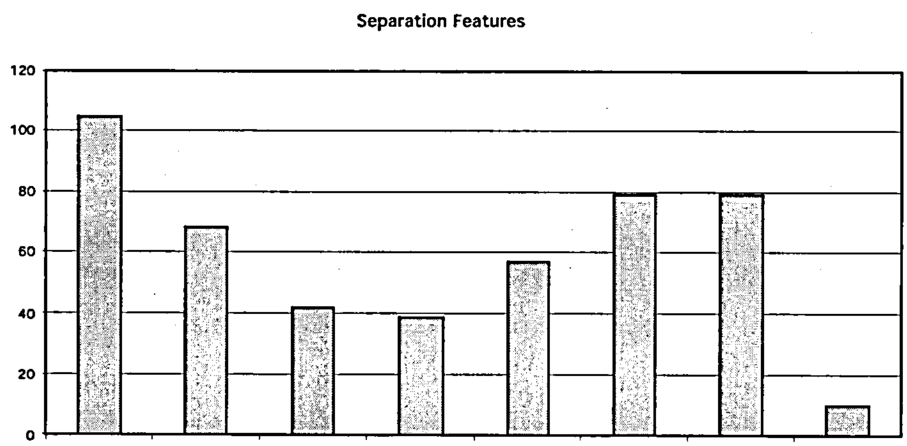

Figure 16. Types of Separation Features at Responding Sites

Vegetative buffers were the feature most often cited by respondents as effective at avoiding or reducing recreational impacts (43)(though it should be noted that vegetative buffers were also the most commonly present feature as shown in Figure 15). Reasons commonly cited for effectiveness included the benefits of vegetation for wildlife shelter and habitat (7), for visual screening (8), and for noise reduction (4). Vegetative buffers that discourage access (i.e., with thorns, etc.) were indicated several times as being particularly effective. One respondent also mentioned the erosion control benefits of vegetative buffers, and one respondent cited the "naturalness" of using a vegetative buffer as a benefit. The cost-effectiveness of vegetative buffers was also cited as a benefit (as compared to other features). Potential problems cited by respondents with vegetative buffers include that they don't always keep out dogs and that they may not allow for desired visual access.

After vegetative buffers, both bridges/boardwalks and viewing platforms/overlooks were the features most often cited as being effective (30 each). Bridges/boardwalks and viewing platforms/overlooks were also tied as the second most commonly present feature at the sites. By far the most common benefit cited for both bridges/boardwalks, and viewing platforms/overlooks was that the features restrict/confine/structure access. Both features were also cited as providing predictability of human use for wildlife, and in preventing the creation of alternative "social" or "renegade" trails (guard rails on boardwalks were specifically mentioned). Viewing platforms were cited as effective due to the ability to view wildlife at a distance (thus avoiding contact), and by providing an interesting destination for public (increased visitor satisfaction). Boardwalks were cited as being particularly good for protection of certain types of habitat (wetlands, sand dunes, salt flats) and species (i.e., protection of seabird nesting burrows). A problem cited for both viewing platforms and boardwalks was cost (for both construction and maintenance).

Fencing was the third most cited effective feature, followed by open space buffers. Fencing was cited as effective at preventing access into sensitive areas by both people and dogs. Fencing allows some visual access while preventing physical access, and can protect restored areas (i.e., allowing vegetation to grow). Fencing was also cited by one respondent as the preferred method to protect bluff slope habitat from public access impacts. Potential problems cited with fencing were unattractiveness and cost. A commonly indicated benefit of open space was potential large distance between public and wildlife, which creates room for wildlife to see and react to public (may allow for wildlife avoidance of public, or wildlife escape routes).

Moats, sloughs, and levees were cited as most effective about five times each. The cited benefits of moats, sloughs, and levees include the creation of physical separations (often unpassable) and distance and the confinement/restriction of public access.

In terms of trail types, perimeter/loop trails were most often cited as the most effective trail type (loop trails were also cited as the most common type of trail present). Cited benefits of loop trails included reduction of traffic (public passes only once, generally one direction), looped trails provide a focused use that helps prevent renegade trails, and they require only one trailhead/parking area. Linear dead end trails were cited as potentially encouraging renegade trails as public are enticed to wander past the end of the trail. There were several comments on the benefits of trails in general including providing the "path of least resistance" for public which prevents renegade trails and helps provide for public safety/confines public use. Another benefit of trails and separation features in general that was cited several times was predictability. Paved trails were mentioned as having positive noise reduction values and limiting cuts in ground. Several respondents cited the benefits of having interesting destinations and routes in general.

Prohibition of Trail Development. 107 respondents indicated there are areas within their sites where trail development is prohibited. 42 sites do not have areas prohibited from trail development. Eight respondents did not answer the question.

The most common reason indicated by respondents for prohibiting trail development was for habitat/species protection (91). The 91 references to habitat/species protection included:

- 28 general references to habitat or species protection
- 20 specific references to wetlands/marshes/bogs
- 6 specific references to dunes
- 12 specific references to threatened/endangered species
- 5 specific references to waterfowl and 3 references to birds in general
- 10 specific references to nesting species/areas
- 2 specific references to breeding species (marine mammals and birds)
- 1 each specific reference to riparian habitat, monarch butterflys, mammals, shoreline protection, and agriculture protection

The second most common reason indicated for prohibiting trail development was due to designated wilderness area, research area, or site regulations (32). Eight respondents indicated protection of cultural/archeological/historic resources, and ten respondents indicated inhospitable terrain/safety. Five respondents indicated that trails were prohibited to provide a buffer for adjacent property or for privacy, two respondents indicated erosion control, and two respondents indicated deterrence of access in general as reasons for prohibiting trail development. Additional reasons indicated included money/staff (2), lack of space (2), to prohibit dumping, to protect hunting area, to prevent predator access, to prevent native species displacement, and lack of public demand.

Respondents were asked to explain if they felt prohibition of trail development has or has not been an effective management technique for avoiding or reducing the recreation impacts on wildlife at their sites.

The majority of respondents indicated prohibition of trail development has been an effective management technique (75). Four respondents mentioned that trail prohibition is effective, but only if alternative adequate trails are provided (one respondent said observation platforms are sufficient as alternatives to trails). Four respondents cited limiting of people as the reason for trail prohibition effectiveness. Two respondents indicated prevention of habitat destruction and disturbance. Two respondents indicated that the prohibited areas must be properly controlled and signed and one respondent cited the need for species specific prohibitions. Other reasons for effectiveness included distribution of people over a broader area and distribution of people to perimeter of the area.

Seven respondents felt that prohibition of trail development has not been an effective management technique for avoiding or reducing the recreation impacts on wildlife at their sites. Four respondents indicated the lack of public abiding by rules as the reason for ineffectiveness.

One respondent felt that forcing dispersed access had a negative effect, and one respondent indicated the resulting lack of visitor predictability resulting from prohibition of trail development.

Eight respondents did not know if prohibition of trail development has or has not been an effective management technique. Three respondents indicated the need for more science, before being able to judge effectiveness, and two respondents indicated the impacts to wildlife from trails were less than impacts from commercial and residential development.

Respondents were asked for any additional information that may help in understanding the trail siting and buffer design at their sites. Respondents' comments included several specific trail siting and design strategies at their site, such as trails built on levees, trails built on existing roads, the use of trial and error trail siting, species-specific needs resulting in trail design on a case-by-case basis, trails built for cost-effectiveness, recreational and educational goals as guides for trail development, respect for site as guide for trail development, and avoidance of wildlife contact as guide for trail development.

2. Public-Use Management and Stewardship

Area Closures. Respondents were asked to identify which types, if any, of area closures they employ at their site (Figure 17).

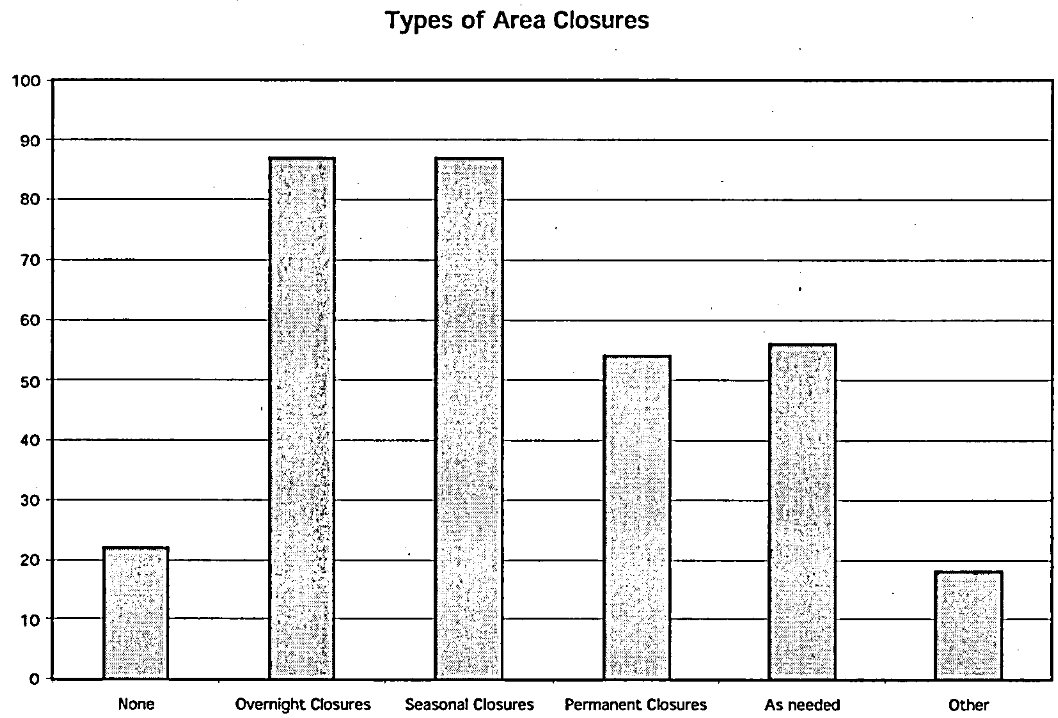

Figure 17. Types of Area Closures Employed by Respondents

The most common types of area closures employed by respondents are overnight and seasonal. Many respondents also employ area closures on an "as-needed" basis. Many of these respondents indicated that the reasons for "as-needed" closures were based on seasonal species-specific needs, so could have been grouped with seasonal closures (nineteen respondents total). Specifically, respondents indicated closures on an "as-needed" basis for bald eagle nesting sites, colonial nesting shorebirds, nesting animals in general, breeding bird colonies, heron rookeries, alligator nesting, wood duck nesting, and shellfish harvesting. Additional "as-needed" reasons for closures included flood conditions, drought conditions, storm damage, or general repair needs (21), high public use (3), public safety (2), specific management needs (2), and for research. Six respondents who marked "as-needed" did not specify a reason. Closures indicated under the "other" category included the limiting of access *type*, construction closures, closures of dune areas only, closure of banding areas, and closure of fields irrigated with sewage.

Respondents were asked to explain why they feel closing certain areas of their site has or has not been an effective management technique for avoiding or reducing the impacts of human activities on wildlife.

The following provides a summary of respondent comments and are grouped, to the degree possible, by closure type. General overall responses and additional specific responses are also summarized.

General Comments. The overwhelming majority of the respondents felt area closures have been an effective management technique. Several respondents, however, cited compliance issues as a challenge for effectiveness of area closures. Specifically, three respondents indicated that closures are effective only if enforced and maintained on a constant basis. Two respondents cited low compliance with closures at their site and one added that though law enforcement responses can be effective, they come with high costs and negative public relations. Another respondent indicated that due to many points of entry and limited staff, encroachment on a closed area could occur. Similarly one respondent indicated that closures are effective on inland sites, but not effective along the shoreline. One respondent indicated the importance of involving the public in area closings and openings in an effort to get public "buy in" and to increase compliance. Finally, one respondent cited the practice of not marking trails in an effort to decrease access without employing official area closures.

Several respondents indicated that area closures are driven by safety and maintenance needs not wildlife protection, though one respondent cited the indirect benefits for wildlife of closures for personal safety. Additionally, one respondent cited the safety benefits and visitor satisfaction from closures that separate uses.

Overnight Closures. The most common reason given for why overnight closures have been an effective management technique for avoiding or reducing the impacts of human activities on wildlife can be grouped under the general category of wildlife/habitat protection/recovery (26). More specific wildlife protection benefits mentioned included several references to protection of nesting sea turtles (5), waterfowl (3), nesting shorebirds (3), and nocturnal/crepuscular foraging animals (2). Also mentioned was protection of the Northeastern Beach Tiger Beetle, migratory nesting species, protection of bear feeding areas, and generally providing higher quality nesting and feeding habitat. Finally, two respondents mentioned better security as the reason why overnight closures have been effective.

Reasons indicated for possible ineffectiveness of overnight closures included lack of visitor compliance with closure (3). One respondent couldn't speak to effectiveness due to lack of data, and one respondent stated no impact "either way" was noticed.

Seasonal Closures. Like overnight closures, the most common reason cited for effectiveness of seasonal closures can be grouped under the general category of wildlife/habitat protection/recovery (28). Specific wildlife protection benefits cited included protection for nesting birds (11), waterfowl (8), nesting turtles (2), and eagle nests (2). Additional comments included the provision of higher quality nesting and feeding habitat, protection of mouse burrows, alligator nests, shorebirds, waders, breeding harbor seals, Canada geese, Piping plover nesting and migratory nesting, as well as shellfish regeneration and intertidal species recovery. Two respondents mentioned the potential cost savings of seasonal closures when visitation is low.

One respondent indicated compliance issues as a potential reason why seasonal closures may not be effective, and one respondent cited lack of data available to evaluate effectiveness.

Permanent Closures. The majority (16) of the respondents who employ permanent closures at their sites indicated general wildlife/habitat protection/recovery as why the closures have been effective. Specific wildlife protection benefits cited by respondents included protection for waterfowl (4) and waders (2), provision of higher quality nesting and feeding habitat (2), reduction of nest abandonment, protection for migratory nesting, increase of shellfish population, and protection for endangered plant species. One respondent indicated that upon permanently closing a two-mile trail, bald eagles have successfully bred every year where previously they failed to produce any young.

One respondent stated that the significance of no access in terms of effect on wildlife is highly debated.

Visitor Number Limitations. 105 respondents indicated they do limit the number of visitors on their site. 48 respondents do not limit the number of visitors, and 4 respondents did not answer.

The most frequently given reason for limiting the number of visitors was due to the carrying capacity of the habitat or the facility (41), followed by the desire to decrease impact on wildlife/habitat (20). Other reasons for limiting numbers of visitors included increasing visitor satisfaction (7), staff limitations or logistics (4), visitor safety (4), legislation or regulations (2), and to limit impacts to research (1).

Respondents were asked to explain why they feel that visitor limits have or have not been an effective management technique for avoiding or reducing the impacts of human activities on wildlife.

The vast majority of respondents indicated they felt visitor limits have been an effective management technique for avoiding or reducing impacts. The most frequently given reason for why limits have been effective was the reduction of impacts on wildlife and/or habitat (22), followed by reduction of impacts on habitat. Four respondents indicated increase in visitor satisfaction as to why limits have been effective. Other reasons for effectiveness included safety, regulation of harvest/overuse of resources, and provision for short term protection for wildlife. One respondent indicated that visitor limits are especially effective when combined with education. Two respondents mentioned the need to define levels of acceptable change, select indicators, and set carrying capacity.

Two respondents indicated that visitor limits have not been an effective management technique for avoiding or reducing impacts on wildlife. One respondent indicated that limits do enhance the visitor experience, however, and one respondent indicated that parking has no effect on wildlife in a day use area.

Five respondents indicated that they did not know if visitor limits have or have not been an effective management technique. Three respondents indicated a lack of data, and one respondent pointed to a lack of staff and funds for monitoring.

Visitor Activity Restrictions. 137 respondents restrict certain activities on their sites. 17 respondents do not restrict activities, and three respondents did not answer the question.

Respondents were asked to specify what activity types they restrict and why, and to explain why they feel that restricting certain activities has or has not been an effective management technique for avoiding or reducing recreational impacts on wildlife at their site.

Respondents' answers to what types of activities are restricted can be classified into eighteen general categories (Figure 18). The following provides a summary of respondent comments and are grouped, to the degree possible, by type of restricted activity. General overall responses and additional specific responses are also summarized.

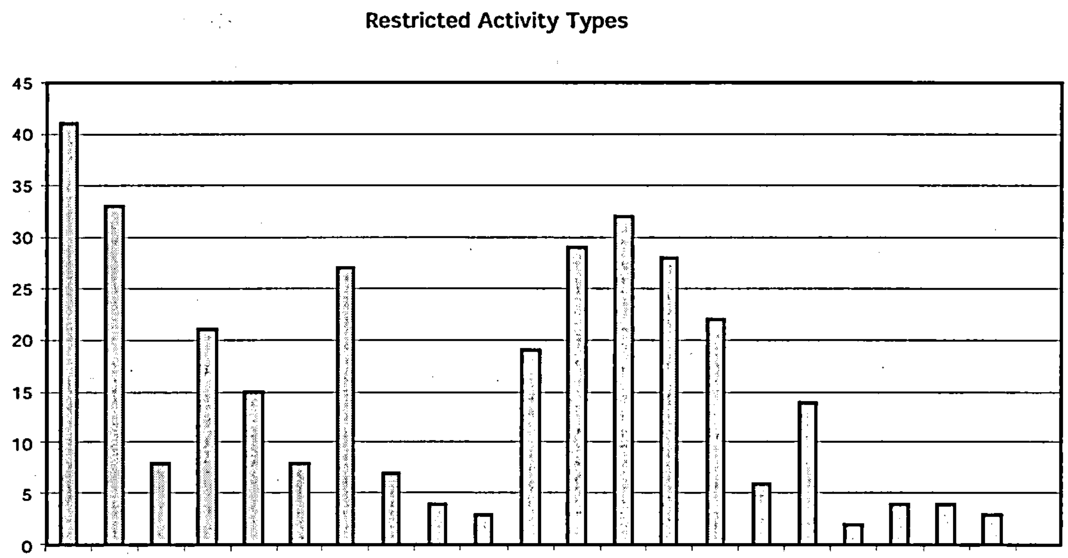

Figure 18. Types of User Activity Restrictions Employed by Respondents

General Comments. The vast majority of the respondents felt restrictions on activity types were an effective technique to reduce impact on wildlife, though two respondents in general comments indicated restrictions are only effective if enforced. One respondent indicated in a general comment that activity type restrictions had not been effective because most impacts came from permitted uses such as hiking and camping. Five respondents specifically said they did not know if activity type restrictions were effective due to lack of data, lack of enforcement, or because the restrictions were not specifically for wildlife.

Boat Restrictions. Thirty respondents employ some sort of boat restrictions including restrictions on type, size, speed, and accessible area. All respondents who employ restrictions on boats felt the restrictions were effective. The most frequently cited reason for boat restrictions was to prevent or reduce disturbance to wildlife, especially nesting shorebirds and waterfowl. Additional reasons for effectiveness indicated by respondents included; reduction of noise pollution, reduction of impacts from wakes, reduction of hydrocarbons in water, reduction of exotic invasive species (by restricting gas engines), reduction of propeller scarring of seagrass beds.

One respondent indicated insufficient staff to regulate restrictions as a potential challenge to effectiveness.

Jetskis. Although jetski restrictions could fall under the general heading of boat restrictions, they are discussed under a separate category due to the high volume of respondents who specifically mentioned jetski restrictions.

All respondents who imposed jetski restrictions at their sites felt the restrictions were effective in reducing disturbance to wildlife from noise, pollution, harassment, and habitat impacts. One respondent specifically noted that minimization of jetskis has encouraged birds to use the area for feeding.

Non-motorized Water-Oriented Uses. Restricted uses under this category include windsurfing and swimming. Respondents gave no specific comments on reasons for limitations. One respondent indicated that insufficient staff limited efforts to regulate windsurfing restrictions. No other specific comments on effectiveness were given.

Horses. Respondents felt limitation of horses was an effective technique because horses increase the environmental impact of trails, horses can cover much area and so increase access to outlying areas, and because horses directly disturb wildlife. One respondent indicated, however, that though horses on their site are restricted to trails, the riders do stray from the trails.

Hunting/Trapping/Fishing. The only specific comment related to hunting/fishing/trapping restrictions was that hunting restrictions are difficult to enforce.

Collecting. One respondent indicated that restrictions on collecting have helped educate the public about the resource. One respondent indicated that restrictions on collecting are difficult to enforce.

Pet Restrictions. Within the category of pet restrictions, eight respondents specifically mentioned restrictions on unleashed dogs.

Most respondents felt that pet restrictions were an effective technique to avoid or reduce impacts on wildlife because pet restrictions benefit sea turtle and shorebird nesting success, beach mice, waterfowl and shorebirds. One respondent indicated that pet restrictions have not been effective due to political pressure to allow fox hounds on the site, and one respondent mentioned the difficulty of enforcing leash restrictions.

Please note that pet restrictions are also discussed under restrictions on user behavior.

Kites/Model Planes. One respondent indicated that kites may resemble birds of prey.

Non-Wildlife Dependent Activities. National Wildlife Refuges by law only allow specified wildlife dependent activities. Respondents indicated that restricting non-wildlife dependent activities is an effective technique because: wildlife dependent activities have less impact, are less destructive and are less disturbing to wildlife; sanctuaries for wildlife are provided; restricting activities reduces the total number of visits and, therefore, minimizes adverse effects on wildlife, allows managers time to determine impacts and adjust accordingly, provides for greater visitor satisfaction, and the associated cost savings of restricting uses can be used to enhance management programs or wildlife oriented recreational opportunities.

ATVs/ORVs. The vast majority of the respondents felt restricting ATVs/ORVs was an effective management technique. The most common benefits of restrictions indicated by respondents were: protection of ground nests; reduced impact to vegetation and soil; reduced wildlife mortality; protection of wildlife habitat; limitation of new areas opened up for predator travel; wetland protection from rutting, trail hardening, and channelization of water sheet flow; protection of dune habitat; decrease in noise pollution; decrease of human incursion into isolated habitat areas.

One respondent mentioned the difficulty of enforcing ATV/ORV restrictions.

Motorized Vehicles (including cars, motorbikes, snowmobiles). All the comments on restrictions of motorized vehicles felt the restrictions are an effective technique. Specific benefits of restrictions indicated by respondents include: protection of dune habitat; reduction of noise; reduction of erosion; reduction of wildlife mortality; protection of vegetation from severing, trampling, and compaction; limitation of overall access to site; reduction of impacts to shorebirds, beach mice, and seals.

Bicycles. The majority of respondents felt restrictions on bicycles were an effective technique. Specific benefits of bicycle restrictions indicated by respondents included: protection of ground nests, reduction of soil compaction and erosion, protection of vegetation, decrease in user conflicts, reduction of environmental impact of trails, limitation of overall access to site, reduction of wildlife disturbance.

One respondent indicated that since bicycles do not have a large negative impact on wildlife, restrictions on bicycle use is not an effective technique to reduce impacts.

Skateboarding/Skating/Sandboarding. One respondent indicated that rollerblades increase environmental impact of trails.

Active Organized Recreation. Activities under this category include frisbee, golf, ballplaying, and horseshoes. No specific comments were provided for this category.

Camping/Campfires. One respondent indicated that limiting camping to designated areas reduces damage to natural resources.

Jogging/Walking. One respondent indicated that night walking on beach impacts sea turtles. One respondent indicated jogging is more disturbing to wildlife and detracts from wildlife oriented recreation.

All but Limited Passive Use. One respondent indicated that restricting uses to all but limited passive use allows area to support unique ecological features. Respondents also indicated that foot traffic only on trails increases visitor satisfaction, eliminates noise disturbance of wildlife, reduces trail erosion, and limits costs associated with maintenance.

Miscellaneous. This category includes all other restricted activities indicated by respondents including metal detectors, sunbathing, chainsaws, generators, and dumping.

Restrictions on User Behavior. 137 respondents restrict user behavior at their sites. 13 respondents do not restrict user behavior and seven respondents did not answer.

Respondents were asked to specify which user behaviors are restricted, the reason for the restrictions, and why they feel user behavior restrictions have or have not been an effective management technique for avoiding or reducing recreational impacts at their site.

Types of restrictions on user behavior can be grouped into sixteen general categories (Figure 19). The following provides a summary of respondent comments and are grouped, to the degree possible, by type of user behavior restriction. General overall responses and additional specific responses are also summarized.

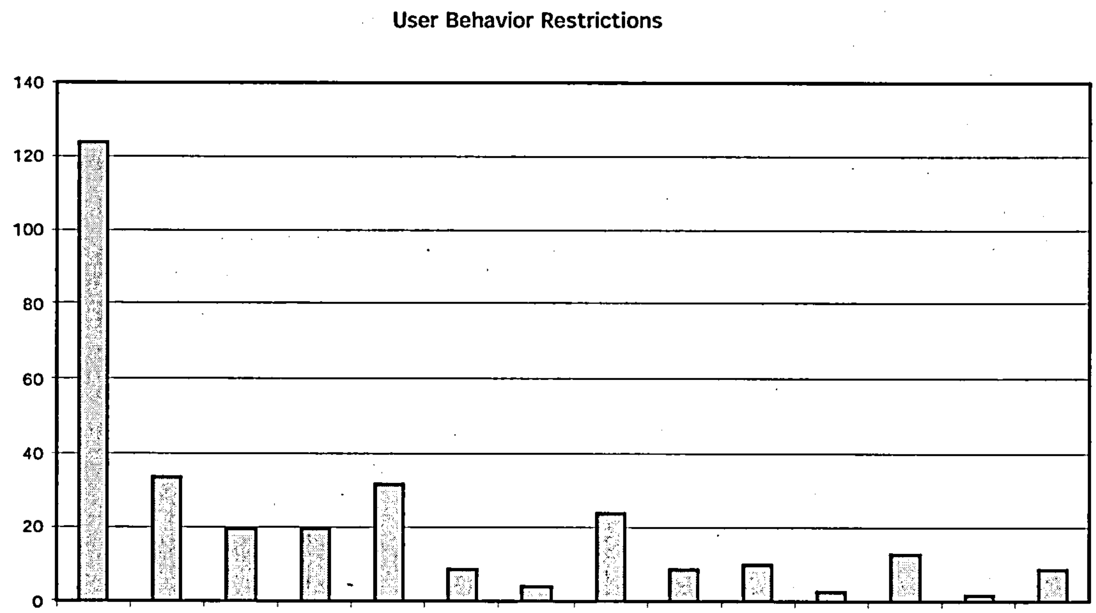

Figure 19. Types of Behavior Restrictions Employed by Respondents

General Comments. The majority of the respondents felt that restricting certain activities was an effective management technique for avoiding or reducing recreational impacts on wildlife. In general, respondents indicated that activity restrictions protect resources overall. More specifically, respondents indicated that restricting type of use restricts the overall number of potential users, keeps public use focused in developed areas, provides continuity for visitors and, if supported by the public, new users will abide by restrictions due to "peer pressure." One respondent indicated that by comparing their site to similar sites, they were able to prevent impacts by imposing proactive restrictions before a problem occurs.

Though only four respondents specifically stated that activity type restrictions have not been an effective technique, several more respondents indicated specific challenges to the success of activity type restrictions. Several respondents indicated the need for enforcement of the restrictions and for education of visitors. One respondent indicated that law enforcement staff (not park staff) lack sensitivity to wildlife needs. One respondent mentioned the specific problem of having a site that has high rate of new visitors, with a high tourist attendance and high rate of turnover in the community. In this case, efforts to "train" new users must be ongoing and enforcement must be continuous, which is problematic. One respondent mentioned the difficulty of enforcement without being invasive.

One respondent indicated that activity type restrictions control impacts, but do not eliminate them. Finally, one respondent indicated that behavior restrictions are not needed with proper trail siting and design.

Six respondents did not know if restricting activity types was an effective technique. Several indicated lack of data.

Pet Restrictions. The most commonly restricted activity type among respondents falls under the heading of pet restrictions. 24 respondents had general pet restrictions (e.g., no pets), 9 respondents required dogs to be under voice control, 9 respondents specifically allow dogs on the beach, 2 respondents required visitors to clean up after dogs, and 80 respondents required dogs/pets to be on leashes (sometimes of various lengths and in various specific areas of the sites).

The most common reason indicated by respondents for pet restrictions was for the protection of wildlife from harassment. Many respondents indicated benefits to birds from restrictions, specifically shorebirds, waterfowl, overwintering geese, nesting terns, bald eagles, and peregrine falcons. Other wildlife mentioned specifically as benefiting from pet restrictions were sea turtles and sea turtle nests, marine mammals, and terrestrial species. One respondent indicated that pet restrictions were especially effective in avoiding or limiting wildlife impact when wildlife is confined to a small, diminishing habitat. The safety and visitor satisfaction of other visitors was also mentioned frequently as a reason for pet restrictions. One respondent mentioned the secondary benefit of leash laws is they likely encourage owners to pick up waste as well.

Several respondents indicated that the effectiveness of pet restrictions was dependent upon enforcement. One respondent stated that leash laws are commonly ignored, but that compliance increases with visitor education about the benefits of leash laws.

Site Access Restrictions. One respondent indicated that the extremely limited access at their site has increased species productivity and population levels and has allowed previously extirpated species to return to site. One respondent indicated that though access restrictions keep public to a defined area and thus leave other areas for wildlife only, the areas are so small and fragmented that this strategy only works to a small degree.

Please note that access restrictions are also discussed under area closures.

Removal/Collecting. One respondent indicated that though collecting restrictions were put in place to conserve an educational resource (tidepools) birds have also benefited from preservation of a food source.

Feeding Wildlife. One respondent indicated that feeding restrictions keep most species non-aggressive.

There were no additional comments provided for the remaining categories under user behavior restrictions.

Enforcement. Respondents were asked to explain how, if at all, they enforce public use regulations at their site, and why they feel that their public-use enforcement mechanisms have or have not been effective at avoiding or reducing the effects of human activities on wildlife.

Types of enforcement mechanisms indicated can be grouped into 11 general categories (Figure 20). The following provides a summary of respondent comments and are grouped, to the degree possible, by enforcement type. General overall responses and additional specific responses are also summarized.

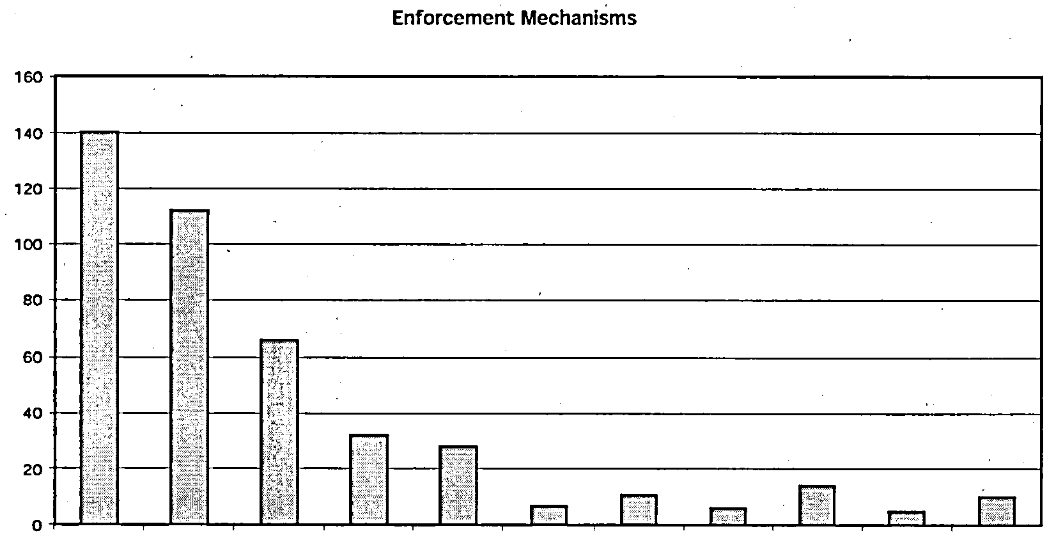

Figure 20. Types of Public Use Enforcement Mechanisms Employed by Respondents

General Comments. The majority of respondents indicated that their public-use enforcement mechanisms have been effective at avoiding or reducing the effects of human activities on wildlife. Comments included the need for various degrees of enforcement, including the comment that simply having some sort of staff presence increases effectiveness (though another respondent indicated that enforcement is only effective if staff witnesses violations), and that the public generally understands and respects environmental messages and conservation ethics and wants to do the "right thing" and that restrictions are more effective with public involvement. However, one respondent also indicated the importance of enforcement to keep public from "taking advantage" of the site and another respondent indicated noticing a resurgence of unacceptable behavior appearing during periods of lax enforcement. One respondent indicated the importance of providing alternative sites for other activities in addition to enforcing restrictions. Several respondents indicated that enforcement mechanisms assist in educating the public. One respondent indicated that success of enforcement mechanisms was due to docents and self-policing by the public. Many respondents indicated that limited staff and funds affect success of enforcement mechanisms.

Thirteen respondents specifically indicated that enforcement mechanisms had not been effective at reducing or avoiding impacts to wildlife. Several of those respondents indicated lack of staff as a primary reason for reduction of success. Respondents specifically mentioned the difficulty of patrolling outlying areas and the lack of formal entrance and exit areas to monitor area closures. One respondent also indicated that relying on volunteers to assist with enforcement is not generally successful, as most volunteers would rather help with field research, rather than enforcement. Two respondent indicated that enforcement mechanisms are geared towards managing recreational use, not wildlife. Another respondent indicated that public use restrictions were much more effective than enforcement mechanisms in avoiding or reducing impacts to wildlife. One respondent mentioned that being part of a national system was beneficial in that many visitors are familiar with common regulations. Finally, one respondent indicated that there will always be a small percentage of people who do not follow guidelines who will therefore have an impact on wildlife.

Ten respondents did not know if enforcement mechanisms were effective. Many of those respondents required more data.

Ranger Patrols/Law Enforcement. Several respondents indicated that ranger patrols and/or law enforcement were effective enforcement mechanisms because personal contact creates an opportunity to answer questions and educate the public to reduce future violations, especially effective in areas with high repeat usage. One respondent indicated that the public recognized and appreciated the patrols. Several respondents indicated that ranger patrols were effective but that it was impossible to be "everywhere at once." One respondent indicated that seven days a week patrolling has been very effective, though another indicated that random, once a week patrols should suffice. One respondent indicated the success of aerial patrols because they are generally unseen and users know they may be under surveillance. Several respondents mentioned the importance of combining enforcement mechanisms with other techniques such as interpretive programs and signage as being particularly effective. One respondent indicated that law enforcement with strong court support is essential to avoid or reduce human impacts on wildlife. One respondent indicated that similar areas without enforcement mechanisms show escalating law enforcement problems. Two respondents cited ranger patrol/law enforcement as being particularly effective relative to hunting, poaching, and fishing restrictions.

Lack of staff/funds and too large an area to adequately patrol were the most commonly cited challenges for ranger patrol and/or law enforcement success.

Signage. Several respondents indicated that signage is effective when combined with patrolling/staff presence. Two respondents indicated that signage was effective at keeping users within certain areas. Respondents indicated that signage must be properly worded and visible, and colorful and descriptive. One respondent indicated that signage is somewhat effective, but that noncompliance can not be stopped, only deterred.

Printed Material. One respondent indicated that printed material does not work as an enforcement mechanism because the public feels they have certain rights to the site and they "do as they please."

Education. Two respondents indicated that enforcement through education is their most effective tool, though one of these indicated in addition that the education must be ongoing due to new visitors at site. Two respondents indicated a combination of education/interpretive programs with staff interaction/ranger patrols is the most effective enforcement mechanism.

Visitor Center. One respondent indicated the visitor center was a successful enforcement mechanism because all visitors must first stop in visitor center so everyone hears about the site's regulations.

Education and Outreach. Respondents were asked to specify what types, if any, of education and outreach programs they offer (Figure 21).

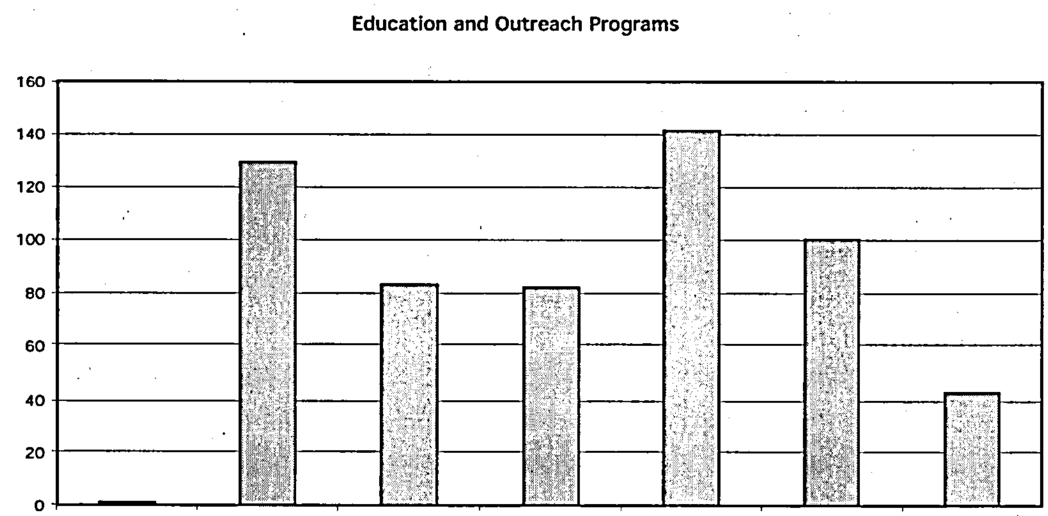

Figure 21. Education and Outreach Programs Employed by Respondents

The most common types of education and outreach programs include the use of written materials and self guided tours/interpretive signs.

Respondents were asked to explain why they feel that education and outreach programs have or have not been an effective management techniques for avoiding or reducing impacts from human activity on wildlife at their site.

The following provides a summary of respondent comments.

General Comments. The majority of respondents felt education and outreach programs have been an effective management techniques. Several respondents indicated educational efforts have resulted in a more educated, responsible and appreciative visitor thereby reducing recreational impacts on wildlife. One respondent indicated that educational efforts result in both immediate and long term behavior changes. Respondents also commented on the benefit of education in fostering public support for the site, and a few respondents also added that an educated user may educate other users. It was noted by several respondents that education works very well where a high portion of the visiting public is local and that working with the local community and local schools is very effective. Several respondents indicated the importance and benefit of educating children, one respondent added that education of children can result in changes in parent behavior, and one respondent indicated many adults volunteer at the site after attending educational programs. One respondent indicated the connection between education, which improved local public understanding of the site, and the resulting passage of a local ordinance to protect the site. One respondent indicated that as a result of public education efforts, local landowners participated in conservation easements. Finally one respondent indicated that personal contact via docents/naturalists is a very effective technique, and another respondent indicated the value of training all staff, including volunteers, to provide consistent responses to visitor questions and actions.

Several respondents did indicate that education and outreach programs have not been an effective management technique. Many of those respondents indicated lack of staff and funds as the reason the programs were not effective. Several respondents indicated that education without enforcement was not enough, and that more staff was needed to accomplish both strategies. One respondent indicated that successful outreach takes commitment and consistency to be done correctly. Several respondents mentioned lack of participation or lack of interest from the public in educational efforts, that many casual park visitors are not interested in participating in passive educational programs, including reading interpretive signs and printed materials. However, one of the respondents did indicate that a well-paid, well-trained ranger/interpreter was a very successful tool in preventing impacts. As mentioned above, several respondents indicated a lack of success due to seasonal visitation from a broad area, the small number of visitors reached and high turnover. One respondent mentioned potentially conflicting messages from other county, state or federal programs and one respondent felt educational programs were basically unnecessary as the visitor learns from other sources such as school and television.

Five respondents indicated that they did not know if education and outreach programs were successful.

3. Wildlife Management

Respondents were asked what types, if any of wildlife management and monitoring techniques do they employ at their sites specifically to avoid or reduce impacts from human activities on wildlife (Figure 22). Wildlife monitoring was the most frequently identified technique, followed by habitat modification, restoration or enhancement.

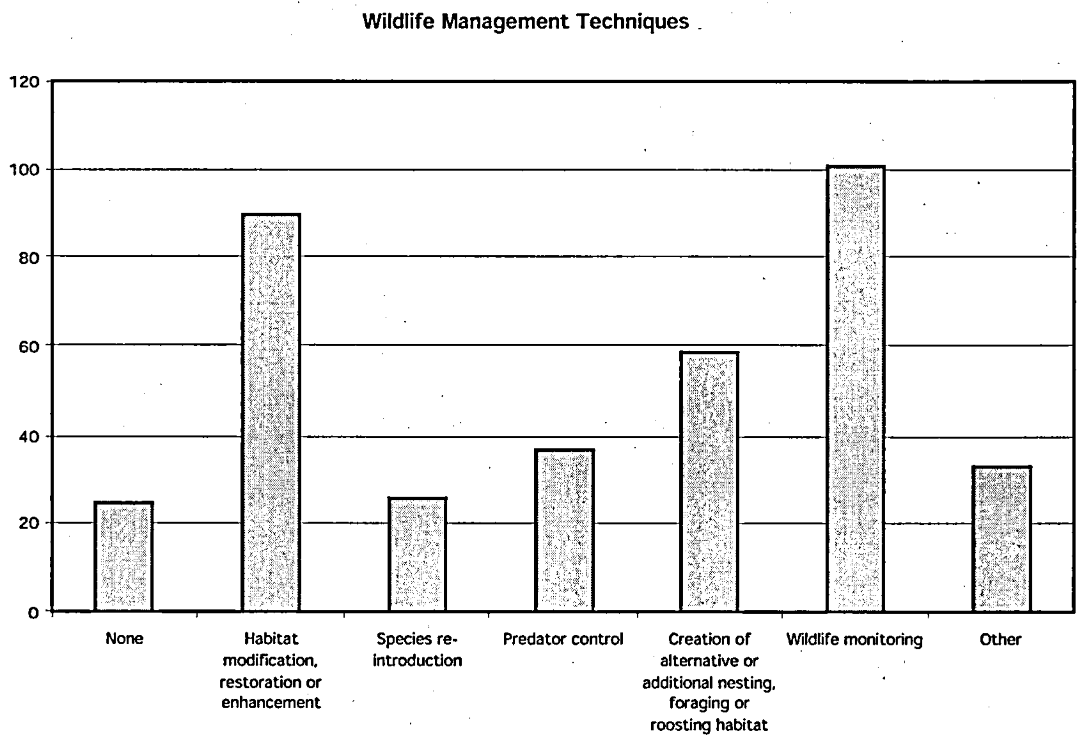

Figure 22. Wildlife Management and Monitoring Techniques to Avoid or Reduce Impacts From Human Activities on Wildlife Employed by Respondents

Respondents were asked to explain whether they feel that the wildlife management and monitoring techniques employed at their site have or have not been effective in avoiding or reducing impacts from human activities on wildlife.

The majority of respondents felt wildlife management and monitoring techniques have been effective. The following provides a summary of specific comments on wildlife management.

Wildlife Monitoring. Most respondents who commented specifically on monitoring indicated that wildlife monitoring has been effective because monitoring establishes a baseline and enables staff to track efforts to protect wildlife, and assists staff in making decisions to implement any management changes. Respondents also indicated that monitoring programs increase public involvement and sense of stewardship and can map critical habitat for specific species which can then be avoided by visitors.

Habitat Modification, Restoration, Enhancement. Several respondents indicated that habitat modifications allowed provision of high quality public access that maintains reasonable wildlife use and keeps public out of critical habitat areas. Respondents also indicated that habitat restoration and enhancement can correct prior human alterations and increase wildlife numbers and biodiversity. One respondent indicated that by modifying habitat and providing additional nesting areas, they have had little or no impact on wildlife at their site.

Predator Control. Several respondents indicated that control of predators has had a positive effect on wildlife, though one respondent indicated that predator control was the least effective technique due to the highly urban environment surrounding the site.

Creation of Alternative or Additional Nesting, Foraging, or Roosting Habitat. Two respondents indicated that creation of alternative nesting habitat has been successful for osprey and wood ducks. However, one respondent indicated that osprey platforms were not effective, probably because the area is too heavily used by the public.

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RESEARCH

Impacts of Experimentally Applied Mountain Biking and Hiking on Vegetation and Soil of a Deciduous Forest

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ABSTRACT / Many recent trail degradation problems have been attributed to mountain biking because of its alleged capacity to do more damage than other activities, particularly hiking. This study compared the effects of experimentally applied mountain biking and hiking on the understory vegetation and soil of a deciduous forest. Five different intensities of biking and hiking (i.e., 0, 25, 75, 200 and 500 passes) were applied to 4-m-long × 1-m-wide lanes in Boyne Valley Provincial Park, Ontario, Canada. Measurements of plant stem density, species richness, and soil exposure were made before treatment, two weeks after treatment, and again one year after treatment. Biking and hiking generally had similar effects on vegetation and soil. Two weeks after treatment, stem density and species richness were reduced by up to 100% of pretreatment values. In addition, the amount of soil exposed increased by up to 54%. One year later, these treatment effects were no longer detectable. These results indicate that at a similar intensity of activity, the short-term impacts of mountain biking and hiking may not differ greatly in the undisturbed area of a deciduous forest habitat. The immediate impacts of both activities can be severe but rapid recovery should be expected when the activities are not allowed to continue. Implications of these results for trail recreation are discussed.

Managers of natural areas consider recreational impacts along trails and on campsites to be their most common management problem (Godin and Leonard 1979, Washburne and Cole 1983). The field of recreation ecology, which developed to address this problem, initially focused largely on the impacts of hikers (Cole 1987a). Impacts of recreation on trails can vary between activity types (e.g., hikers, horses, and motorcycles) (Weaver and Dale 1978), so it is important to know the impacts of new forms of recreational activity, such as mountain biking.

The addition of mountain biking to trails in recreation areas has caused considerable concern. Some hikers feel that bikers should be excluded from existing trails because of the potential damaging effect of moving wheels (Cessford 1995). The Sierra Club cited potential degradation of the environment as a reason for developing guidelines and policies on biker access to trails (Coello 1989). Some park supervisors and managers have also attributed trail damage to mountain biking (Chavez 1996, Schuett 1997). A number of factors may contribute to trail degradation following the addition of mountain bikes, including biker behavior and the physical impact of bikes.

Numerous studies have focused on the behavior basis for mountain biking impacts (Watson and others 1991, Chavez and others 1993, Ruff and Mellors 1993, Cessford 1995, Schuett 1997, Goeft 1999, Symmonds and others 1999, 2000). Much less research has focused on the physical impacts of mountain biking. One study (Wilson and Seney 1994) appears in the primary literature and several others are unpublished (Petit and Pontes 1987, Goeft 1999). Wilson and Seney (1994) compared the soil erosion caused by mountain bikes, hikers, horses, and motorcycles using experimentally applied passes in Montana. They found that horses made more sediment available to erosion than mountain bikes, hikers or motorcycles, which did not differ significantly from each other or from the control. Their experiment was conducted on an existing trail with a history of prior, multiple use. Additional studies are needed to answer questions about how mountain bikes impact vegetation and soils at early stages of trail formation and how these impacts compare with those caused by other activities (e.g., hiking).

In areas with established trail systems, a common problem reported by managers is the tendency of users to go off-trail, creating impromptu paths (Cole 1985). Off-trail use can result in parallel tracks or trail widening where the main trail is more difficult to traverse

KEY WORDS: Recreational impacts; Mountain bike; Hiking; Forest plants

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than adjacent surfaces (Bayfield 1973, Lance and others 1989), or may result in new, informal trails where users cut through undisturbed vegetation as a shortcut or to gain access to attractions (Coello 1989, Cessford 1995). Because it becomes difficult to discourage the use of obvious impromptu trails, managers need to know how many off-trail passes are needed to create a trail and if this threshold differs for biking and hiking. If the effects of biking and hiking are similar, then managers can make use of previous hiking studies (Cole and Schreiner 1981) to predict where and when biking impacts are likely to occur.

The purpose of this study was to compare the effects of mountain biking and hiking on the soil and understory vegetation of an undisturbed deciduous forest at the initial stage of trail formation. To isolate the physical impacts of each activity, the behavior of bikers and hikers was standardized. By measuring soil and vegetation parameters before and after experimentally applied biking and hiking passes, we assessed differences between effects of biking and hiking, under the unique circumstances of the experiment. The study was conducted in a deciduous forest for two reasons. First, deciduous forests with sensitive, forb-dominated understories are among the most susceptible terrestrial habitats to damage by recreational activity (Kuss 1986, Cole 1987b, 1995c). Therefore, potential differences in the amount of impact from biking and hiking should be more easily observed in this vegetation type than in more resistant types. Second, forest is the preferred environment of mountain bikers (Ruff and Mellors 1993) and is therefore a likely setting for future bicycle paths.

Materials and Methods

Study Area

The study was conducted in Boyne Valley Provincial Park (44°05′N, 80°08′W), located 60 km northwest of Toronto, Ontario, Canada. A site was selected within the park that satisfied two criteria: (1) a mature deciduous forest with continuous canopy, and (2) absence of timber harvesting. The site occupies an area of approximately 270 ha, at an elevation of 420–470 m. The dominant tree cover is sugar maple (*Acer saccharum* L.), and the predominant soil type is a well-drained fine sandy loam of the Hillsburgh soil series (Hoffman and others 1964).

Experimental Design

The experiment consisted of two treatments: activity type (hiking or biking) and pass intensity (0, 25, 75, 200, and 500 passes), resulting in ten treatment combinations. A maximum of 500 passes was chosen based on the finding of Cole and Bayfield (1993) that 500 passes was sufficient to cause at least a 50% reduction in vegetation cover for most vegetation types. Each of the ten treatment combinations was randomly assigned to one of ten treatment lanes within a 50-m-long × 5-m-wide block. Lanes were 5 m long and 1 m wide (Figure 1A). Lanes were separated by a buffer zone of 5 m to avoid potential treatment carryover effects and to allow access for taking measurements. The 50 cm at each end of the 5 m lane were used as buffer zones so that the sampled portion was 4 m long × 1 m wide. The meter-wide plots were divided into three zones (center, middle, and outer) to allow for spatial variation in biking and hiking impacts (Figure 1B). The ten blocks were set up at least 5 m away from one another and at least 25 m from the edge of the forest.

Treatment Application

Each block was positioned on a slope so that the treatment lanes ran perpendicular to slope contours. An effort was made to position each block so that terrain microtopography was as homogeneous as possible from one end to the other. Slopes were measured with a clinometer at each of the ten lanes along the base of each block. The mean slope measurements for the ten chosen blocks ranged from 9.0° to 14.7°. Block locations were also selected to share the same southerly aspect. The centerline of each lane was marked by five wire pegs tied with flagging tape to indicate the path to be followed by bikers and hikers.

Biking and hiking treatments were applied by the same four participants, weighing between 57 and 73 kg. To apply hiking passes, three hikers wore lug-soled hiking boots and one wore rubber-soled running shoes. Three mountain bikes, two Norco Kokanees and one Raleigh Legend, each weighing 13.5 kg, were used to apply biking passes. All three bikes had 18-inch chrom-alloy frames, with heavily lugged tires (65.4 cm diameter, and 4.9 cm width), with 21 speed Shimano front and rear derailleur gears, and Shimano cantilever hand brakes. The total weights of bikes plus riders ranged from 70.5 to 86.5 kg.

Biking and hiking treatments were applied from the start of the last week of June to the middle of the second week of August 1997. The total number of passes required for an individual block (1600) was scheduled to be completed over a one-week period. The number of passes to be completed on a particular lane was distributed over the same number of days so that on a given day a 25-pass lane might receive two passes per person while a 500-pass lane would receive

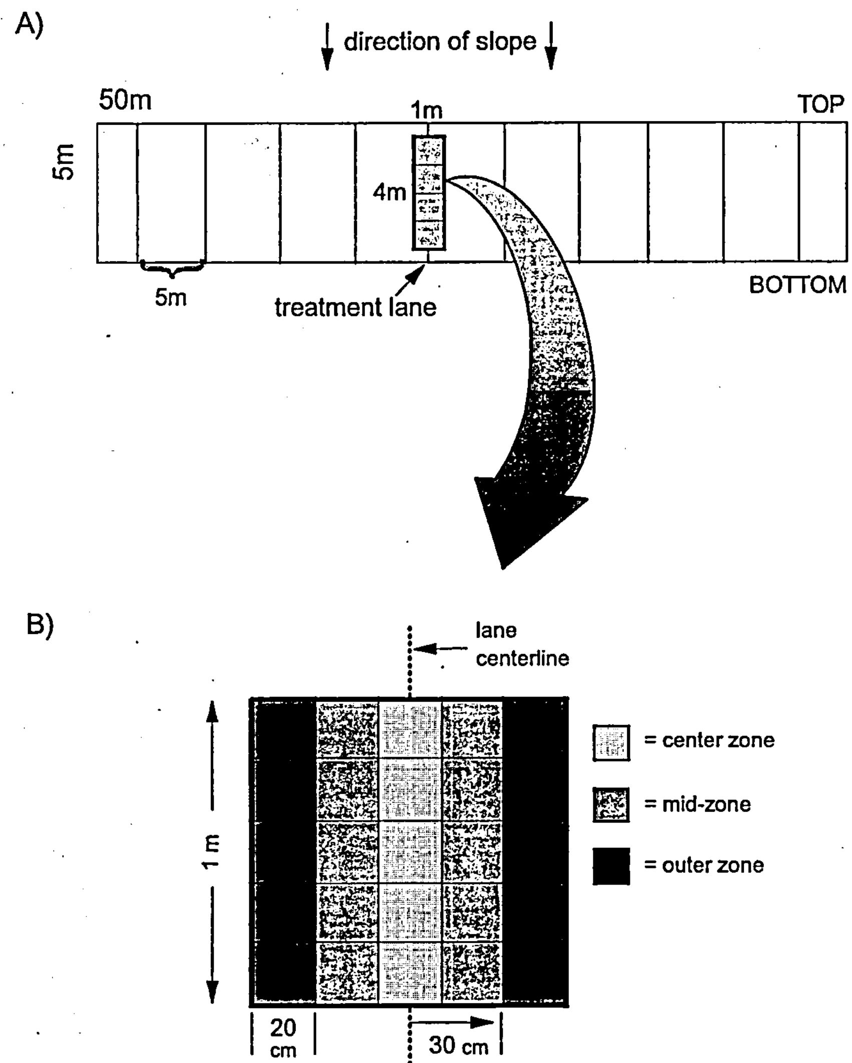

Figure 1. (A) Location of the ten treatment lanes per 50m × 5m block. (B) Enlargement of a 1-m × 1-m quadrat showing the three quadrat zones (center, middle, outer).

40. As well, the number of passes scheduled to be completed on a given day were distributed among all participants in order to balance weight differences.

A pass was a one-way walk or bike trip down a lane following the premarked centerline path. Bikers could not make uphill passes, even in the lowest of 21 gears, due to slope, rough terrain, and tree sapling density, so passes by both hikers and bikers were only made downhill. Hikers moved at a natural gait, adjusting their pace on steeper slopes and over rough terrain to maintain balance. During the initial passes down a given lane, hikers would occasionally stumble away from the lane centerline, or slide their boots over steeper sections, until a path developed. Bikers traveled at a moderate speed, usually allowing bicycles to roll down lanes without pedaling where the slope would allow. Brakes were applied as needed to keep bicycles under control. Over rough terrain, some firm braking, occasional skidding, and some side-to-side movement of the front tire was required to maintain balance until a path developed. Once participants reached the bottom of a lane, they would turn and circle around the nearest end of the block back to the top of the lane to make a second pass. Treatment application schedules were adjusted to avoid heavy rain events for the safety of bikers and hikers. Blocks received approximately 19 mm of rain during treatment application.

To calculate the surface area covered by one pass of a hiker or bicycle, and the contact pressure applied by each, boot sole and tire measurements were taken. Hiker footwear had a mean single sole contact area of 215.1 cm^2 (range 200.0–228.8 cm^2). The surface area contacted by two bicycle tires on the ground at any given moment (without a load being applied) was calculated as 224.3 cm^2 from an equation based on the tire geometry of agricultural vehicles: $S = 0.7 \times$ undeflected tire radius $\times$ tire width (Soane and others 1981a, 1981b), where S is the contact area of one tire, radius = 32.7 cm, and tire width = 4.9 cm. The total surface area contacted by a hiker would therefore be (assuming six steps per 4 m of lane) 1290.6 cm^2, and that by a biker would be tire width $\times$ 4 m $\times$ 2 wheels = 3920 cm^2. The pressure applied over one foot step was calculated as the weight of each hiker divided by the area covered by their boot sole. Hikers applied a mean pressure of 0.29 kg/cm^2 (range 0.27–0.32 kg/cm^2). A similar approach was used to calculate the pressure applied over two bicycle tires at rest. Using bike plus biker weights and the contact area calculated above, the mean pressure applied by bicycle and rider was 0.35 kg/cm^2 (range 0.31–0.39 kg/cm^2).

Response Variables

Three variables commonly used to assess recreational impacts were measured. First, the loss of vegetation following treatment application was measured by the change in vascular plant stem density from pretreatment stem density. Second, the loss of species richness was measured by the change in the number of plant species present. Third, the increase in the amount of soil exposed was measured.

Measurements were made immediately before biking and hiking passes were applied, and then two weeks after treatment application and again one year after treatment application.

Pretreatment measurements. A 1-m^2 wooden frame quadrat was positioned on the ground so that the lane centerline marked the center of the quadrat as well. String was attached to the 1 m^2 frame to divide it into twenty-five 20-cm $\times$ 20-cm cells (Figure 1B). To accommodate the presence of saplings and other obstacles in the sampling area, a second quadrat was prepared that used removable thin wooden planks, instead of string, to outline the 25 cells. To consider the spatial differences in treatment effects from the center of the lane to its edges, the five columns of quadrat cells were grouped into three categories, or quadrat zones. The center column of five cells was referred to as the center zone, the two columns on either side of the center (i.e., ten cells) were called the middle zone, and the two outside columns of cells (i.e., ten cells) became the outer zone (Figure 1B). Measurements were made and recorded for each individual cell before being summarized for the three zones. Once measurements were completed for a quadrat, its position was marked at four corners using pegs tied with flagging tape so that the same exact spot would be used again during posttreatment sampling.

Vascular plants present in a cell were identified to species and species were each categorized as one of six growth forms: tree-seedlings (stem <1 cm diameter, height <1 m), tree saplings (stem >1 cm diameter, height >1 m), shrubs and vines, ferns, forbs (broadleaved herbaceous plants), and graminoids (grasses and sedges). Mature trees were not encountered within the sampled lane areas. Once identified, the plants in each quadrat cell were counted. To avoid the problem of how to define individual plants (complicated by clonal growth), plants were counted by their aboveground stems only. Due to the dense clustered growth of the graminoids, they could not be enumerated as discrete stems with confidence. Instead, each graminoid species was simply observed as either present or absent in a given quadrat cell. Graminoid data were therefore only used in species richness calculations.

Exposed soil was defined as bare ground of the A_1 horizon, free of macroscopic vegetation, leaf litter, twigs, moss, or humus. Soil exposure was visually estimated for each quadrat cell using a five-point scale: 0 (0–20%), 1 (21–40%), 2 (41–60%), 3 (61–80%), and 4 (81–100%).

Two weeks after treatment application. Effects of biking and hiking were first measured two weeks after treatment application. A two-week waiting period was recommended by Cole and Bayfield (1993) as the amount of time required to allow damage to vegetation to become apparent. Quadrats were repositioned using corner markers to ensure identical placement and the procedure used to measure pretreatment conditions was repeated during posttreatment sampling. Vascular plant stems present were classified as intact, damaged, dead, or absent. Intact stems were those found in their original condition. Damaged stems were those found with evident tissue loss (missing leaves), with impact-induced injury (broken stems, crushed plant body), or with yellowing or wilting plant parts. Dead stems were those with no green pigment and were brittle to the touch. Absent stems were simply missing. New shoots (<10 in total) were not included in the posttreatment vegetation survey. Soil exposure was estimated visually as in the pretreatment sampling, using the same five-point scale (0–4).

One year after treatment application. Posttreatment sampling was repeated one year after treatment application. A one-year period was recommended by Cole and Bayfield (1993) as the amount of time required for damage to either diminish or become more apparent, depending on the resiliency of the vegetation type.

Vascular plant stems were classified as present or absent. Soil exposure was estimated visually as in pretreatment sampling, using the same five-point scale (0–4).

Treatment Effects

Measurements taken during pretreatment and posttreatment sampling were used to calculate the following response variables. For each variable, data for the four quadrats per treatment lane were summed for each quadrat zone (center, middle, outer).

Loss of vegetation after two weeks. This was defined as the percentage of original vegetation found damaged, dead, or absent two weeks following treatment application. It was calculated as follows:

$$\frac{\text{number of original stems found damaged, dead, or absent 2 weeks after}}{\text{number of stems present before}} \times 100\%$$

where the words before and after refer to pre- and posttreatment measurements.

Loss of vegetation after one year. This was defined as the percentage of original vegetation that was absent one year following treatment application. It was calculated as follows:

$$\frac{\text{number of original stems found absent 1 year after}}{\text{number of stems present before}} \times 100\%$$

Treatment lanes where no plant stems were present initially (14 of 300 lanes) were not included in the analysis.

Loss of species after two weeks. This was defined as the percentage of initial species that were not present (i.e., all stems were dead or absent) two weeks following treatment application. It was calculated as follows:

$$\frac{\text{number of species found dead or absent 2 weeks after}}{\text{number of species present before}} \times 100\%$$

Loss of species after one year. This was defined as the percentage of initial species that were absent one year following treatment application. It was calculated as follows:

$$\frac{\text{number of species found absent 1 year after}}{\text{number of species present before}} \times 100\%$$

Increase in soil exposure after two weeks or one year. This was defined as the difference in cover estimates before and either two weeks or one year after treatment application. It was calculated as follows:

$$\%\ \text{exposed soil (2 weeks or 1 year) after} - \%\ \text{exposed soil before}$$

Statistical Analysis

To determine whether there were any preexisting differences among lanes assigned to different treatments, pretreatment (before) values for each response variable were compared using a three-factor split-plot analysis of variance (ANOVA). The two whole-plot factors were activity type (biking or hiking) and pass intensity (number of passes made). The split-plot factor was quadrat zone. This analysis was carried out using the PROC MIXED procedure of SAS (SAS Institute Inc., 1996). Data were square-root transformed to help meet assumptions of normality and equality of variance. This analysis revealed no significant pretreatment effects (Thurston 1998).

To assess statistical significance of posttreatment (after) effects, the three-factor analysis described above was repeated for each of the three response variables. Significant interaction terms involving quadrat zone made it necessary to analyze treatment effects for each zone separately. Data for each zone were analyzed with a two-factor ANOVA for a randomized complete-block design, using the PROC GLM procedure of SAS (SAS Institute Inc., 1996). The two treatment effects were activity type (biking and hiking) and pass intensity (0, 25, 75, 200, and 500 passes). Data were arcsine square-root-transformed for loss of vegetation and loss of species data after two weeks, square-root-transformed for soil exposure data, and log-transformed for loss of vegetation after one year data.

Results

Vegetation Composition

Fifty-five vascular plant species were encountered in pretreatment sampling (Appendix 1). The most common species were two forbs, *Arisaema triphyllum* (L.) Schott. (20 stems per lane), and *Caulophyllum thalictroides* (L.) Michx. (11 stems per lane), and seedlings of the tree *Acer saccharum* (7 stems per lane). A total of six different growth forms were encountered: forbs, tree seedlings, ferns, shrubs and vines, tree saplings, and graminoids. Based on total stem density, forbs ranked first with 77% of all stems, followed in turn by tree seedlings (17%), ferns (3%), shrubs and vines (2%), and tree saplings (1%).

Treatment Effects After Two Weeks

Loss of vegetation. Vegetation loss was significantly affected by pass intensity, by quadrat zone, and by the

Table 1. Analysis of variance results for treatment effects on loss of vegetation, species richness, and increase in soil exposure after two weeks in three quadrat zones (Combined or Separated)[a]

	F value		
Source of variation	Loss of vegetation	Loss of species richness	Increase in soil exposure
Combined			
Activity type (*A*)	0.6	0.5	2.3
Pass intensity (*P*)	40.1**	16.3**	53.7**
$A \times P$	1.8	0.8	0.8
Quadrat zone (*Z*)	223.2**	188.6**	186.6**
$A \times Z$	2.4	1.1	0.9
$P \times Z$	11.8**	6.0***	25.0**
$A \times P \times Z$	0.9	0.4	0.3
Separated			
Center zone			
Activity type	0.01	3.0	0.7
Pass intensity	48.7**	19.4**	37.8**
$A \times P$	1.6	0.6	0.3
Middle zone			
Activity type	3.6	0.04	0.3
Pass intensity	20.9**	6.5**	5.5*
$A \times P$	0.6	0.3	33.7**
Outer zone			
Activity type	0.3	0.07	0.2
Pass intensity	2.0	1.2	2.3
$A \times P$	1.5	0.6	1.0

[a]Blank = $P > 0.05$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

interaction effect of pass intensity × zone. This interaction reflects the significant pass intensity effect detected in the center and middle zones but not in the outer zone (Table 1, Separated). In contrast, neither activity type nor any interaction effect including activity type was significant (Table 1).

Vegetation loss generally increased with increasing pass intensity for the two activity types combined (Figure 2a). In the center zone, mean vegetation loss increased significantly from 16%–31% on control lanes (0 passes), to 86%–100% on treated lanes (25–500 passes). In the middle zone, vegetation loss increased significantly from 14% on control lanes (0 passes) to 58%–79% on treated lanes (25–500 passes). In the outer zone, vegetation loss did not differ significantly with the number of passes made, ranging from 14% to 28%.

Mean vegetation loss did not differ significantly between biking and hiking treatments (Table 1, Combined). Nor were there any significant interactions between activity type and pass intensity, in any zone (Table 1, Separated). Mean vegetation loss over all pass intensities was greatest in the center zone (80% for biking, 81% for hiking), moderate in the middle zone (55% for biking, 47% for hiking), and least in the outer zone (19% for biking, 22% for hiking) (Figure 3a).

Loss of species. Species loss was significantly affected by pass intensity, by quadrat zone, and by the interaction effect of pass intensity × zone (Table 1, Combined). Again, this interaction effect reflects the significant pass-intensity effect detected in both the center and middle zones but not in the outer zone (Table 1, Separated). Species loss was not affected by activity type or by any other interaction (Table 1).

Species loss generally increased with increasing pass intensity for the two activity types combined (Figure 2b). In the center zone, species loss increased significantly from 28% on control lanes (0 passes) to 74%–99% on treated lanes (25–500 passes). In the middle zone, species loss differed significantly from 4% on control lanes (0 passes) to 22%–41% on treated lanes (25–500 passes). In the outer zone, no significant treatment effects were found, with species loss ranging from 6% to 14%.

Mean species loss did not differ significantly between biking and hiking treatments (Table 1, Combined), or were there any significant interactions between activity type and pass intensity in any zone (Table 1, Separated). Mean species loss over all pass intensities was greatest in the center zone (80% for biking, 71% for hiking), moderate in the middle zone (27% for biking, 26% for hiking), and least in the outer zone (8% for biking, 11% for hiking) (Figure 3b).

Increase in soil exposure. Soil exposure was significantly affected by pass intensity, by quadrat zone, and by the interaction of the two (Table 1, Combined). The interaction resulted from the significant pass intensity effect being detected in both the center and middle zones but not in the outer zone (Table 1, Separated). Neither activity type nor any interaction involving activity type was statistically significant when all three zones were considered together (Table 1).

In the center zone, mean soil exposure increased gradually and significantly from 1% on control lanes (0 passes) to 49% on treated lanes (Figure 2c). In the middle zone, mean soil exposure increased significantly with pass intensity but to a lesser extent than in the center zone, ranging from 1% for control lanes (0 passes) to a maximum increase of 21% for treated lanes. In the outer zone, no significant treatment effects were found. Mean increase in soil exposure ranged from −0.2% to 1%.

Mean soil exposure did not differ significantly between biking and hiking treatments in any zone (Table 1, Separated). Mean soil exposure over all pass intensities was greatest in the center zone (30% for biking lanes, 23% for hiking lanes), moderate in the middle

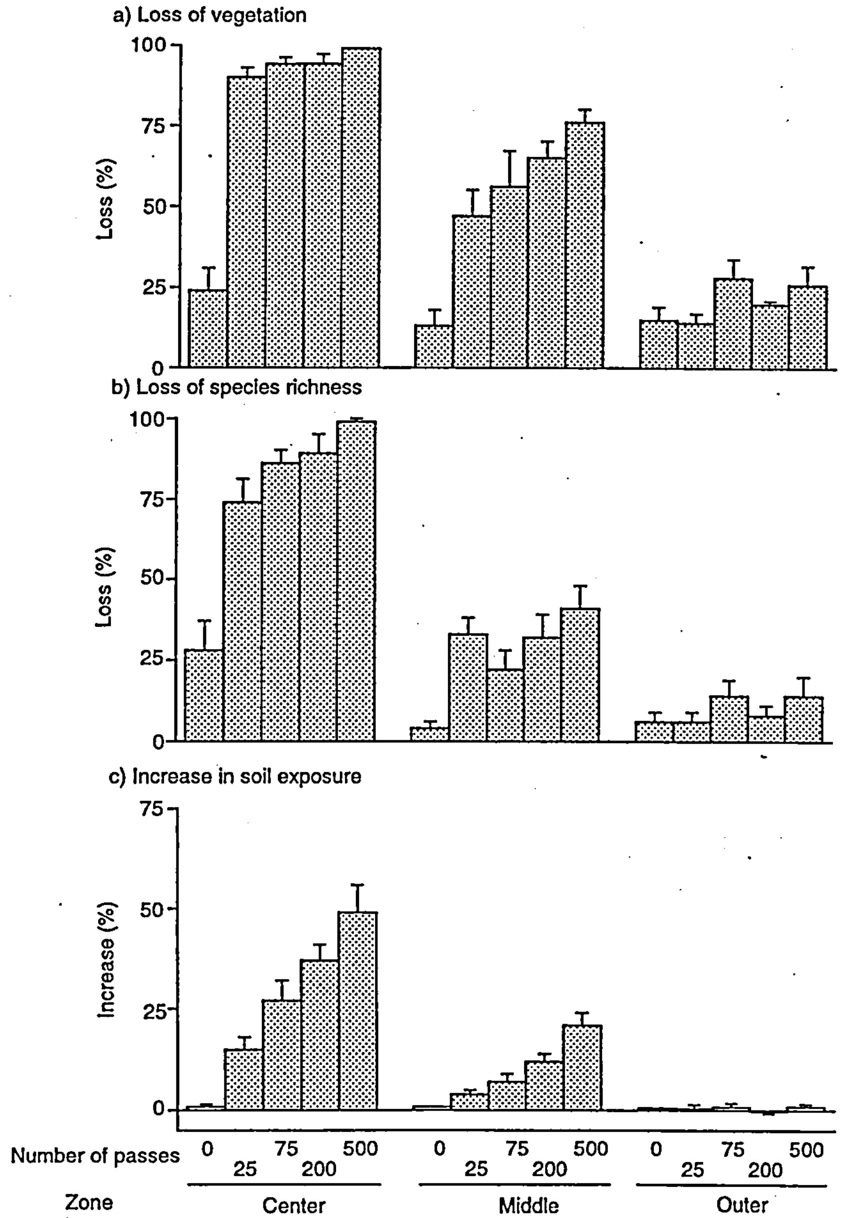

Figure 2. Effect of increasing pass intensity on the mean (±1 SE) loss of vegetation, loss of species richness, and increase in soil exposure two weeks after treatment in the three quadrat zones for the two activity types (biking and hiking) combined.

zone (10% for biking lanes, 8% for hiking lanes), and least in the outer zone (0.6% for both activities) (Figure 3c).

Analysis of variance results for soil exposure in the middle zone indicated a significant interaction between activity type and pass intensity (Table 1, Separated). This interaction was due to the fact that soil exposure following biking was only significantly greater than hiking at one pass-intensity (i.e., 500 passes) (Thurston 1998).

Treatment Effects After One Year

Loss of vegetation. Vegetation loss did not differ significantly between activity types or among pass intensities (Table 2). There was a significant difference among zones, however. Mean vegetation loss in the outer zone (7%) and in the middle zone (11%) were significantly less than in the center zone (31%) for all pass intensities and activity types combined. None of the interaction effects involving zone, activity type or pass intensity were statistically significant.

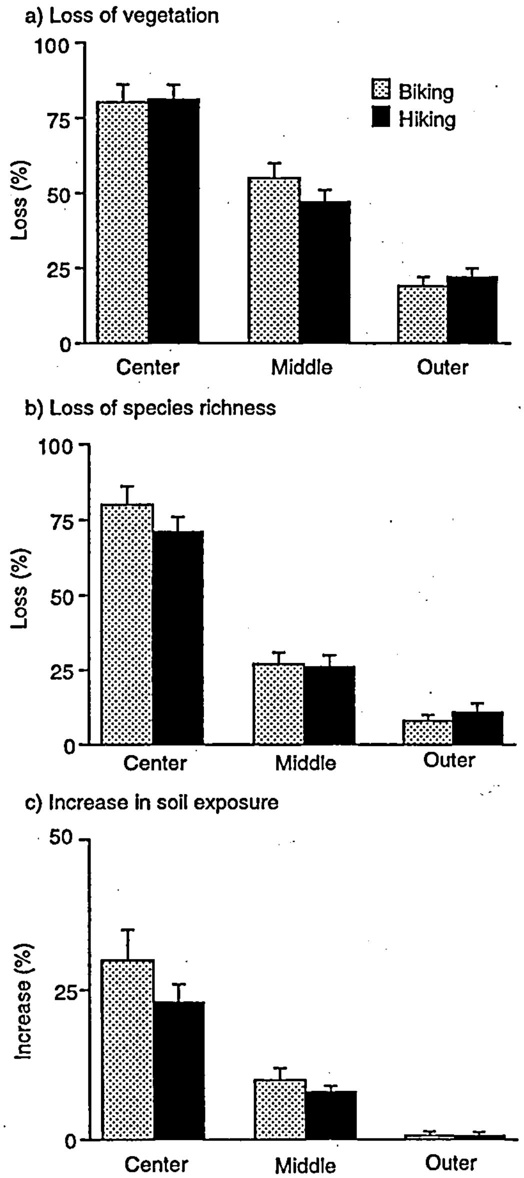

Figure 3. Effect of activity type (biking or hiking) on the mean (±1 SE) loss of vegetation, loss of species richness, and increase in soil exposure two weeks after treatment in the three quadrat zones for the five pass intensities combined.

Table 2. Analysis of variance results for treatment effects on loss of vegetation, species richness, and increase in soil exposure after one year in the three quadrat zones (Combined or Separated)[a]

	F value		
Source of variation	Loss of vegetation	Loss of species richness	Increase in soil exposure
Combined			
Activity type (*A*)	0.07	0.9	0.2
Pass intensity (*P*)	0.8	0.6	1.8
$A \times P$	1.1	1.6	4.1**
Quadrat zone (*Z*)	6.1**	6.1**	9.0***
$A \times Z$	1.0	0.6	0.2
$P \times Z$	0.3	0.4	0.9
$A \times P \times Z$	0.3	0.4	0.5
Separated			
Center zone			
Activity type	1.0	0.4	0.03
Pass intensity	0.8	0.6	2.1
$A \times P$	0.7	1.2	0.7
Middle zone			
Activity type	0.8	1.3	0.4
Pass intensity	0.5	0.7	2.2
$A \times P$	0.5	0.5	1.9
Outer zone			
Activity type	0.04	1.0	0.3
Pass intensity	0.5	0.3	0.9
$A \times P$	0.9	0.8	1.5

[a]Blank = $P > 0.05$, **$P < 0.01$, ***$P < 0.001$.

Mean vegetation loss for all pass intensities combined ranged from 1% in the outer zone to 34% in the center zone (Figure 4a). Mean vegetation loss for activity types combined ranged from −2% in the outer zone to 42% in the center zone (Figure 5a). The negative value indicates an increase in posttreatment stem density over pretreatment stem density.

Species loss. Species loss did not differ significantly between treatments but it did differ among zones (Table 2, Combined). Mean species losses in the outer zone (6%) and in the middle zone (8%) were significantly less than species loss in the center zone (24%) for all pass intensities and activity types combined. None of the interaction effects involving zone, activity type or pass intensity were statistically significant.

Mean species loss for activity types combined ranged from −3% in the outer zone to 30% in the center zone (Figure 4b). Mean species loss for all pass intensities combined ranged from 2% in the outer zone to 25% in the center zone (Figure 5b).

Increase in soil exposure. Soil exposure did not differ significantly between activity types or among pass intensities (Table 2, Combined). However, the interaction of activity type × pass intensity was significant. This interaction resulted from soil exposure being greater on biking 500 pass lanes than hiking 500 pass lanes but not at lower pass intensities (0–200 passes) (Thurston 1998). There was also a significant difference in soil exposure among quadrat zones, with the center (4%) and middle zones (2.4%) greater than the outer zone (0.2%). None of the other interaction effects involving zone, activity type, or pass intensity were statistically

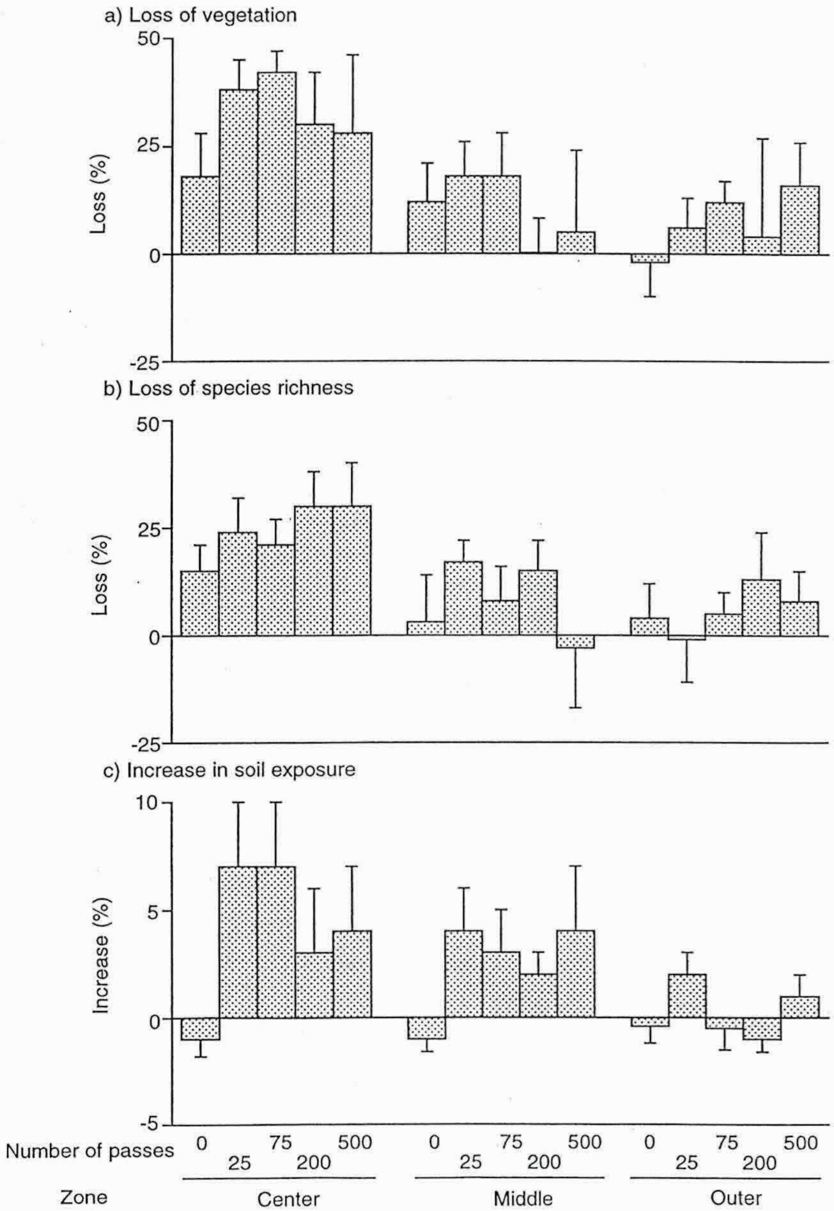

Figure 4. Effect of increasing pass intensity on the mean (±1 SE) loss of vegetation, loss of species richness and increase in soil exposure one year after treatment in the three quadrat zones for the two activity types (biking and hiking) combined.

significant. Mean values for exposed soil over both activity types ranged from −1.1% to 7.0% (Figure 4c). Mean soil exposure for all pass intensities combined ranged from −0.6% to 4% (Figure 5c).

Discussion

Three principal findings emerged from this study. First, impacts on vegetation and soil increased with biking and hiking activity. Second, the impacts of biking and hiking measured here were not significantly different. Third, impacts did not extend beyond 30 cm of the trail centerline. These findings are discussed in turn below, followed by suggestions for future research and the management implications of our results.

Pass-Intensity Effects After Two Weeks

In the center zone, both vegetation loss and species loss occurred rapidly with biking or hiking activity. After only 25 passes nearly every plant stem present in the center zone was damaged. Effects were less pronounced in the middle and outer zones because bikers and hikers only came in contact with vegetation when they strayed from the lane centerline. The asymptotic

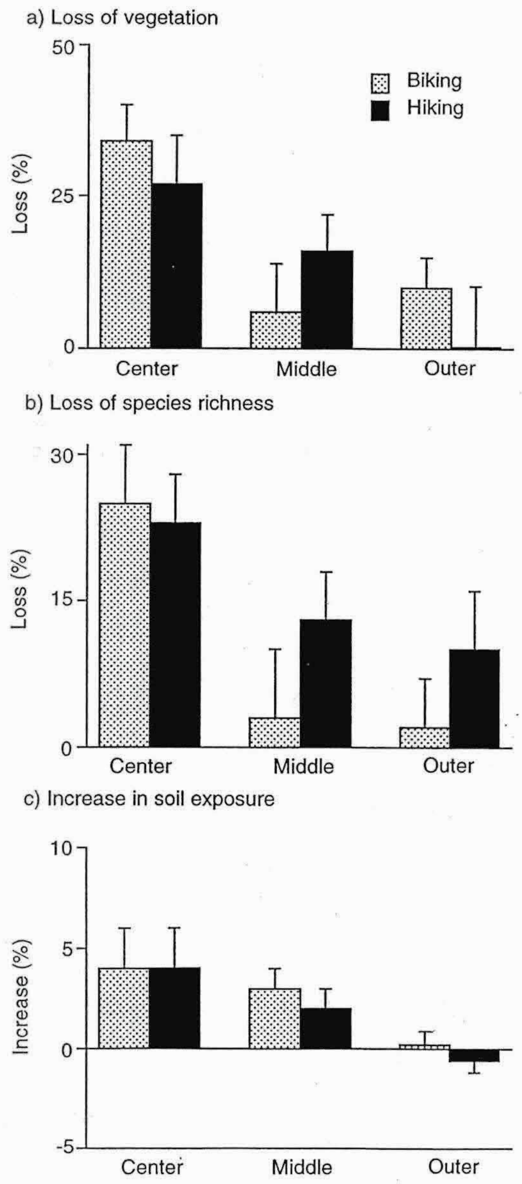

Figure 5. Effect of activity type (biking or hiking) on the mean (±1 SE) loss of vegetation, loss of species richness and increase in soil exposure one year after treatment in the three quadrat zones for the five pass-intensities combined.

pattern of vegetation loss with increasing amount of recreational activity found here is characteristic of deciduous forests with understories dominated by erect forbs. Numerous studies have identified closed-canopy forests among the habitats most susceptible to recreational impact (Kuss 1986, Cole 1979, 1987a, b, 1995a, b). The loss of species due to recreational activity is likely controlled by several species attributes. First, growth forms with tall, succulent stems and broad leaves, such as the erect forb species observed in this study, are easily crushed and broken by recreational activity, while growth forms with narrow leaves and flexible stems, such as graminoids, are more resistant (Sun and Liddle 1993a, b). Second, rare species are more likely to be lost than common species. Both attributes may have contributed to species loss in this study because erect forbs dominated the sampled lanes and approximately one third (35%) of the species present initially in treatment lanes were represented by five or fewer stems.

Soil exposure increased almost linearly from the lowest pass lanes to the highest rather than asymptotically, as was observed for vegetation loss. Mean values for increased soil exposure did not exceed 49% on the 500 pass lanes of the center zone, whereas vegetation loss reached 99% on the same lanes. These results indicate that the loss of organic horizons does not occur as rapidly or does not become as severe at low trampling intensities as does vegetation loss. This is explained simply by the fact that as vegetation is damaged and killed by low levels of use, surface organic layers (i.e., leaf litter) are only just beginning to be scuffed away (Cole 1987a). Cole (1987b) found that soil exposure below 100 passes per year was negligible, and Quinn and others (1980) observed that bare ground did not appear until after at least 250 passes were made.

Pass-Intensity Effects After One Year

One year following treatments, neither vegetation loss nor species loss was significantly greater on treated lanes than on control lanes. Most of the herbaceous plant species at the study site were perennials, with their perennating buds located at or below the soil surface (Gleason and Cronquist 1991). In these species, aboveground stems may be damaged or removed in a given season, but if the perennating organ remains intact, plants should be able to replace lost stems in following seasons. Presumably, resprouting from dormant buds would account for the absence of any treatment effect after one year. Our results support Cole's (1987a, 1995b) suggestion that deciduous forest understory plants have high resilience (i.e., the ability to subsequently recover) when the recreational activity is not continuous.

The amount of soil still exposed after one year in treated lanes did not differ significantly from control lanes. The absence of a detectable treatment effect was likely due to the addition of deciduous tree leaves to the forest floor in the autumn following treatment application. Over-winter reduction in exposed soil has been attributed to leaf fall by a number of investigators (e.g., Legg and Schneider 1977, Cole 1987b, Hammitt and Cole 1987).

Activity-Type Effects

For the response variables measured in this study, there were no significant differences between hiking and mountain biking treatments. One possible explanation is that when vulnerable plants are directly contacted by a weight-bearing surface they will be affected no matter what the weight-bearing surface is, once a certain weight threshold is met. If weights of user groups are only slightly different, as with hikers (e.g., 60 kg) and mountain bikers (e.g., 75 kg, bike and biker included), there should be little difference in their impact on vegetation and soil. In this study, the weight applied per unit area of ground contacted (i.e., contact pressure) was very similar. Biker contact pressure (0.35 kg/cm^2) was only 0.06 kg/cm^2 more than the contact pressure of a hiker balanced on one foot (0.29 kg/cm^2). However, when the weights of two user-groups are considerably different, as with hikers (e.g., 85 kg) and horses (e.g., 550 kg), the magnitude of damage to vegetation is clearly greater for the larger weight-bearing activity (Weaver and Dale 1978).

Spatial Dependency of Effects

The magnitude of biking and hiking effects on vegetation and soil declined sharply with distance from the center of the treatment lane. After a maximum of 500 passes, visible impact was concentrated within a narrow zone, no greater than 30 cm from the lane centerline. The center zone of a treatment zone received the most concentrated use, and consequently, revealed the most severe impact even at low pass intensities. The middle zone received only occasional passes of bikers and hikers when they strayed from the lane centerlines, therefore revealing only moderate impact. In the outer zone almost no foot or bike tire contacted the ground and no changes in parameters could be detected after treatments were applied.

Identifying the scale of impact for recreational activities puts into perspective the relative amount of damage they cause.

Future Research

Our study compared the impacts of biking and hiking under a particular set of conditions so additional studies conducted under other conditions are needed to test the generality of our findings. In these studies, it would be useful to compare impacts for (1) a maximum of more than the 500 passes applied here, (2) uphill rather than downhill passes, (3) established rather than new trails, (4) habitats other than deciduous forest, and (5) wet rather than dry conditions.

If future research confirms our finding that the physical impacts of mountain biking on vegetation and soil seem to be no worse than those of hiking, then there must be other reasons for the belief that mountain biking is to blame for recent trail degradation problems. One possibility is that behavioral differences between bikers and hikers are responsible for reports of greater biking impact. Bikers, in general, enjoy the challenge of obstacles on the trail, such as bumps and jumps, gullies, roots, rocks, and surface water (Symmonds and others 1999, 2000). Many of these features are the result of erosion. If mountain bikers seek out eroded areas, and hikers do not, then bikes will in fact contribute further to soil erosion problems. A second possibility is that mountain bikers simply contribute further to the overuse of trails. In other words, it may not be the activity of mountain biking per se that is to blame for these problems but rather the addition of this user group to hikers and others that has exacerbated overuse problems on already crowded trails (Ruff and Mellors 1993).

Mountain bikes are also be alleged to cause damage because of the inherent conflict between recreational user groups sharing the same space. Conflicts between user groups that differ in technology and methods of travel are common, such as between cross-country skiers and snowmobilers, or canoeists and those using motorboats (Watson and others 1991). Bikers move faster than hikers and equestrians, and these slower-paced users have complained that bikers startle them and present a safety hazard (Keller 1990). Mountain bikes have also been characterized as mechanized by hikers and managers and are therefore judged as inappropriate in a natural setting (Cessford 1995). In recreational conflict research, conventional wisdom states that users of more physically obtrusive technologies are resented by users of less obtrusive technologies (Devall and Harry 1981). Since mountain bikes are visually obtrusive, objectionable to other users, and leave easily identifiable evidence of their passing in the form of tire marks, they are commonly assigned as the cause of environmental damage (Cessford 1995).

Management Implications

Resource managers have no objective basis for managing biking activity in natural areas without research results. If further research on mountain biking impacts confirms our finding that biking and hiking can have similar physical impacts, then managers should be able to use results of past hiking impact studies to predict where and when biking impacts are likely to occur.

Appendix 1. Species composition and mean stem density of vascular plants present in the 100 experimental lanes before treatments were applied[a]

Species	Mean stem density (stems per lane)
Forbs	
Arisaema triphyllum	20.05
Caulophyllum thalictroides	11.43
Other species	14.84
Total	46.32
Tree seedlings	
Acer saccharum	6.86
Fraxinus americana	1.76
Other species	1.53
Total	10.15
Ferns	
Dryopteris carthusiana	0.54
Athyrium filix-femina	0.40
Other species	0.82
Total	1.76
Shrubs and vines	
Cornus alternifolia	0.55
Solanum dulcamara	0.51
Other species	0.08
Total	1.14
Tree saplings	
Acer saccharum	0.62
Ostrya virginiana	0.12
Other species	0.05
Total	0.79
Graminoids	
Carex pedunculata	4.21
Carex radiata	0.42
Other species	0.44
Total	5.07

[a]Species are grouped by growth form. Nomenclature follows Gleason and Cronquist (1991). Other species include: Forbs—*Maianthemum canadense, Trillium* spp., *Circaea quadrisculata, Veronica officinalis, Taraxacum officinale, Polygonatum pubescens, Geranium robertianum, Ranunculus abortivus, Smilacina racemosa, Viola pubescens, Hieracium aurantiacum, Waldstenia fragariodes, Actaea pachypoda, Ranunculus recurvatus, Galium triflorum, Epipactus helleborine, Thalictrum pubescens, Aralia nudicaulis, Aquilegia canadensis, Allium tricoccum, Oxalis stricta, Scrophularia marilandica, Asarum canadense, Aster lanceolatus, Impatiens pallida*; Tree seedlings—*Prunus serotina, Tsuga canadensis, Ostrya virginiana, Ulmus rubra, Populus grandidentata, Thuja occidentalis, Fagus grandifolia, Tilia americana*; Ferns—*Onoclea sensibilis, Matteuccia struthiopteris, Dryopteris marginalis*; Shrubs and vines—*Sambucus canadensis, Vitis riparia, Ribes cynosbati*; Tree saplings—*Fraxinus americana, Prunus serotina, Fagus grandifolia*; Graminoids—sedges: *Carex arctata, Carex deweyana*; grasses: *Poa alsodes, Elymus hystrix, Glyceria striata, Schizachne purpurescens.*

Managers of natural areas also need to know how quickly impromptu or informal trails can form when people leave the main path and whether this threshold number of passes differs for hiking or biking. From the results of this study, it would appear that informal trails should not form any more quickly for biking than for hiking. However, managers should be aware that the immediate impacts of both activities can be severe, and obvious trails will form after relatively very few passes (i.e., less than 500). If these initial trails are not allowed to persist, rapid recovery should be expected in a deciduous forest habitat with a forb-dominated understory, at least for the range of use intensities employed here.

Acknowledgments

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Effects of Recreation on Rocky Mountain Wildlife: Online Bibliography

New Find

Airola, Daniel A. 1986. Brown-headed cowbird parasitism and habitat disturbance in the Sierra Nevada. Journal of Wildlife Management 50 (4) :571-575.

Abstract

Please Note: Abstracts containing equations or symbols may be incorrect due to the loss of superscript, subscript, underline and other styles. Refer to the original publication before citing this reference.

Abstract: I studied nest parasitism by the brown-headed cowbird (Molothrus ater) in the northern Sierra Nevada to determine parasitism rates of host species, effects of differing availabilities of human- and live-stock-based foods (habitat disturbance) on parasitism rates, and impacts on host populations. Twenty-six of 206 nests and family groups with dependent young (including 8 species) were parasitized. Parasitism was strongly associated with habitat disturbance; 27.1% of groups of susceptible host species in highly disturbed areas contained cowbird young vs. 8.7% in less disturbed areas. Parasitized family groups contained 76% fewer host young than unparasitized groups. Productivity of susceptible species was reduced by 20.6 and 6.6% in highly and moderately disturbed areas, respectively, and by 6.1% in the total study area. Hosts that prefer riparian habitats are most likely to decline due to cowbird parasitism.

Additional Keywords

birds/passerine/Molothrus ater/disturbance/cowbird/Passeriformes

New Find

Effects of Recreation on Rocky Mountain Wildlife: Online Bibliography

New Find

Bauer, Hans-Günther, Stark, H., Frenzel, P. 1992. Disturbance factors and their effects on water birds wintering in the western parts of Lake Constance. Der Ornithologische Beobachter 89 (2) :81-91 (English Summary p. 109).

Abstract

Please Note: Abstracts containing equations or symbols may be incorrect due to the loss of superscript, subscript, underline and other styles. Refer to the original publication before citing this reference.

Authors' Summary: From October to April 1988/89, 1989/90 and 1990/91 wintering waterbirds and all possible disturbance factors were simultaneously recorded at three study sites in the western part of Lake Constance. Compared to earlier studies a further increase in the number of disturbances in the Ermatingen Basin could be demonstrated, which was mainly due to open boats (canoes, rowing boats). The results underline a central tendency towards an increase in the use of the lake for human recreation during these months. In Constance Bay which is of great ecological importance for wintering Goldeneye, the population is decreasing significantly as the number of boats increases. In general, the pressure on win- tering waterfowl in all three study sites has reached such a high degree that it is of great importance to establish larger protected areas, to stop water sports and fishing for pleasure from October to March, and to impose a permanent ban on hunting.

Additional Keywords

birds/waterfowl/Goldeneye/canoeing/rowing/waterbirds

New Find

Effects of Recreation on Rocky Mountain Wildlife: Online Bibliography

New Find

Fredrickson, L. H., Reid, F. A. 1988. Waterfowl use of wetland complexes. Pages 1-6 in Managing waterfowl habitats: Breeding, migrating, wintering.. USDI Fish and Wildlife Service, Office of Information Transfer, Fort Collins, Colorado.

Abstract

Please Note: Abstracts containing equations or symbols may be incorrect due to the loss of superscript, subscript, underline and other styles. Refer to the original publication before citing this reference.

Abstract (from U.S. Fish & Wildlife Service 1995): Refuge management may require manipulation of soil and water to produce habitat structure or essential foods. Production of foods does not assure their use by waterfowl. Foods are accessible only if appropriate water depths are maintained during critical time periods, habitats are protected from disturbance, and habitats that provide protein and energy are close together. Disturbance is particularly important, and recognition of the influence of disturbance on access to and acquisition of needs throughout the annual cycle is essential. Subtle disturbances by bird watchers, researchers, and refuge activities during critical biological events may be as detrimental to waterfowl populations as hunting or other water-related recreation such as boating. At certain locations, predators or activities associated with barge traffic, oil exploration, or other industrial or military operations are detrimental to waterfowl. [Abstract by Dahlgren and Korschgen]

Additional Keywords

birds/waterfowl/birdwatching/walking/wetlands

New Find

Effects of Recreation on Rocky Mountain Wildlife: Online Bibliography

New Find

Gutzwiller, K.J. 1995. Recreational disturbance and wildlife communities. Chapter 10 in Knight, R.L.//Gutzwiller, K.J., editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C..

Abstract

Abstract (H. Youmans, MCTWS): Our understanding of how recreational activities influence communities is just developing. Investigators have focused on individuals, family groups and populations. Recreationists can directly alter competitive, facilitative and predator-prey relationships. For instance, human presence may confer a competitive advantage to scavenger species with short flushing distances - over those more disrupted by human presence (as has been found with crows and gulls compared to eagles when all are using the same food source), with the result that the least tolerant species may be out-competed. Flushing of colonial nesting birds by humans has been shown to increase predation through abnormal predation events. Disturbance can directly increase predation by increasing predator contacts or by dispersing young, with the result that stragglers displaced from familiar surroundings are preyed upon. Species displacement caused by recreationists can alter species richness, abundance and composition in wildlife communities. Survivability of displaced animals is reduced as a result of unfamiliarity with new habitats and conflict with established conspecifics. When habitat conditions are altered, community attributes change. This can include vegetation, characteristics of snow cover and soil impacts, including collapsing of burrow systems.

Management Options for Coexistence: Minimize recreation-induced changes to normal interactions among species, reduce wildlife displacement and maintain and restore the floristic and structural heterogeneity of wildlife habitat. This can be accomplished by establishing specific times, places and modes of travel for public access that minimize impacts to vulnerable species. Managers should also educate nature viewers and photographers on how to modify their actions to avoid inducing abnormal levels of predation. Displacement can be reduced by controlling the proximity, frequency, duration and seasonal timing of disturbances, especially for species at high risk. Such efforts may involve establishing buffer zones or restricting access during crucial periods of a species annual cycle and concentrating activity in already-altered sites while protecting previously undisturbed or mildly impacted areas.

Additional Keywords

wildlife - collective/recreation/human disturbance

New Find

Effects of Recreation on Rocky Mountain Wildlife: Online Bibliography

New Find

Van de Zande, A. N., Berkhuizen, J. C., van Latesteijn, H. C., ter Keurs, W. J., Poppelaars, A. J. 1984. Impact of outdoor recreation on the density and number of breeding bird species in woods adjacent to urban residential areas. Biol. Conserv. 30 :1-39.

Abstract

Please Note: Abstracts containing equations or symbols may be incorrect due to the loss of superscript, subscript, underline and other styles. Refer to the original publication before citing this reference.

Authors' Abstract: Outdoor recreation is often supposed to have an important impact on wildlife, although this assumption has not been tested very often. The resulting lack of knowledge becomes apparent in situations where parties with conflicting interests disagree on the number of visitors an area can sustain without major repercussions.

In 1980 the possible effects of recreation intensity upon bird densities were studied in seven study plots adjacent to urban residential areas in The Netherlands. Of the 31 bird species found, only 13 could be studied in detail, being present in at least 20 territories. Significant negative correlations between recreation intensities and bird densities were found for 8 of these 13 species.

The slopes of the regression lines enabled us to rank the 8 species in a sequence of decreasing susceptibility. The results indicate that the disturbance is caused rather by the recreation intensity during the week than by the recreation intensity at weekends.

Additional Keywords

birds/residential/urban/breeding/disturbance/Netherlands/woodland birds/bird counts/bird densities/conservation planning/deciduous woods/displacement models/recreation/recreation impact/recreation intensity

New Find