Draft Report

Lower Kenai Peninsula Summer Off-Road Vehicle Trail Stream Crossings

Michael Wiedmer

March 2002 Draft

Alaska Department of Fish and Game **Habitat and Restoration Division**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Habitat and Restoration Division Manuscripts, Technical Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions..

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

DRAFT REPORT

LOWER KENAI PENINSULA SUMMER OFF-ROAD VEHICLE TRAIL STREAM CROSSINGS

by
Michael Wiedmer
Habitat and Restoration Division, Anchorage

Alaska Department of Fish and Game
Habitat and Restoration Division
333 Raspberry Road, Anchorage, Alaska, 99518-1599

March 2002 Draft

.

Michael Wiedmer
Alaska Department of Fish and Game, Habitat and Restoration Division
333 Raspberry Road, Anchorage, AK 99518-1599

This draft document may not be cited without permission of the author.

INTRODUCTION

The Lower Kenai Peninsula (LKP—the western Kenai Peninsula from the Kasilof River to Kachemak Bay) is a popular recreational area, readily accessible to over half Alaska's population in a day's drive (Figure 1). Sport fishing, hunting, snowmachining, cabins, sightseeing, and other outdoor recreational opportunities draw many residents and non-residents to the LKP.

Streams of the LKP provide important sport and commercial fisheries resources. Deep Creek, and the Ninilchik and Anchor rivers on the LKP are among the most popular sport fishing streams in Alaska (Howe et al. 1998). In 1999, sport anglers spent 47,895 angler days on these three streams, catching Dolly Varden *Salvelinus malma*, steelhead/rainbow trout *Oncorhynchus mykiss*, coho salmon *O. kisutch*, chinook salmon *O. tshawytscha*, pink salmon *O. gorbuscha*, and sockeye salmon *O. nerka* (A. Howe, Alaska Department of Fish and Game, Anchorage, personal communication). Salmon produced by LKP drainages also help support the Cook Inlet commercial fishery. In addition to targeted sport fish, round whitefish *Prosopium cylindraceum*, slimy sculpin *Cottus cognatus*, three-spine stickleback *Gasterosteus aculeatus*, and Pacific lamprey *Lampetra tridentata* occur in the Deep Creek watershed (King and Breakfield 1999) and may occur in other LKP watersheds as well. Dolly Varden, coho and chinook salmon, and steelhead/rainbow trout are the most commonly observed species in the upper portions of LKP watersheds.

During the last decade, the LKP has witnessed considerable change. Between 1990 and 1999, the human population of this area grew an estimated 27% (Williams 1999). Part of this growth resulted from a dramatic increase in commercial timber harvest, which was essentially absent from the area prior to 1988. Since 1988, timber has been harvested within approximately 46,000 ha (114,000 acres) of the LKP (Figure 2). Roads built to various standards accessed all harvest units. Seismic explorations for petroleum hydrocarbons in the 1950s and 1960s (J. Davis, Western Geophysical, Anchorage, personal communication) incidentally created a dense network of backcountry travel corridors. Because of these past natural resource exploration and development activities, the LKP now has a network of roads and trails in excess of 2,889 km (1,795 mi) (Figure 2).

Most of the existing backcountry roads and trails are physically accessible by modern off-road vehicles (ORVs), primarily small 4 - 8 wheel drive all-terrain vehicles (ATVs). At higher elevations (> 490 m; 1640 ft), low vegetation and relatively flat terrain allows cross-country ATV travel, even in the absence of previously constructed corridors.

Use of these transportation corridors appears to be increasing, particularly during summer (non-snow) months. For example, between 1988 and 1998, ORV use by moose hunters in the Anchor River and Deep Creek watersheds increased 320% (P. Dunn, Alaska Department of Fish and Game, Anchorage, personal communication).

Public access to public lands is a stated goal of both the State of Alaska (e.g., 6 AAC 80.060 *Recreation*) and the Kenai Peninsula Borough (KPB; e.g., KPB Coastal Management Program Policy 4.0 *Recreation and Public Access*). However, excessive, unplanned, unintended, or poorly understood motorized public access can conflict with other important coastal resources, such as fish habitat and water quality. In 1990, the Wildlife Conservation Division of the Alaska Department of Fish and Game (ADF&G) reported that north of Homer:

Figure 1.-Lower Kenai Peninsula and study area.

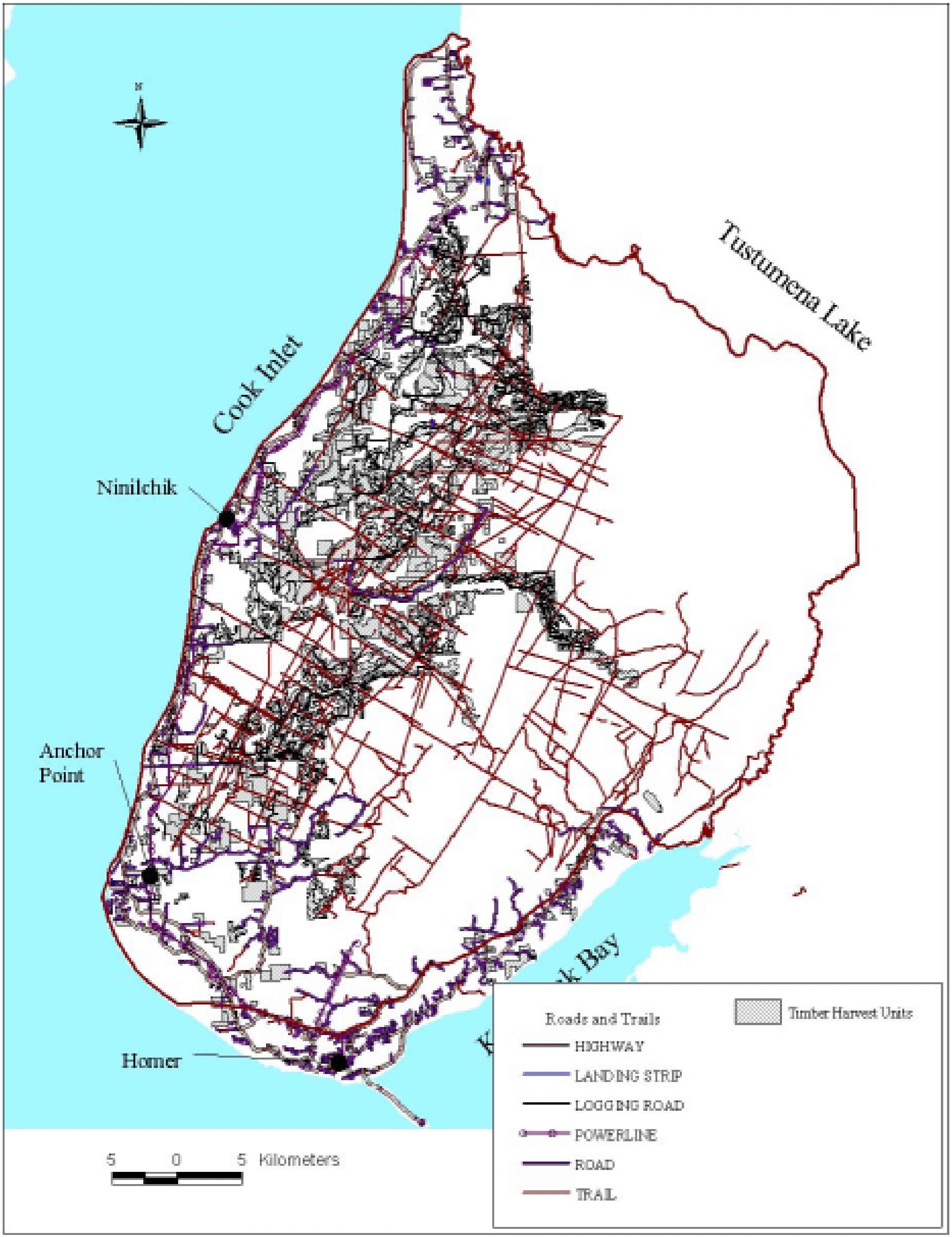

Figure 2.-Study area roads, trails, and timber harvest units. Not all existing travel or utility corridors are mapped.

"(t)he trail networks developed by moose hunters traverse virtually all terrain and habitat types. Environmental degradation, including both soil erosion and loss of vegetation, is extensive. This degradation is approaching a level which could be considered a significant habitat loss." (ADF&G 1990).

The ADF&G, Habitat and Restoration Division, conducted a preliminary ORV trail stream crossing inventory in September 1999 on a small portion of the upper Anchor River and Deep Creek drainages. Our preliminary survey identified and characterized 45 stream crossings: 27 in the Anchor River and 18 in the Deep Creek watersheds. Thirty-six sites had exposed soil, 31 sites had denuded bank vegetation, 25 sites had increased widths, 37 had pooled or running water on the trail, 34 had bank alterations, and 22 had all characteristics. These characteristics are indicators of increased risk of sediment introduction into stream courses, alterations of stream bank structure and function, and potential changes to surficial hydrology. Substantial non-riparian wetland impacts were noted adjacent to 13 crossings (29%).

Observed impacts included sediment routes into stream courses (Figure 3); stream courses used as ORV trails (Figure 4); riparian zones used as travel corridors (Figure 5); high trail crossing densities (Figure 6); and adjacent non-riparian wetland impacts (Figure 7).

One of the major human-induced impacts to stream resources in Alaska and throughout the United States is the introduction of fine sediments to streams. Sediments can clog interstitial spaces of spawning gravels, thereby reducing reproductive success of commercially and socially important fish populations. Sedimentation can also reduce primary and secondary aquatic production, thereby reducing growth and survival of fish. In addition, ford sites often destabilize stream banks and can block fish passage through increased width/depth ratios. In addition to the timber harvest areas and roads at mid-elevations, and commercial, residential, and recreational development at low elevations, ORV trails are a source of these impacts in the study area. While single trail crossings may be insignificant, many crossings, in combination with other resource developments, can cumulatively impact water quality and fish habitat.

Because of these concerns and because no systematic spatial and temporal ORV impact and use information was available, we conducted the synoptic stream crossing inventory and trail head temporal use survey presented here to assess the distribution and character of ORV trail stream crossings on the LKP and the seasonality of trail use. We focused on stream crossings because ADF&G has particular management interest in fish-bearing streams and because we could conduct a large-scale spatial inventory of crossing points (as compard to mapping the total trail network) in the time and budget available.

In this project, we have collected information providing a watershed perspective of cumulative impacts to streams and adjacent wetlands resulting from ORV use. We intend that results presented here will aid future decisions on methods and means to provide continued access to public lands while limiting impacts to sensitive and important habitats.

STUDY AREA

The 270,000 ha (666,000 acre) LKP study area is bounded by the Tustumena Lake/Kasilof River drainage on the north, Kachemak Bay on the south, Cook Inlet on the west, and Fox River on the east (Figure 1). Elevations range from sea level at Cook Inlet and Kachemak Bay to 870 m (2850 ft) at

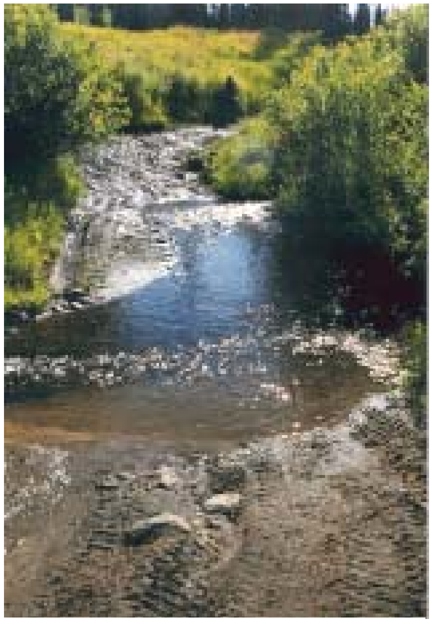

Figure 3.-Sediment entry into coho salmon spawning and rearing habitat in the Upper Anchor River.

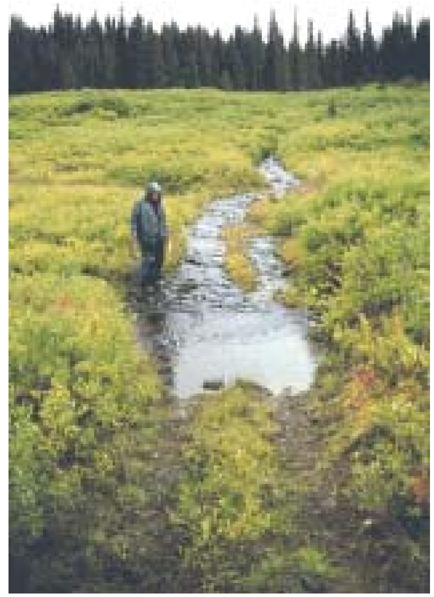

Figure 4.-Stream channel used as ORV trail, Upper Deep Creek watershed.

Figure 5.-ORV trail system paralleling South Fork Deep Creek.

Figure 6.-High crossing densities across Deep Creek headwaters.

Figure 7.-ORV trail fanning in wetland adjacent to the Anchor River.

Ptarmigan Head in the Caribou Hills. Length of mapped streams in the study area totals 1,890 km (1,174 mi).

We did not include in the study area the densely populated areas of Homer and East End Road. We excluded these areas to avoid disturbing residents and because much of this area is traversed with deep ravines that hinder ORV use.

The study area is within Game Management Unit 15C, which has a moose hunting season from August 20 to September 20. Motorized vehicles can be used to transport moose hunters, gear, and meat during this season, except for the periods September 11-14, and September 17-20 (ADF&G 2000).

In upland sites, Lutz spruce *Picea glauca x sitchensis* forests grow to an elevation of approximately 500 m; low shrub and herbaceous alpine vegetation dominate at higher elevations. Riparian vegetation within 100 m of stream courses in the study area is dominated by woody shrubs, forbs and herbs, and spruce forest. Terrain in the study area is relatively flat to gently rolling; slopes do not exceed 40% and typically are less than 10%.

The State of Alaska (managed by the Department of Natural Resources, DNR) is the largest land owner within the study area, followed by the federal government (U. S. Fish and Wildlife Service, Kenai National Wildlife Refuge) (Table 1 and Figure 8).

Within the study area are several specially designated areas, including the Kenai National Wildlife Refuge, the Anchor River/Fritz Creek, Kachemak Bay, and Fox River Flats critical habitat areas, and several Kenai Peninsula Borough anadromous stream habitat protection zones (Figure 9).

Table 1.-Study Area land ownership.

Landowner	Hectares	Acres	% of Total
State	90,112	222,666	33.8%
Native Corp.	62,744	155,040	23.5%
Federal	55,492	137,121	20.8%
Private	39,443	97,465	14.8%
Borough	11,896	29,394	4.5%
University	5,999	14,824	2.2%
Other	1,225	3,027	0.5%
City	53	130	0.0%

METHODS

SYNOPTIC SPATIAL INVENTORY

Between September 11 and 15, 2000, we inventoried ORV trail stream crossing sites within the LKP study area. Two observers plus pilot flew in a Bell 206 helicopter at altitudes between 50 and 300 m above ground level (agl). Where terrain was uniform and vegetation cover limited, we flew higher to inventory at faster rates. We flew along all contiguous stream courses until a visible ORV trail stream crossing site (site) was observed. ORV trails were distinguished from other trails (e.g., animal and snowmachine trails) by their linearity and the presence of dual parallel ruts, indicating the passage of multi-wheeled or tracked vehicles. When a stream crossing was identified, we reduced our altitude (if necessary) to approximately 20 – 50 m agl and circled the site. The front seat observer navigated and photographed the site both with a 35 mm SLR camera using 200 ISO color print film and with digital video. The back seat observer assigned a station identifier to the site, assessed the site based on a suite of potential characteristics (Table 2), and recorded the coordinates of the site with a non-differential Garmin GPS 12 XL global positioning system unit. Because we circled, rather than hovered, over sites, our measured

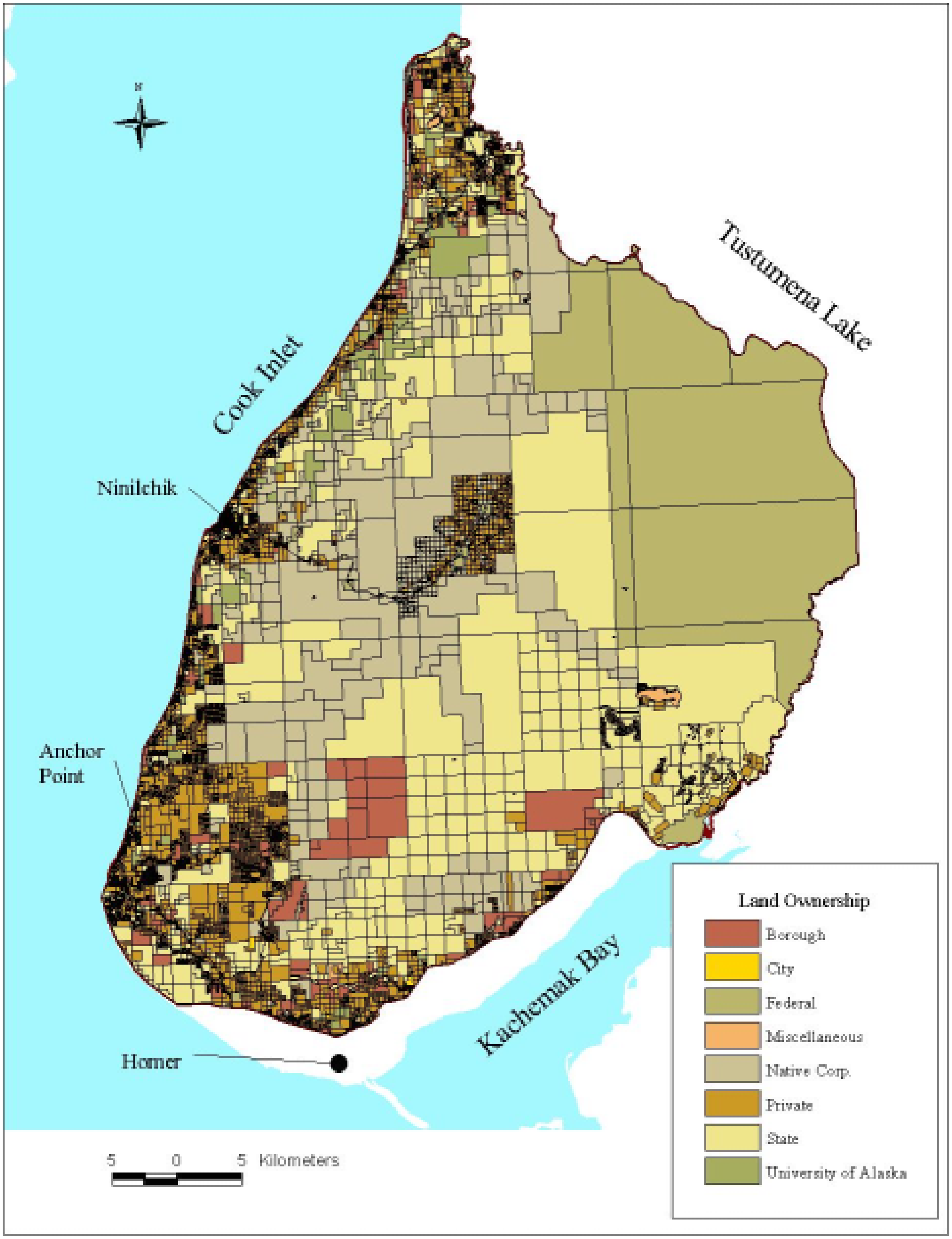

Figure 8.-Study area land ownership.

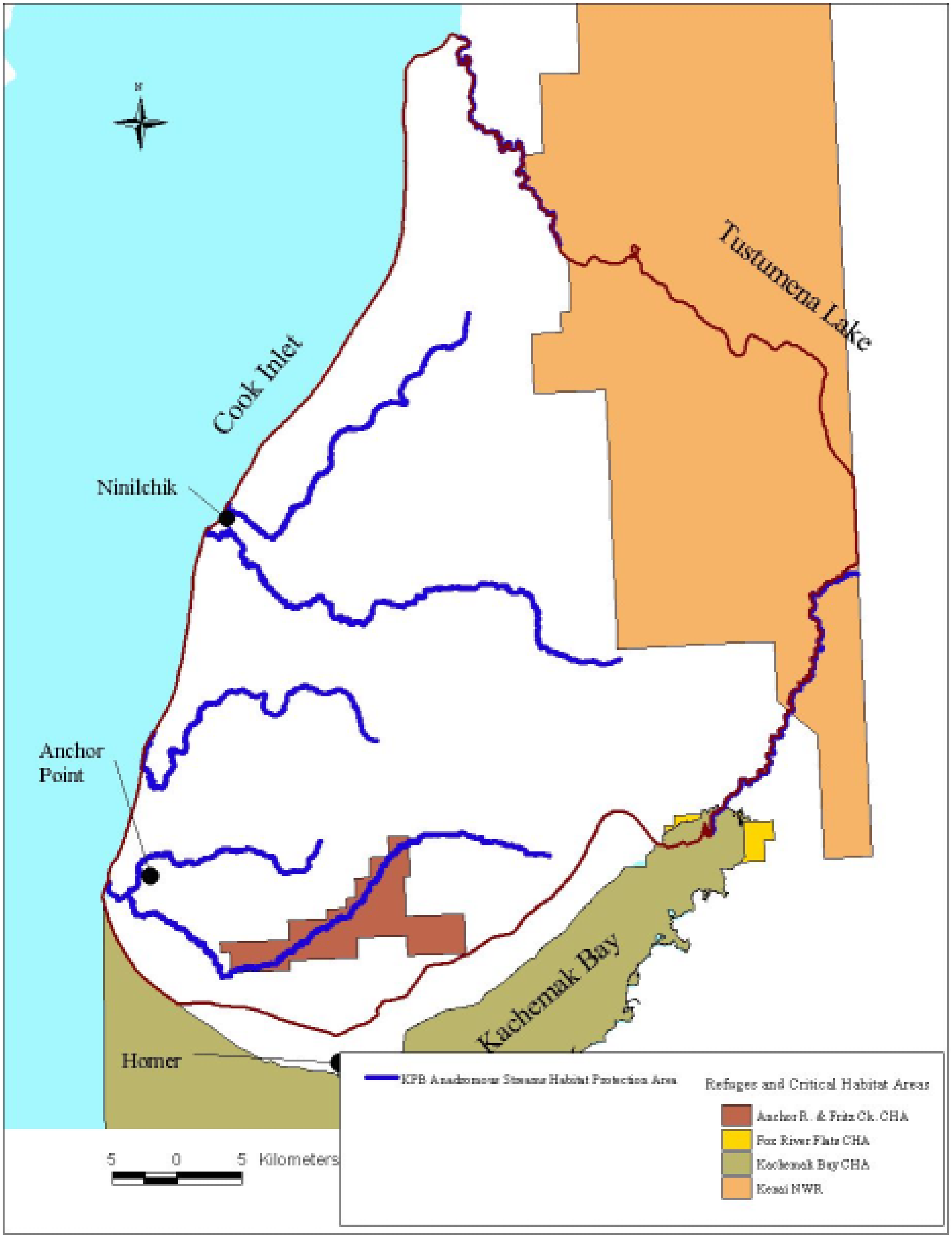

Figure 9.-Specially designated areas within the study area.

coordinates were up to 200 m from the actual location. Where multiple tracks crossed a stream within a short distance (typically within ~200 m), we identified one site and recorded the number ofindividual crossings at that site. We did not land at individual sites. We were on the ground only at sites that were coincidentally selected (and photographed) as survey sites for a separate fish habitat survey.

Table 2.-Site Impact Indicators.

Parameter Present? (Y/N)	Description
Exposed Soil	Visible beneath trail adjacent to stream
Denuded Bank	Vegetation on stream banks eliminated from trail tread
Increased Width	Channel width ≥ 2x wider than unimpacted channel
Surface Water	Water pooled or running on trail surface
Bank Alteration	Topography of stream banks altered

In the field we assessed the historic origin of the trails that crossed streams at each site (Table 3). These field determinations were verified post-survey by consultation with aerial photographs, timber harvest records, and KPB land ownership records.

We used digital 1- and 5-m resolution aerial orthophotographs, 1:63,360 USGS topographic and hydrographic maps, and local knowledge to delineate 12 separate watersheds within the study area. We further divided each watershed into upper and lower subwatersheds, divided at the 305 m (1000 ft) contour (Figure 10 and Table 4). This contour corresponds with the KPB Coastal Zone boundary.

To generate a Site Impact Index (SII) for each site, we summed the positive site impact parameters for that site, yielding a Site Score (SS) ranging from 0 to 5, and multiplied by the number of crossings at that site. We calculated a Relative Area Impact Index (RAII) by:

$$RAII = \frac{\sum_{k=1}^{n} SII_k}{TASL}$$

where:

n = Sites within a given area, and

$TASL$ = Total area stream length (km).

We calculated a Mean Crossing Index (MCI) by:

$$MCI_a = \frac{RAII_a}{c_a}$$

where:

a = A given area, and

c = Number of crossings within area.

Table 3.-Historic Trail Origin Classes.

Trail Origin
Highway Shoulder
Power Line
Property/Cabin Access
Recreational Trail
Recreational Trail/Winter Logging Road
Section Line
Seismic Line
Seismic Line/Property Access
Seismic Line/Recreational Trail
Seismic Line/Summer Logging Road
Seismic Line/Winter Logging Road
Summer Logging Road
Winter Logging Road

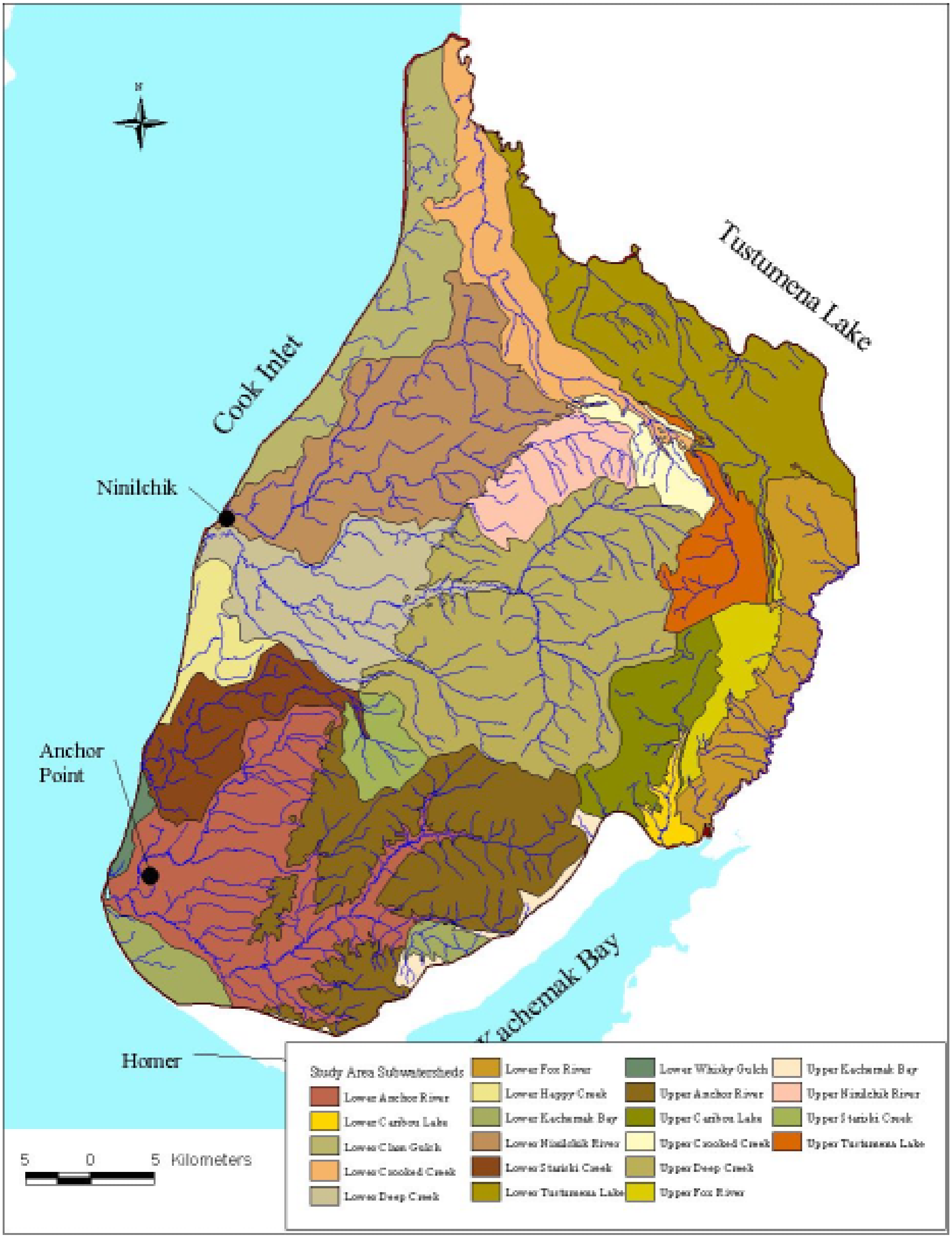

Figure 10.-Study area subwatersheds.

Table 4.-Study area watersheds and subwatersheds. Significant anadromous fish-producing watersheds in bold.

Watershed	Sub-watershed	Area		
		ha	acres	%
Anchor River	**Lower**	**29,320**	**72,449**	**11**
	Upper	**28,600**	**70,671**	**11**
Total		**57,920**	**143,120**	**21**
Caribou Lake	**Lower**	**1,707**	**4,217**	**1**
	Upper	**9,253**	**22,864**	**3**
Total		**10,960**	**27,082**	**4**
Clam Gulch	Lower	14,385	35,547	5
	Upper	0	0	0
Total		14,385	35,547	5
Crooked Ck.	**Lower**	**12,687**	**31,348**	**5**
	Upper	**3,597**	**8,887**	**1**
Total		**16,283**	**40,235**	**6**
Deep Creek	**Lower**	**17,259**	**42,648**	**6**
	Upper	**39,311**	**97,138**	**15**
Total		**56,570**	**139,785**	**21**
Fox River	**Lower**	**13,234**	**32,701**	**5**
	Upper	**4,670**	**11,541**	**2**
Total		**17,904**	**44,242**	**7**
Happy Creek	Lower	4,593	11,350	2
	Upper	0	0	0
Total		4,593	11,350	2
Kachemak Bay	Lower	5,008	12,374	2
	Upper	1,819	4,495	1
Total		6,827	16,869	3
Ninilchik R.	**Lower**	**27,490**	**67,927**	**10**
	Upper	**7,734**	**19,110**	**3**
Total		**35,224**	**87,037**	**13**
Stariski Creek	**Lower**	**10,374**	**25,633**	**4**
	Upper	**3,953**	**9,767**	**1**
Total		**14,326**	**35,401**	**5**
Tustumena L.	**Lower**	**26,399**	**65,231**	**10**
	Upper	**7,366**	**18,203**	**3**
Total		**33,765**	**83,434**	**13**
Whisky Gulch	Lower	843	2,083	0
	Upper	0	0	0
Total		843	2,083	0
Grand Total		269,601	666,184	100

TRAIL HEAD TEMPORAL USE SURVEY

Between June 19, and October 12, 2001, ADF&G Homer-area staff conducted biweekly surveys of 3 selected ORV trail heads approximately 30 km (18 mi) NE of Homer near the end of East End Road (Figure 11). This period closely approximated the 2001 snow-free season at the higher elevations accessed by these trail heads. These trail heads were selected because they appeared to provide access to the most heavily impacted areas identified in the September 2000 synoptic spatial inventory and because they could be efficiently surveyed by road from Homer. Based on local consultation, trail heads A and B were thought to principally provide access to undeveloped areas in the Upper Anchor River and Deep Creek watersheds; Trail head C was thought to provide significant access to developed lands near Caribou Lake. Trail head B combined counts from the large KPB/State of Alaska borrow site complex when the access road gate was open, or from the gate location itself when locked.

On Tuesday and Friday evenings between approximately 1730 and 2000 hours each trail head was visited in the same sequence for approximately 15 min/site. At each site, all parked highway vehicles, parked ORV trailers, and parked or operating ORVs were tallied.

RESULTS

SYNOPTIC SPATIAL INVENTORY

We identified 324 ORV trail stream crossing sites within the study area (Figure 12). Of the 324 sites, 56 had multiple channel crossings. In total we identified 475 individual channel crossings. Most sites (63%) were in upper watersheds (> 305 m, 1000 ft), even though only 35% of the total study area stream net was above 305 m. The study area-wide density of sites was 0.17 sites/km (0.28 sites/mi); the overall density of crossings was 0.25 crossings/km (0.40

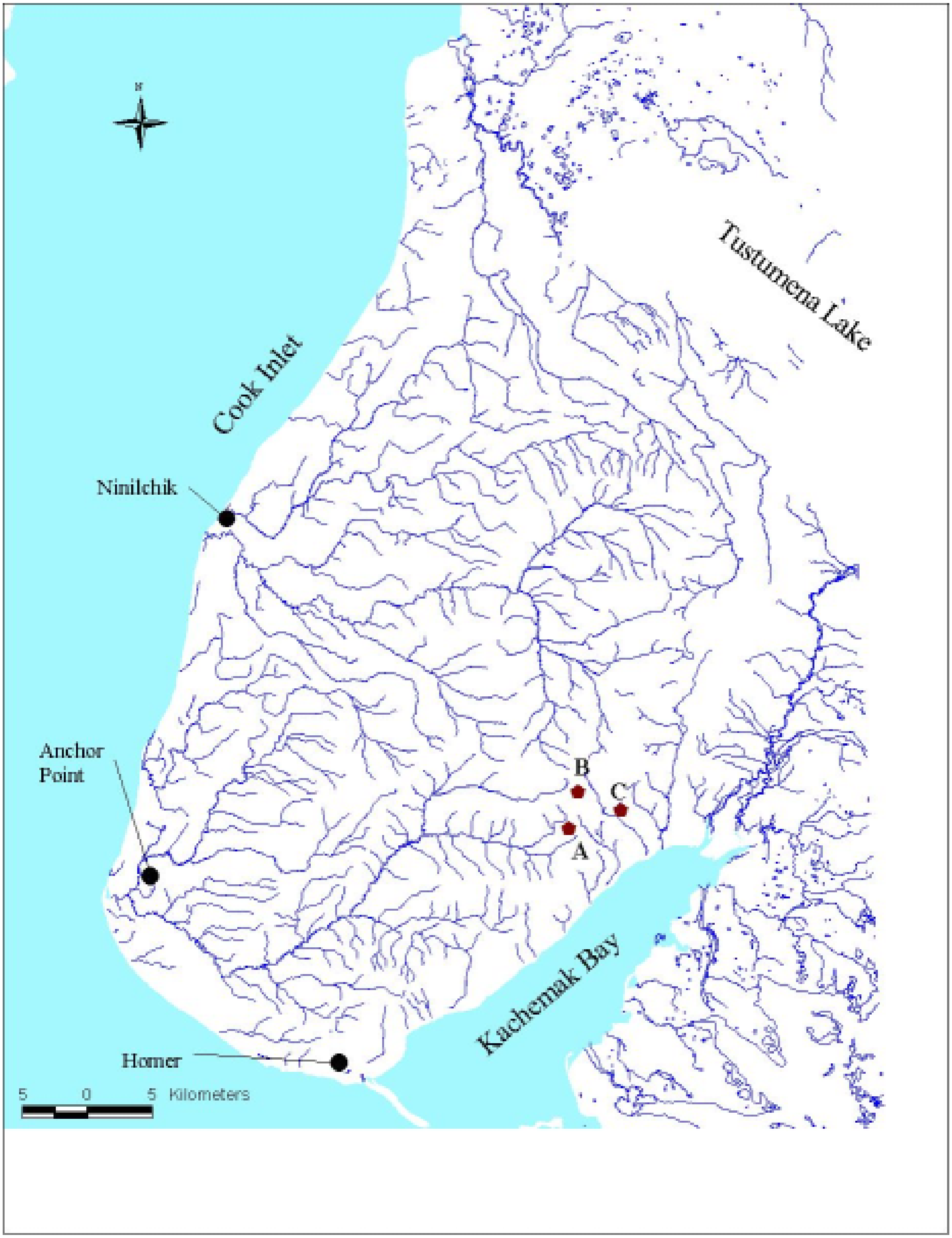

Figure 11.-Trail head locations visited during temporal use survey.

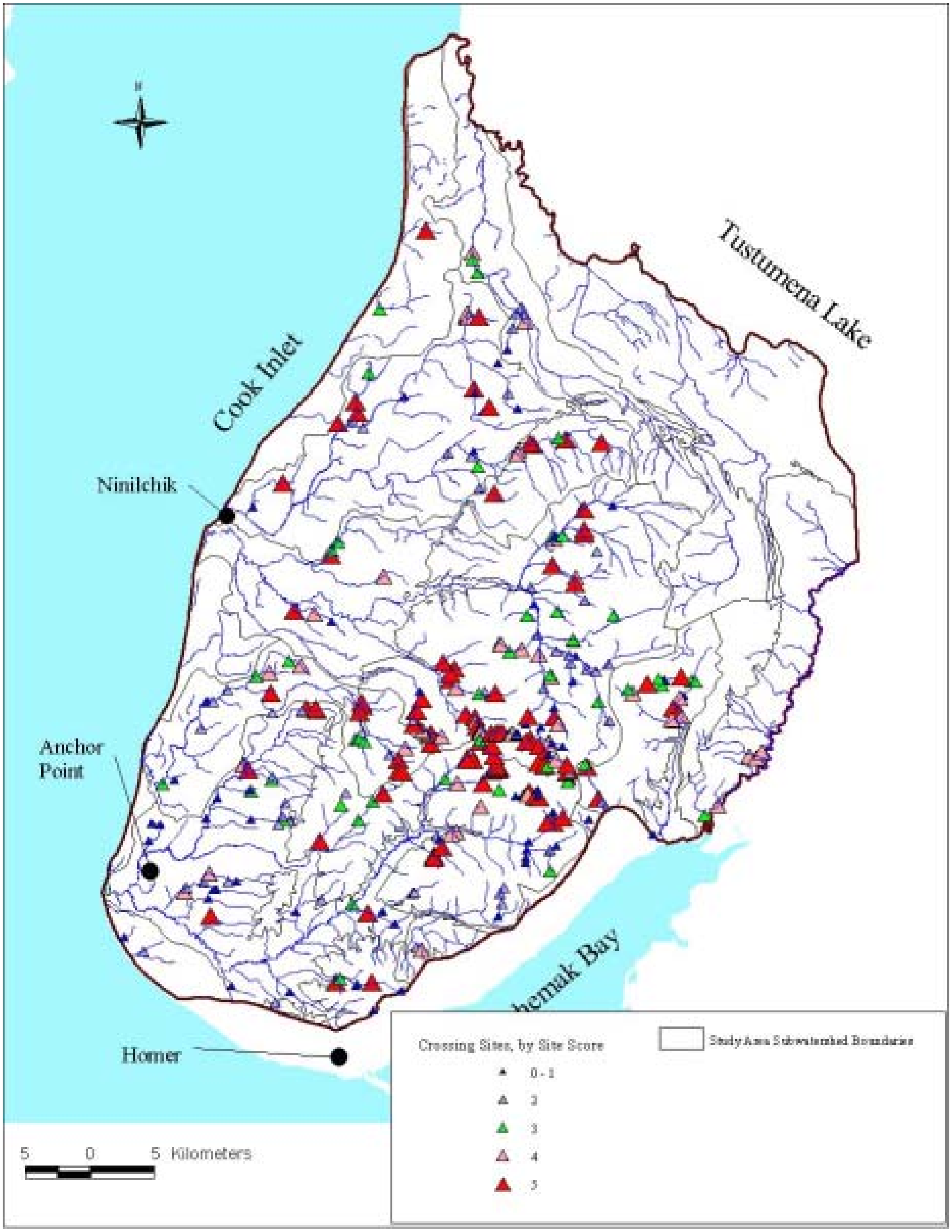

Figure 12.-ORV trail stream crossing sites.

crossings/mi). Certain stream reaches, however, had much higher crossing densities. The upper 3.2 km of South Fork Deep Creek had a density of 9.38 crossings/km (15.13 crossings/mi) (Figure 13).

Bank alteration and exposed soil (present at 80% and 72% of sites) were the most common physical impacts observed; denuded banks (present at 44% of sites) was the least common (Table 5). The study area-wide mean SS was 3.1; the most common SS was 5, least common was 0 (Table 6).

Table 5.-Prevalence of Site Impact Indicators.

Parameter	Positive Occurrences
Bank alteration	261 (81%)
Denuded Banks	142 (44%)
Exposed Soil	234 (72%)
Increased width	174 (54%)
Surface water	193 (60%)

Subwatersheds

Deep Creek Upper (155 crossings, 34% of total) and Anchor River Upper (90 crossings, 18% of total) had the greatest number of crossings (Table 7). Six subwatersheds had no sites (Crooked Creek Upper, Fox River Upper, Tustumena Lake Lower, Tustumena Lake Upper, Happy Creek Lower, and Whisky Gulch Lower).

Caribou Lake Upper (0.9 crossings/km), Clam Gulch Lower (0.8 crossings/km), Anchor River Upper (0.6 crossings/km), Deep Creek Upper (0.6 crossings/km), and Stariski Creek Upper (0.4 crossings/km) had the greatest densities of crossings.

Clam Gulch Lower (5.0), Ninilchik River Upper (4.7), Stariski Creek Upper (3.9), Fox River Lower (3.8), and Deep Creek Lower (3.6) had the highest MCIs.

Table 6.-Frequency of Site Scores

Site Score	Occurrences		Figure
	n	(%)	
0	14	4	14
1	52	16	15
2	62	19	16
3	52	16	17
4	48	15	18
5	96	30	19
Total	324	100	

Clam Gulch Lower (3.9), Caribou Lake Upper (2.9), Deep Creek Upper (1.8), Anchor River Upper (1.7) and Stariski Creek Upper (1.6) had the highest RAIIs.

Landowners

The majority of crossings (290 crossings, 61%) are on State of Alaska land, followed by Native Corporation (65 crossings, 14%), private (50 crossings, 11%), and University of Alaska (41 crossings, 9%) land (Table 8). Crossing density is highest on University land (1.4 crossings/km), followed by State (0.4 crossings/km), and Borough (0.4 crossings/km) land. Crossing density is very low on federal land (0.01 crossings/km) and no crossings exist on city land.

University (5.0), Borough (3.6), Native (3.2), and State (3.1) lands have the highest MCIs. University (7.1), Borough (1.3), and State (1.3) lands have the highest RAIIs.

Fifty percent of all sites scoring 5 are located within only 3% of the study area (Figure 20). Seventy-two percent of all sites scoring 5 are located within only 12% of the study area. Of the land within the 50% polygon, 86% is public land (Table 9). Of the land within the 71% polygon, 83% is public land (Table 10).

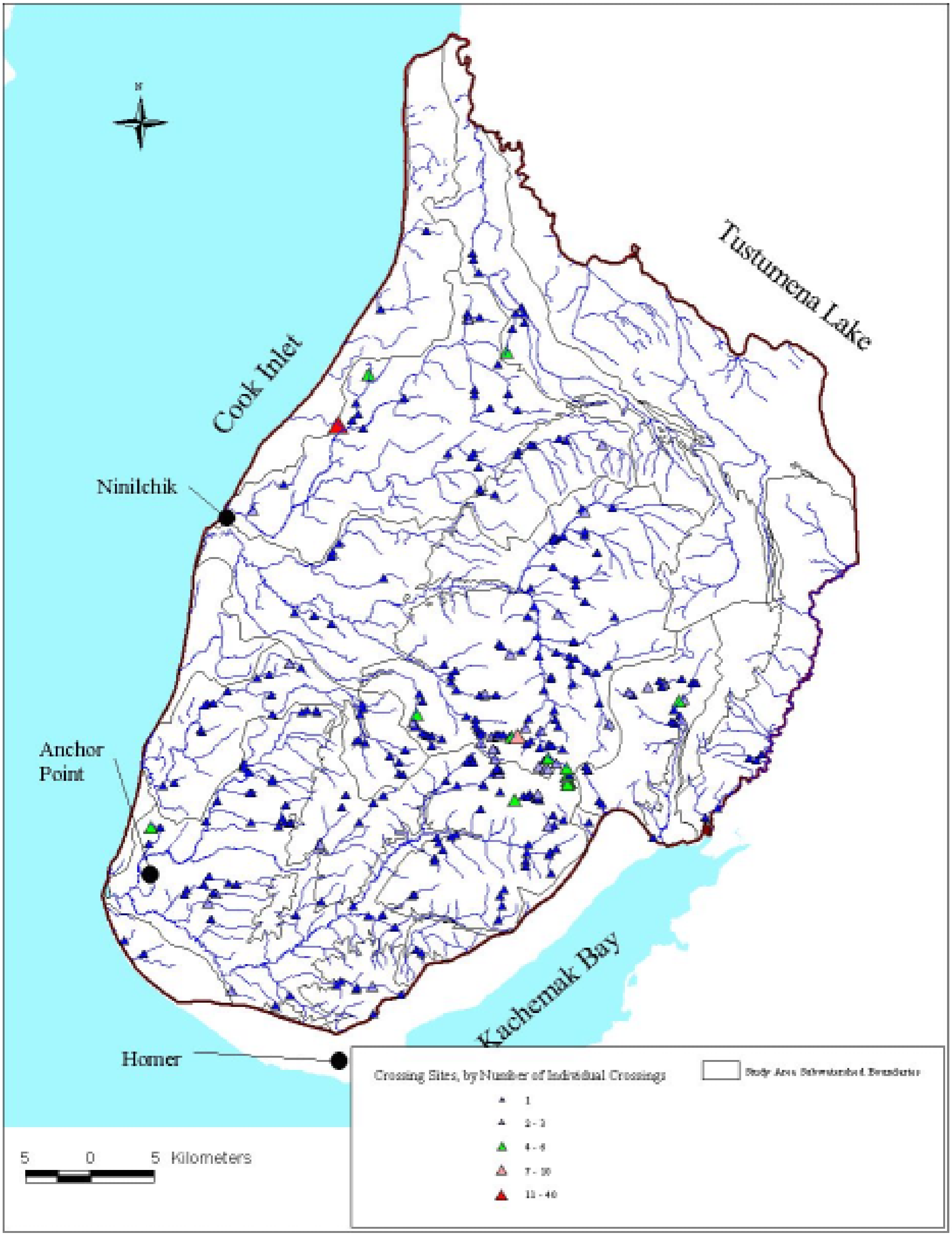

Figure 13.-Number of individual crossings per site.

Table 7.-ORV trail stream crossings data, by subwatershed. Significant anadromous fish-producing watersheds in bold.

Watershed	Subwatershed	Total Area Stream Length			Crossings			
		km	mi	% of Study Area	*n*	Density (*n*/km)	MCI	RAII
Anchor River	**Lower**	**334**	**207**	**18**	**57**	0.2	**2.3**	**0.4**
	Upper	**161**	**100**	**9**	**90**	0.6	**3.0**	**1.7**
Total		**495**	**308**	**26**	**147**	0.3	**2.7**	**0.8**
Caribou Lake	**Lower**	**20**	**12**	**1**	**1**	0.0	**1.0**	**0.0**
	Upper	**38**	**24**	**2**	**33**	0.9	**3.4**	**2.9**
Total		**58**	**36**	**3**	**34**	0.6	**3.3**	**1.9**
Clam Gulch	Lower	53	33	3	42	0.8	5.0	3.9
	Upper	0	0	0	-	-	-	-
Total		53	33	3	42	0.8	5.0	3.9
Crooked Creek	**Lower**	**87**	**54**	**5**	**13**	0.1	**2.1**	**0.3**
	Upper	**21**	**13**	**1**	**0**	0.0	**0**	**0.0**
Total		**108**	**67**	**6**	**13**	0.1	**2.1**	**0.3**
Deep Creek	**Lower**	**157**	**98**	**8**	**7**	0.0	**3.6**	**0.2**
	Upper	**273**	**170**	**15**	**155**	0.6	**3.2**	**1.8**
Total		**430**	**267**	**23**	**162**	0.4	**3.2**	**1.2**
Fox River	**Lower**	**119**	**74**	**6**	**5**	0.0	**3.8**	**0.2**
	Upper	**6**	**3**	**0**	**0**	0.0	**0**	**0.0**
Total		**125**	**77**	**7**	**5**	0.0	**3.8**	**0.2**
Happy Creek	Lower	22	14	1	0	0.0	0	0.0
	Upper	0	0	0	-	-	-	-
Total		22	14	1	0	0.0	0	0.0
Kachemak Bay	Lower	29	18	2	4	0.1	2.0	0.3
	Upper	9	6	0	1	0.1	1.0	0.1
Total		38	24	2	5	0.1	1.8	0.2
Ninilchik River	**Lower**	**198**	**123**	**11**	**35**	0.2	**3.0**	**0.5**
	Upper	**63**	**39**	**3**	**6**	0.1	**4.7**	**0.4**
Total		**261**	**162**	**14**	**41**	0.2	**3.2**	**0.5**
Stariski Creek	**Lower**	**87**	**54**	**5**	**17**	0.2	**2.6**	**0.5**
	Upper	**21**	**13**	**1**	**9**	0.4	**3.9**	**1.6**
Total		**109**	**67**	**6**	**26**	0.2	**3.1**	**0.7**
Tustumena Lake	**Lower**	**139**	**86**	**7**	**0**	0.0	**0**	**0.0**
	Upper	**39**	**24**	**2**	**0**	0.0	**0**	**0.0**
Total		**178**	**110**	**10**	**0**	0.0	**0**	**0.0**
Whisky Gulch	Lower	2	1	0	0	0.0	0	0.0
	Upper	0	0	0	-	-	-	-
Total		2	1	0	0	0.0		0.0
Grand Total		1,879	1,167	100	475	0.3	3.2	0.8

Figure 14.-Example of Site Score 0.

Figure 15.-Example of Site Score 1.

Figure 16.-Example of Site Score 2.

Figure 17.-Example of Site Score 3.

Figure 18.-Example of Site Score 4.

Figure 19.-Example of Site Score 5.

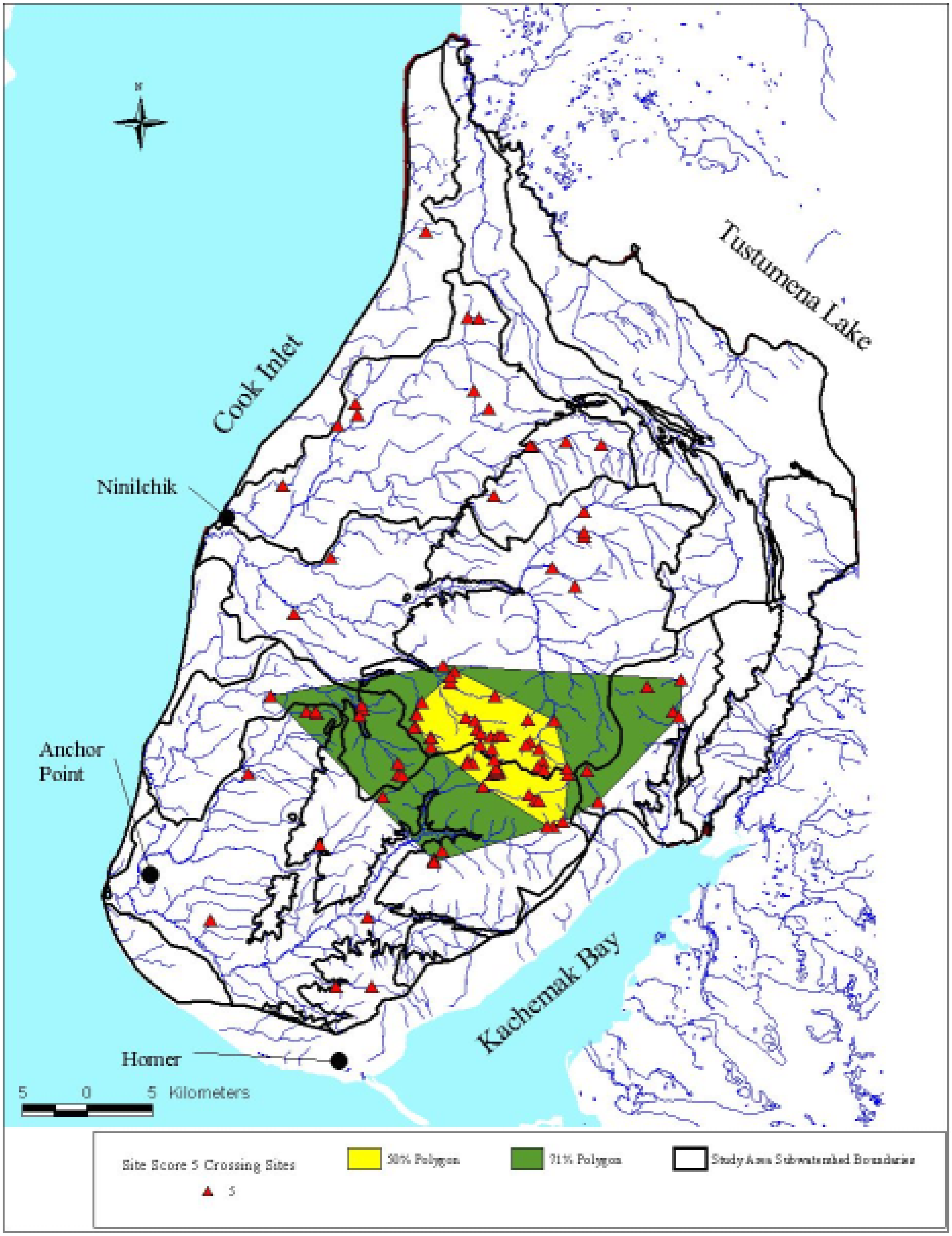

Figure 20.-Study area regions with most intense ORV trail stream crossing impacts. The 50% and 71% polygons contain 50% and 71% of the study area's Site Score 5 sites.

Table 8.- ORV trail stream crossings data, by landowner.

Landowner	Total Area Stream Length			Crossings			
	km	mi	% of Study Area	*n*	Density (*n*/km)	MCI	RAII
Borough	73	45	4%	25	0.3	3.6	1.2
Federal	338	210	18%	2	0.0	2.0	0.0
Native Corp.	437	272	23%	65	0.1	3.2	0.5
Private	262	163	14%	50	0.2	1.9	0.4
Right of Way	12	7	1%	2	0.2	1.5	0.3
State	726	451	39%	290	0.4	3.1	1.2
University of Alaska	29	18	2%	41	1.4	5.0	7.1
City	2	1	0%	0	0.0	0.0	0.0
Total	1878	1167	100%	475	0.3	3.2	0.8

Table 9.-Landownership within the 50% polygon.

Landowner	Area		
	ha	acres	%
Borough	846	2,148	10%
Native Corp.	1,265	3,213	14%
Private	4	10	0%
State	6,784	17,232	76%
Total	8,899	22,603	100%

Table 10.-Landownership within the 71% polygon.

Landowner	Area		
	ha	acres	%
Borough	3,386	8,599	10
Miscellaneous	315	799	1
Native Corp.	4,427	11,244	14
Private	596	1,513	2
State	24,045	61,075	73
Total	32,768	83,230	100

Trail Origin

Seismic Lines (31.8%), Recreational Trails (28.4%), Seismic Line/Winter Logging Roads (9.6%), and Property/Cabin Access trails (9.3%) were the origin of most sites (Table 11). Recreational Trails (32.8%), Seismic Lines (23.8%), Seismic Line/Winter Logging Roads (17.3%), and Property/Cabin Access trails (8.6%) were the origin of most crossings.

Among trail types with more than 5 sites, Seismic Line/Winter Logging Roads (2.65 crossings/site), Recreational Trails (1.70 crossings/site), Power Lines (1.47 crossings/site), and Property/Cabin Access trails (1.47 crossings/site) had the highest mean crossings per site.

Among trail types with more than 5 sites, Winter Logging Roads (4.0), Seismic Line/Winter Logging Roads (4.0), Seismic Line/Summer Logging Roads (4.0), and Seismic Line/Recreational Trails (3.9) have the highest MCIs.

Wetland Impacts

We observed adjacent non-riparian wetland impacts at 76 sites (23%), representing 174 crossings (37%). These sites were not randomly distributed, but were concentrated at the high elevation headwaters of Deep Creek and the Anchor River and mid-elevation tributaries of the Ninilchik River (Figure 21).

Table 9.-ORV trail stream crossing data, by historic origin of trail.

Trail Origin	Sites		Crossings		Crossings/Site		Site Score	
	n	%	*n*	%	Ratio	Rank	Mean	Rank
Highway Shoulder	2	0.6%	2	0.4%	1.00	8	4.0	3
Power Line	17	5.2%	25	5.3%	1.47	4	1.6	13
Property/Cabin Access	30	9.3%	41	8.6%	1.37	5	2.4	12
Recreational Trail	92	28.4%	156	32.8%	1.70	2	3.0	10
Recreational Trail/Winter Logging Road	4	1.2%	4	0.8%	1.00	8	3.3	9
Section Line	3	0.9%	3	0.6%	1.00	8	4.0	3
Seismic Line	103	31.8%	113	23.8%	1.10	7	3.0	10
Seismic Line/Property Access	2	0.6%	2	0.4%	1.00	8	5.0	1
Seismic Line/Recreational Trail	21	6.%	26	5.5%	1.24	6	3.9	8
Seismic Line/Summer Logging Road	7	2.2%	7	1.5%	1.00	8	4.0	3
Seismic Line/Winter Logging Road	31	9.6%	82	17.3%	2.65	1	4.0	3
Summer Logging Road	3	0.9%	5	1.1%	1.67	3	4.4	2
Winter Logging Road	9	2.8%	9	1.9%	1.00	8	4.0	3

TRAIL HEAD TEMPORAL USE SURVEY

Between June 19 and October 12, 2001, we counted a total of 427 pieces of equipment at the three trail heads surveyed. Equipment counts were highest at Trail Head C (*n* = 235, 55%), followed by Trail Head B (*n* = 126, 30%), and Trail Head A (*n* = 66, 15%). Trail head equipment counts were not homogenously distributed throughout the survey period; 71% of the counts occurred during the period August 21 – September 18 (28% of the survey period), which coincided with the Unit 15C moose hunting season (Figure 22). Mean daily equipment counts were 681% higher during the moose hunting season than during the combined pre- and post-hunting seasons (Student's paired one-tailed t-Test, P = 0.0344).

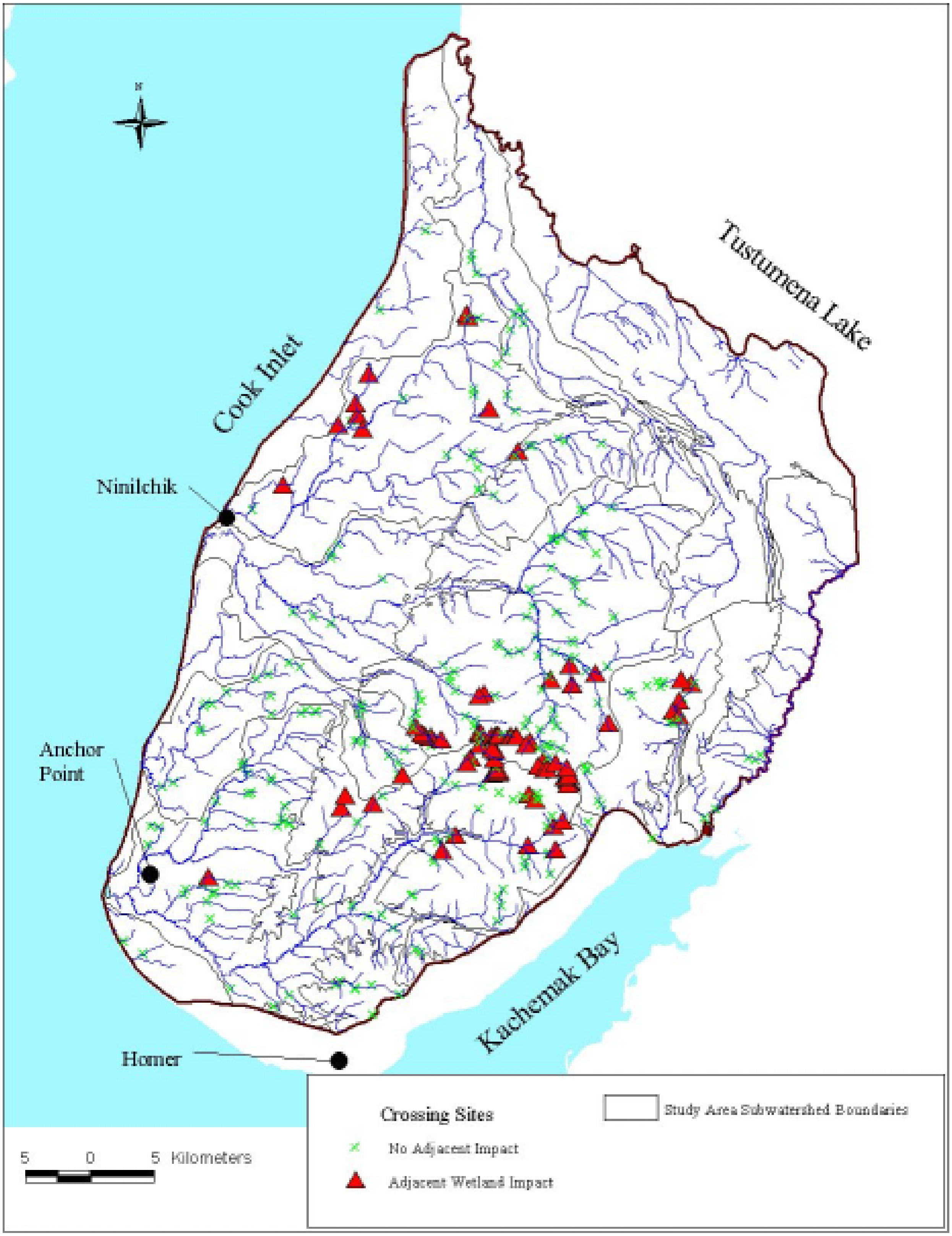

Figure 21.-Sites with adjacent wetland impacts.

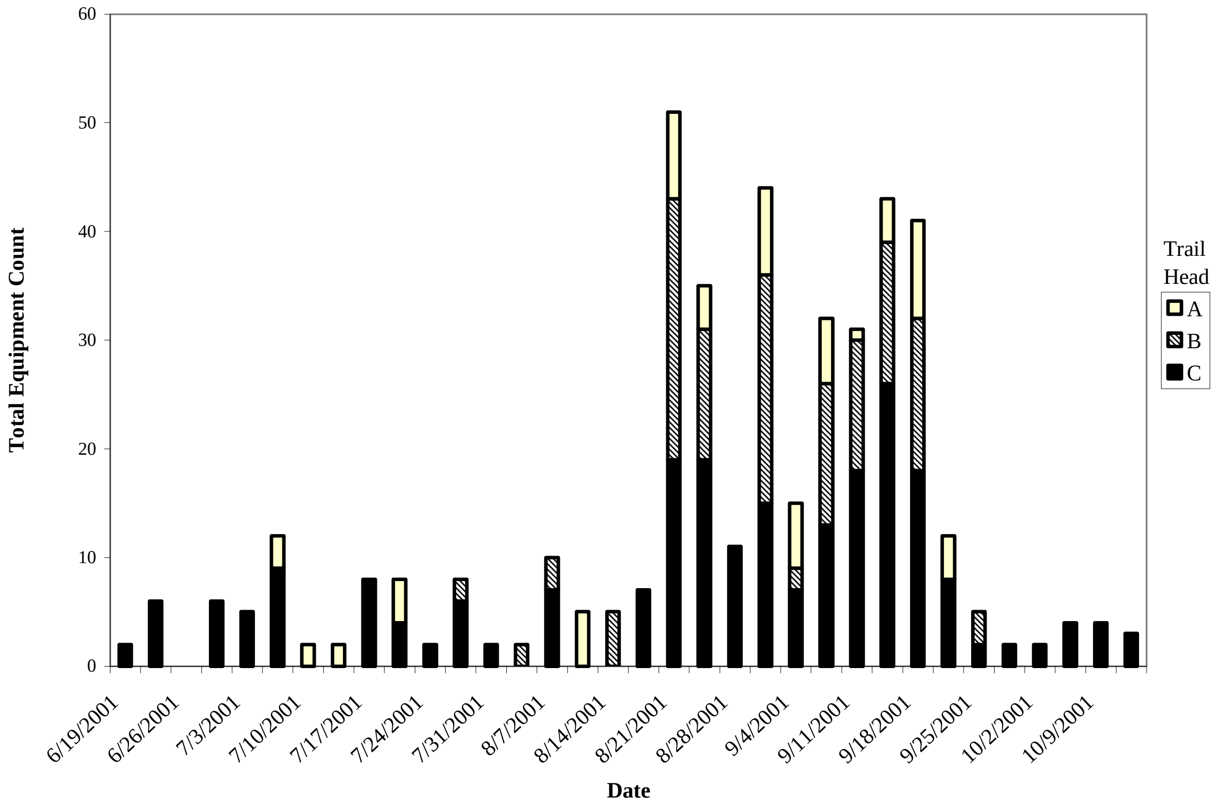

Figure 22.-Seasonal trail head use. Total equipment count is the sum of parked highway vehicles, parked ORV trailers, and parked or operating ORVs.

LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). 1990. Off-road vehicles and hunting in Alaska, a report to the Alaska Board of Game. Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1999. Alaska hunting regulations: effective dates July 1, 1999-June 30, 2000. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau.

Howe, A. L., G. Fidler, C. Olnes, A. E. Bingham, and M. J. Mills. 1998. Harvest, catch, and participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25, Anchorage.

King, B. E., and J. A. Breakfield. 1999. Chinook and coho salmon coded wire tagging studies in the Kenai River and Deep Creek, Alaska, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 99-11, Anchorage.

Williams, J. G. 1999. Alaska population overview: 1998 estimates. Alaska Department of Labor, Research and Analysis Section, Juneau.