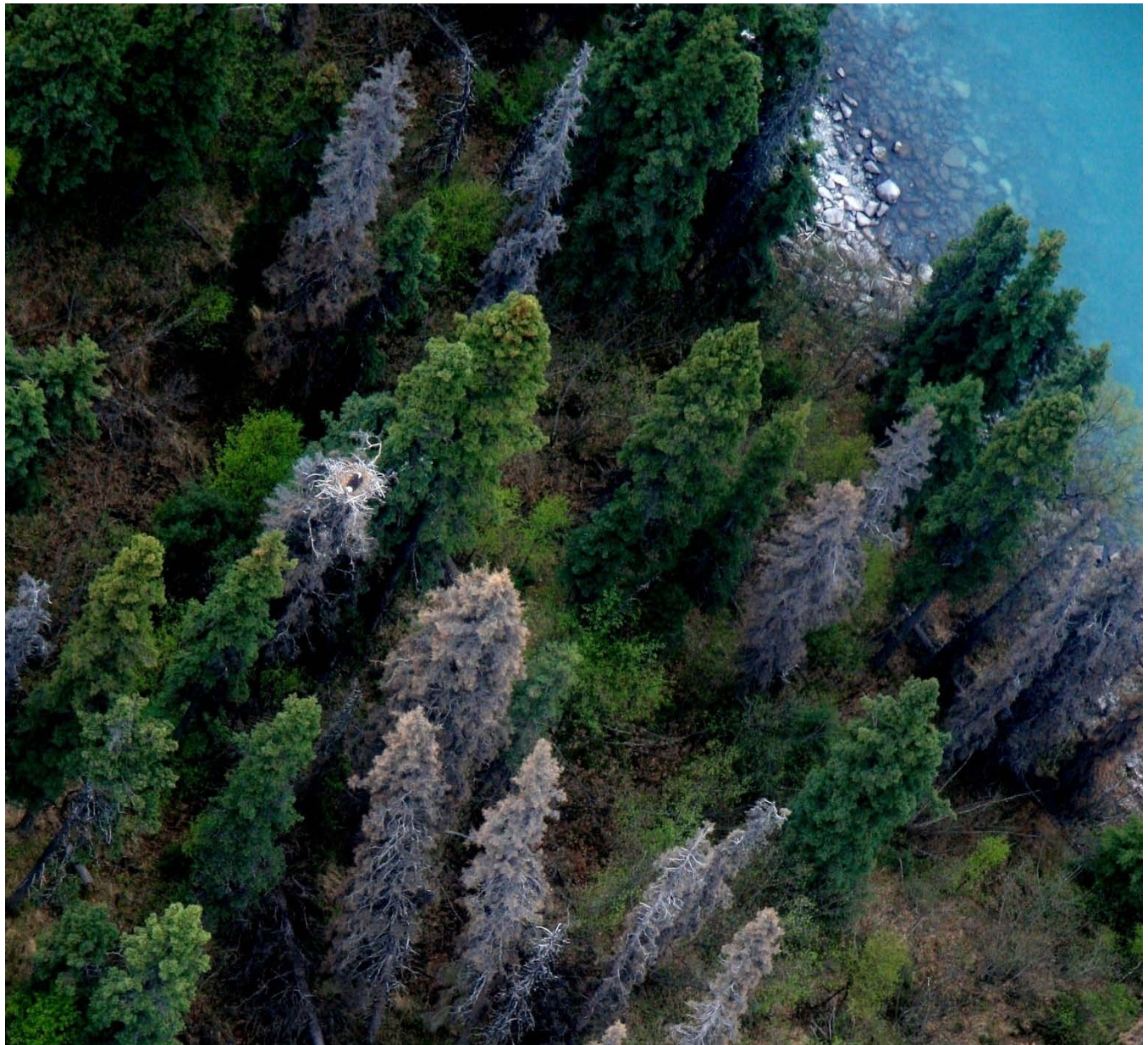




Bald Eagle Nest Survey Lake Clark National Park and Preserve, Alaska

Natural Resource Data Series NPS/LACL/NRDS—2011/313



ON THE COVER

Adult bald eagle in an incubating posture on a nest in a dead spruce along the shore of Lake Clark, LACL.
Photograph by: Ginger Irvine

Bald Eagle Nest Survey Lake Clark National Park and Preserve, Alaska

Natural Resource Report NPS/LACL/NRDS—2011/313

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U.S. Department of the Interior
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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Abstract

Nest occupancy and reproductive success of the large breeding populations of bald eagles (*Haliaeetus leucocephalus*) within parks in the Southwest Alaska Network (SWAN), including Lake Clark National Park & Preserve (LACL), have been selected as a “vital sign” for monitoring as they are indicative of the health of both freshwater and marine ecosystems. Records of nesting activity have been collected regularly in LACL since 1992. Objectives of ongoing eagle monitoring in LACL are to (1) obtain baseline data on population status, and (2) monitor long-term changes in reproductive rates. An additional objective for the 2011 study was to summarize historic LACL bald eagle nesting data. We completed an initial aerial survey in May 2011 to determine nest occupancy, and a follow-up survey in early August to assess productivity. Of the 40 nests found in the interior during the 2011 occupancy survey, 25 (63%) were active. Along the coast, 63% (27 of 43 nests) were active. We revisited 48 of the 52 active nests during productivity surveys. Coastal nests had lower nest success, but higher mean productivity (42% success; 0.77 ± 0.19 SE chicks per active nest) than interior nests (55%; 0.73 ± 0.16). Bald eagle productivity rates exhibited considerable annual variability in LACL since 1992. Efforts should be put forth to determine the causes of this variation as changes in productivity trends over time may indicate attention needs to be paid to broader natural or human-caused changes occurring within LACL ecosystems.

Acknowledgments

We thank Leon Alsworth (NPS – LACL) and Rich Richotte (NPS – LACL) for their excellent piloting skills and assistance with eagle observations. Ginger Irvine (NPS – LACL) provided invaluable logistical support. We appreciate review comments by Heather Coletti (NPS – SWAN), Jeff Shearer (NPS – LACL), Michael Shephard (NPS – SWAN), and Tammy Wilson (NPS – SWAN) that greatly improved this report. The project was funded by the National Park Service SWAN I&M Program with logistical and staff support provided by LACL.

Acronyms

ANILCA	Alaska National Interest Lands Conservation Act
KATM	Katmai National Park & Preserve
KEFJ	Kenai Fjords National Park
LACL	Lake Clark National Park & Preserve
SWAN	Southwest Alaska Network
USFWS	United States Fish & Wildlife Service

Introduction

Alaska has long been considered a stronghold for bald eagles (*Haliaeetus leucocephalus*). Although a bounty system was in place until 1953 (Hodges et al. 1979), eagle numbers were never reduced to the degree experienced in the contiguous 48 states (USFWS 2009). Bald eagles, however, are still susceptible to adverse impacts of human activities particularly during nesting. Logging, mining, and construction on private inholdings, as well as increased recreational use of public lands are potential threats to nesting bald eagles in LACL. Breeding success is also influenced by natural fluctuations in food availability and spring weather (Swenson et al. 1986, Hansen 1987, Gende et al. 1997).

Section 201 of ANILCA states that LACL shall be managed to “protect habitat for and populations of fish and wildlife including, but not limited to, caribou, Dall sheep, brown/grizzly bears, bald eagles and peregrine falcons” (LACL 2009). This mandate requires obtaining baseline data on wildlife species and monitoring their populations to ensure natural and healthy levels. Bald eagles play an important role as keystone predators of seabirds and fish, and success of eagle breeding populations is indicative of the health of freshwater and marine ecosystems (Stalmaster 1987, Armstrong 2008, Bennett et al. 2006, Thompson et al. 2009). As such, eagles have been selected as a “vital sign” for monitoring in parks within SWAN (Figure 1), including LACL, KATM, and KEFJ (Bennett et al. 2006).

The first aerial surveys of bald eagle nests in LACL began in 1984. Initial efforts were often incomplete and did not follow standard methodology. Beginning in 1992, bald eagle nest data were collected in accordance with USFWS guidelines (Bennett 1995). In 1999, a survey protocol specific to LACL was implemented (Putera 1999a). Recently, changes were proposed in methodology used for monitoring bald eagles in the contiguous 48 states that incorporated dual-frame sampling with a double-observer component to correct for biases in nest sightability (USFWS 2009, Sauer et al. 2011). In 2009, work began in KEFJ to field test a protocol for monitoring eagle productivity based on the updated USFWS methods (Thompson et al. 2009, Thompson and Phillips 2011). Ultimately, the goal is to finalize a rigorous survey design for long-term monitoring in LACL, KATM, and KEFJ that will standardize data collection and facilitate comparisons of eagle nest occupancy and productivity between SWAN parks.

Bald eagle surveys in LACL in 2011 followed the 1999 protocol; adoption of SWAN standardized methods is planned for upcoming survey years. Objectives of ongoing eagle monitoring in LACL are to (1) obtain baseline data on population status, and (2) monitor long-term changes in reproductive rates. Additional objectives for the 2011 study were to summarize historic LACL bald eagle nesting data and tabulate data in a format that can easily be transitioned into a standardized SWAN bald eagle database.

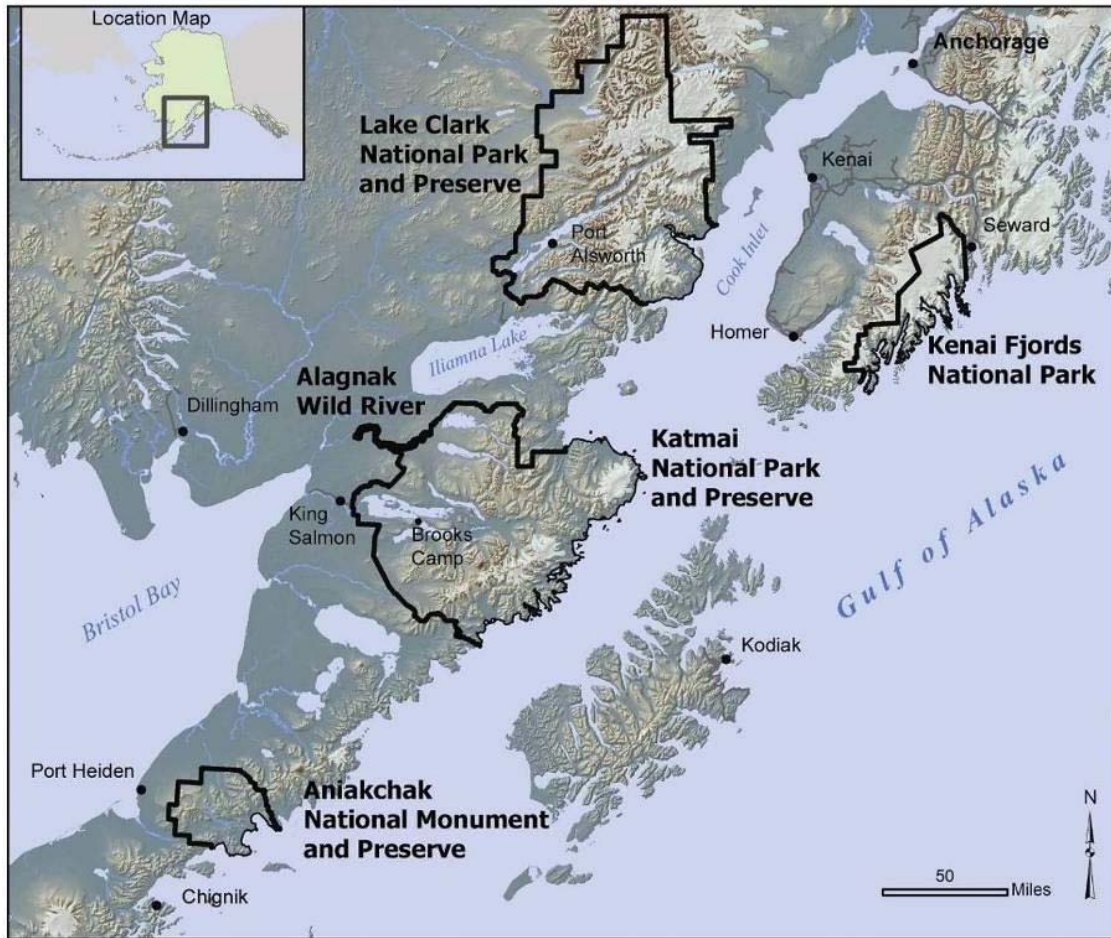


Figure 1. Location of LACL along with locations of the other four national park units within SWAN (figure from Bennett et al. 2006).

Methods

Study Area

LACL encompasses nearly 16,200 km² (6,250 mi²) at the north end of the Alaska Peninsula (Figures 1 and 2). The eastern portion of LACL includes 209 km (130 mi) of coastline dominated by salt marshes and mudflats interspersed with gravel beaches and bedrock cliffs (Bennett et al. 2006). Spruce (*Picea glauca*, *P. sitchensis*) forest and alder (*Alnus* spp.) thickets cover the flats and lower slopes beyond the beaches. Rising to over 2,134 m (7,000 ft), the Alaska and Aleutian mountain ranges form a spine of glacial ice, bedrock, and till separating coastal from interior LACL. A series of long lakes, including 285 km² (110 mi²) Lake Clark, dominate LACL west of the mountains. Vegetation in the interior is a mosaic of spruce (*P. glauca*, *P. mariana*), mixed spruce/birch (*Betula neolaskana*), and black cottonwood (*Populus balsamifera*) forests, shrubland dominated by dwarf birch (*B. nana*), ericaceous dwarf shrub tundra, alpine tundra, and wetlands (Bennett et al. 2006). Climate in the region is transitional between subpolar marine on the coast and continental in the interior (Lindsay 2010).

Bald eagle surveys in LACL covered two areas: interior and coastal (Figure 2). The interior survey region encompassed suitable shoreline habitat surrounding Lake Clark and associated drainages, including the Tanalian, Tazimina, Chulitna, Kijik, and Tlikakila Rivers, and Current and Tommy Creeks. Additionally, smaller lakes and drainages to the north of Lake Clark (Kijik, Lachbuna, Portage, Otter, Twin, Turquoise, Telaquana, and Two Lakes) were included in the interior survey. The coastal survey region consisted of the coastline and associated drainages including Glacier Creek and Red, Johnson, Tuxedni, and Crescent Rivers.

Data Collection

We conducted two aerial surveys during the bald eagle breeding season to determine nest occupancy and productivity in interior and coastal LACL. Survey methodology followed the LACL Bald Eagle Survey Protocol (Putera 1999a). We used a Department of Interior (DOI) Cessna 185 aircraft with a pilot and one observer to conduct an initial survey to determine nest occupancy on May 19 & 24, 2011. Survey dates fell within the window recommended based on estimated nest initiation dates for the area (Putera 1999a). We revisited 44 interior and 44 coastal nests that were active during the 2010, 2009, or 2008 surveys. Survey areas were not systematically searched for new/unknown nests; however, new nests encountered during transit between known nests were recorded. During the survey, we flew at speeds of 130-185 km/hr (70-100 knots) and elevations 46-91 m (150-300 ft) above ground level. The general flight path positioned the plane slightly offshore to see inland from coast and shorelines. Port Alsworth airport (60°12'15.60"N, 154°19'07.94"W) was the base of flight operations. Once located, nests were circled to verify activity. Nests were classified as either "active" or "empty". "Active" referred to nests where eggs, young, or an adult eagle in an incubating posture were present. "Empty" included nests where no adults, eggs, or chicks were present. Nests where adults were present, but there was no sign that reproduction had occurred were also considered "empty". We recorded attributes (Table 1) associated with each nest using ESRI ArcPad 7.1 (ESRI, Inc., Redlands, CA) GIS software loaded on a Panasonic Toughbook (Panasonic Corporation, Osaka, Japan) linked to a Garmin 12XL GPS receiver (Garmin International, Inc., Olathe, KS). An external antenna was attached to the Garmin unit to increase accuracy of GPS locations.

During the second aerial survey (August 6-8, 2011), we used a DOI Aviat Husky with a pilot and one observer to revisit all nests that were classified as active during the May survey. Direct lines were flown between nests. Once a nest was relocated, the pilot and observer independently surveyed the nest for young before consulting each other to determine if counts were consistent. We recorded nest status, number of young, chick developmental stage, and number of adults using ArcPad. Nest productivity status was classified as either “successful” or “failed”. “Successful” referred to nests where at least one young was present. “Failed” included nests classified as active in May that were empty on revisitation, as well as previously active nests where adults were present without chicks in August.

Analysis

We used DNR Garmin 5.4.1 (Minnesota Department of Natural Resources, St. Paul, MN) to export Garmin GPS data in ESRI shapefile format. Both Garmin and ArcPad spatial data were based on the North American 1927 geographic coordinate system and the North American datum 1983 Alaska Albers projected coordinate system. Data were brought into ESRI ArcGIS 9.3 for editing, mapping, and basic analysis.

We used Microsoft Excel 2007 (Microsoft, Redmond, WA) and SigmaPlot 11.0 (Systat Software, Inc., Chicago, IL) to generate summary statistics and graphs. We calculated nest success as the percentage of nests classified as active during the May survey in which at least one young eagle was observed in August. We calculated two metrics of productivity: (1) the average number of young per active nest, and (2) the average number of young per successful nest. We also summarized historic data on the location, number, substrate, and productivity of nests located in interior and coastal LACL. We used Spearman rank correlation to examine relationships between eagle productivity and spring weather conditions recorded at an automated weather station at Port Alsworth, AK between 1992-2011 (weather data available online from the Western Regional Climate Center: <http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?akAPAL>). Weather variables included mean temperature, mean wind speed, and total precipitation for April-May and June-July. Only complete observations with data for both response and predictor variables were used in the correlation analysis.

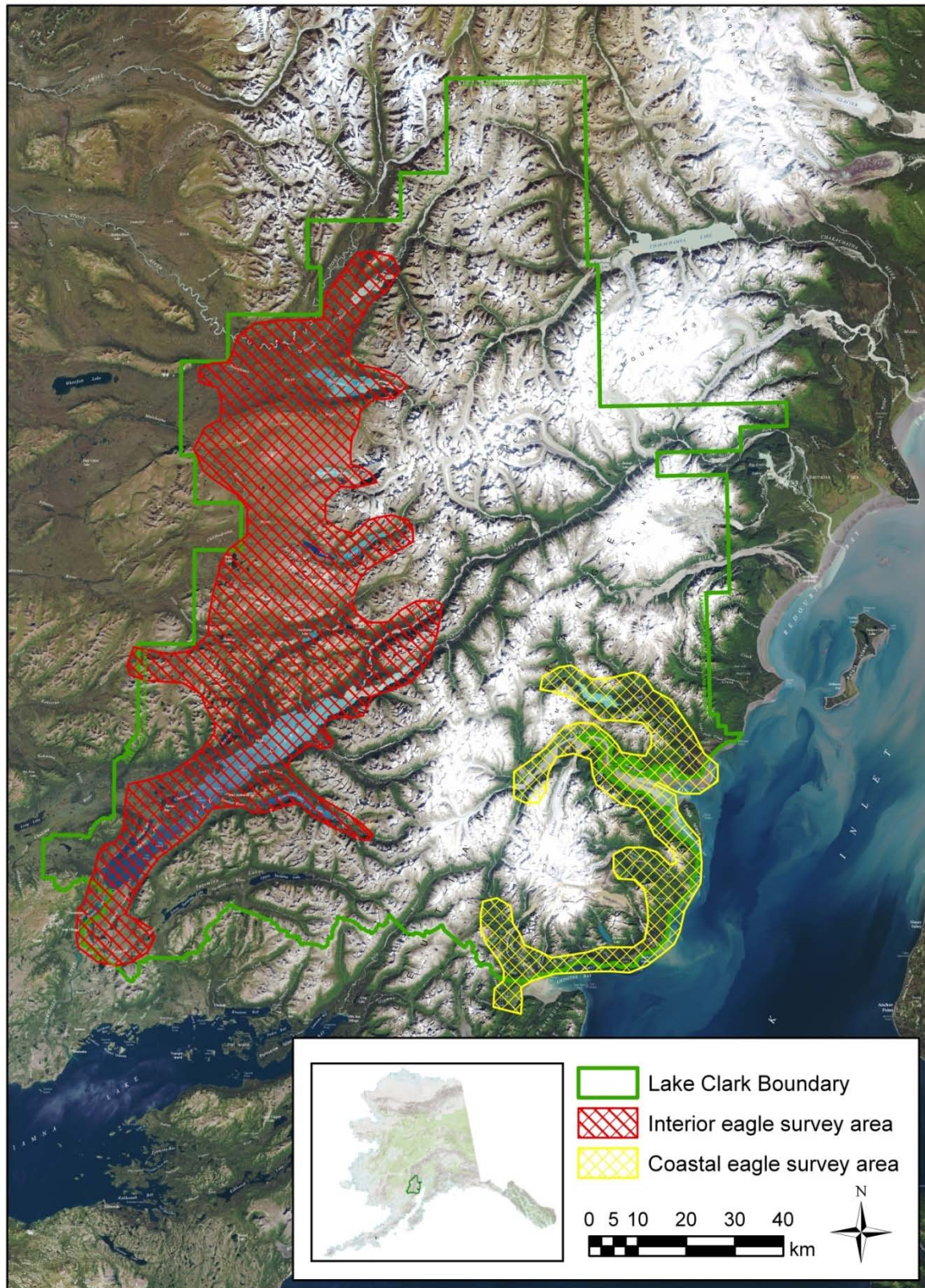


Figure 2. LACL boundary encompassing interior and coastal bald eagle nest occupancy and productivity study areas.

Table 1. Attribute data collected at bald eagle nests detected during 2011 aerial occupancy (EOS) and productivity (LPS) surveys in LACL.

Attribute	Codes	Description
Nest ID	N/A	A unique identifier was assigned to each nest based on the numeric code of the topographic map series and 1:63,360 USGS quadrangle in which it was located. Nests within each quadrangle were numbered consecutively based on order of initial detection.
Location category	I (interior), C (coastal)	General region where nest was located.
Location	N/A	Specific name of area (i.e., lake, river, bay) in which nest was located. Assigned during post-processing.
Nest substrate	S (spruce), C (cottonwood), G (ground), R (rock), O (other)	Tree species or substrate where the nest was located.
Nest occupancy/EOS code	A (active), A/E1 (active, 1 egg), A/E2 (active, 2 eggs), A/E3 (active, 3 eggs), A/1Y (active, 1 young), A/2Y (active, 2 young), A/3Y (active, 3 young), E (empty), NC (not checked), NF (not found), NF-damaged (not found/damaged)	Status of detected nest. "Active" included nests where eggs, young, or an adult in an incubating posture were present. "Empty" included nests where no adults/eggs/chicks were present, as well as nests where adults were present, but there was no sign that reproduction had occurred. "Not found – damaged" included locations where nest remnants were found in tree branches or blown down nests were observed on the ground.
Nest productivity/LPS code	S1 (successful, 1 young), S2 (successful, 2 young), S3 (successful, 3 young), F (fail), NF (not found), NC (not checked)	Status on revisitation of active nests found during the initial survey. "Fail" included empty nests, as well as nests where adults were present without chicks.
Chick stage	1a (small 1 st down), 1b (large 1 st down), 2 (2 nd down), 3a (early contour), 3b (late contour), 3c (contour with down), 3d (complete contour), ND (not determined), N/A	Stage of chick development based on Carpenter (1990).
Number of adults	0, 1, 2, N/A	Number of adult eagles seen at or in close vicinity to the nest during the productivity survey.

Results

2011 Survey

We flew an initial survey to determine the occupancy status of known nests in interior and coastal LACL on May 19 & 24, 2011. Active nests were revisited during a follow-up survey on August 6-8 to determine nesting success and productivity. Total flight time for the initial survey was 7.0 hrs, and 8.3 hrs for the productivity survey.

During the initial survey we checked 88 known bald eagle nests, 44 each in the interior and coastal regions. Two known interior nests, one west of Fishtrap Lake and the other along the Little Mulchatna River, as well as one coastal nest along Crescent River, were not checked due to time constraints. We were unable to locate six previously known interior nests and three coastal nests. During the occupancy survey, we found two unknown/new nests in the interior, one on Island Lodge Island in Lake Clark and the second along the Tazimina River near the dam. We also found two unknown/new nests in the coastal region, one west of Difficult Creek and the second near the mouth of Johnson River. All four new nests were active. Of the 40 nests found in the interior during the occupancy survey, 25 (63%) were active. Along the coast, 63% (27 of 43 nests) were active. Cottonwood and spruce were equally prevalent as nest substrate trees within the interior (Figure 3). Most active coastal nests were located in cottonwood, but spruce and ground substrates were also used.

We attempted to revisit all 52 active nests during the productivity survey (Figure 4). We were unable to relocate four nests. Of the 48 remaining nests, 25 failed (52%) and 23 were successful (48%). There were 0.75 ± 0.12 SE chicks raised per active nest, and 1.57 ± 0.11 SE chicks per successful nest. Coastal nests had lower nest success, but higher mean productivity (42% success; 0.77 ± 0.19 SE chicks per active nest) than interior nests (55%; 0.73 ± 0.16). Chick development was predominantly 3c/3d (feather development either contour with down or complete contour), with the exception of one interior nest with chicks at the 3b (late contour) developmental stage.

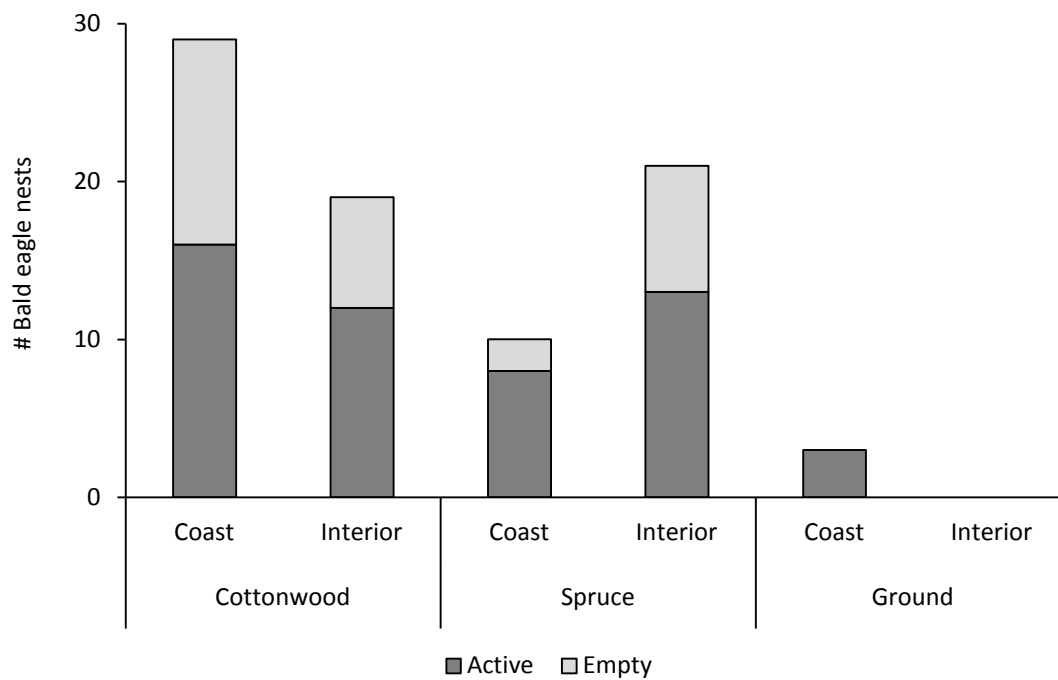


Figure 3. Nest substrates of active and empty bald eagle nests surveyed in 2011 in interior and coastal LACL.

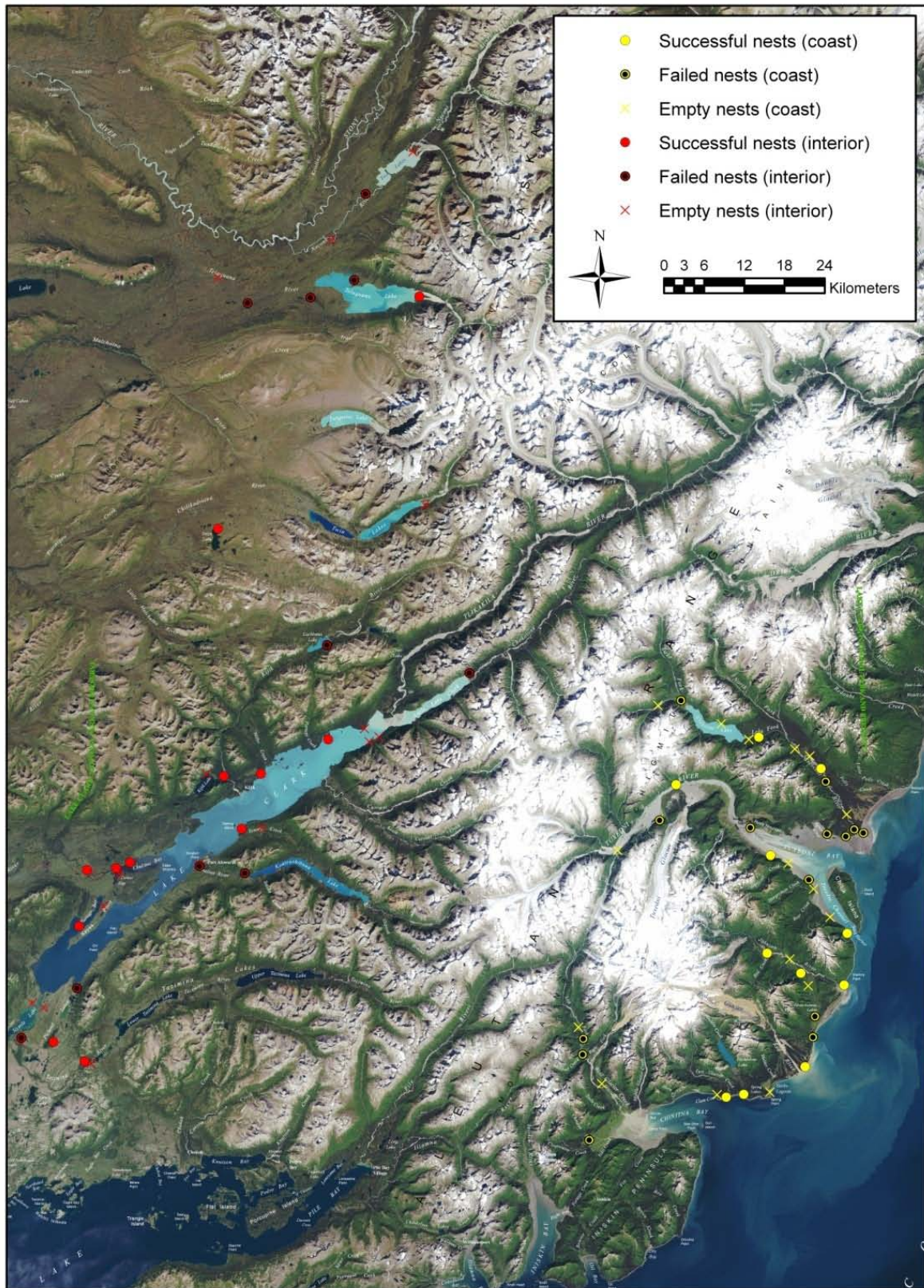


Figure 4. Locations and occupancy/productivity status of bald eagle nests surveyed in interior and coastal LACL in 2011.

Historical Data

Surveys for bald eagle nests within LACL have been conducted periodically since 1984 (Appendix A). During 1984-1991, however, survey efforts did not follow standard methodology. With the exception of 1990, only nest occupancy surveys were conducted. The number of nests monitored varied from 44-86, with occupancy rates ranging from 44-73% (Figure 5, Table 2). Nests were not given unique identifiers, so data on the use and productivity of individual nests over time is lacking.

Table 2. Summary of status and occupancy rates of bald eagle nests monitored during 1984-1991 in interior and coastal LACL.

Year	# Empty nests	# Active nests	Total # nests	Occupancy rate (%)
1984	12	33	45	73.33
1987	20	24	44	54.55
1988	17	38	55	69.09
1989	23	44	67	65.67
1990	34	41	75	54.67
1991	48	38	86	44.19
Mean $\pm$ SE	25.67 $\pm$ 5.38	36.33 $\pm$ 2.88	62.00 $\pm$ 6.91	60.25 $\pm$ 4.47

Beginning in 1992, bald eagle nest survey data were collected following USFWS protocols and entered into an Access database (Bennett 1995). In 1999, a survey protocol specific to LACL was implemented (Putera 1999a). Occupancy and productivity surveys were conducted yearly; exceptions being 1998 and 2002 when no surveys occurred and 2003 when only occupancy surveys were conducted. Nests monitored since 1991 were assigned unique identifiers that allow us to track the success of individual nests over time (Figure 6). From 1992-2011, the number of active nests found within coastal LACL ranged from 3-37 per yr (mean of 22.74 ± 1.88 SE) and from 8-31 per yr (20.05 ± 1.22 SE) in the interior (Figure 7). Cottonwood was the prevalent nest substrate in coastal LACL ($79.87\% \pm 1.50$ SE of active and empty nests; Figures 8 and 9); other substrates included spruce ($14.85\% \pm 1.51$ SE) and ground ($5.28\% \pm 0.38$ SE). In interior LACL, nests were more evenly distributed between cottonwood ($58.16\% \pm 3.08$ SE) and spruce ($40.43\% \pm 2.82$ SE); ground nests were rare ($1.41\% \pm 0.46$ SE; Figures 8 and 10).

Productivity of nests within interior LACL fluctuated over time (Figures 11-13). Nest success fell below the minimum required for stability (Sprunt et al. 1973) in 6 out of 17 yrs where productivity data are available. The mean number of young per active nest fell below the minimum on seven occasions; however, in only three cases were these departures statistically significant (Figure 12). Productivity of coastal nests also varied, but not necessarily in concert with interior fluctuations (Figures 11, 14, and 15). On the coast, nest success fell below the minimum required for stability in 5 out of 16 yrs where productivity data are available. The mean number of young per active nest fell below the minimum on six occasions, two of which were statistically significant (Figure 14). On average, nest success was higher for spruce ($63.25\% \pm 3.93$ SE; Figure 16) than for cottonwood nests ($50.82\% \pm 2.52$ SE).

Historical nest success and productivity were not significantly correlated with spring/summer temperatures or wind speeds. In the interior, there was a negative correlation between the mean

number of young per active nest and total April-May precipitation ($r_s = -0.59$, $p = 0.019$; Figure 17). For coastal nests, this relationship was not significant ($r_s = -0.25$, $p = 0.37$). There was a strong negative correlation between coastal nest success and total June-July precipitation levels ($r_s = -0.76$, $p = 0.0012$; Figure 18), and an insignificant negative correlation between interior nest success and June-July precipitation ($r_s = -0.51$, $p = 0.052$). Precipitation in June-July also exhibited insignificant negative correlations with the mean number of young per active nest in both coastal ($r_s = -0.50$, $p = 0.069$) and interior ($r_s = -0.45$, $p = 0.086$) regions (Figure 19).

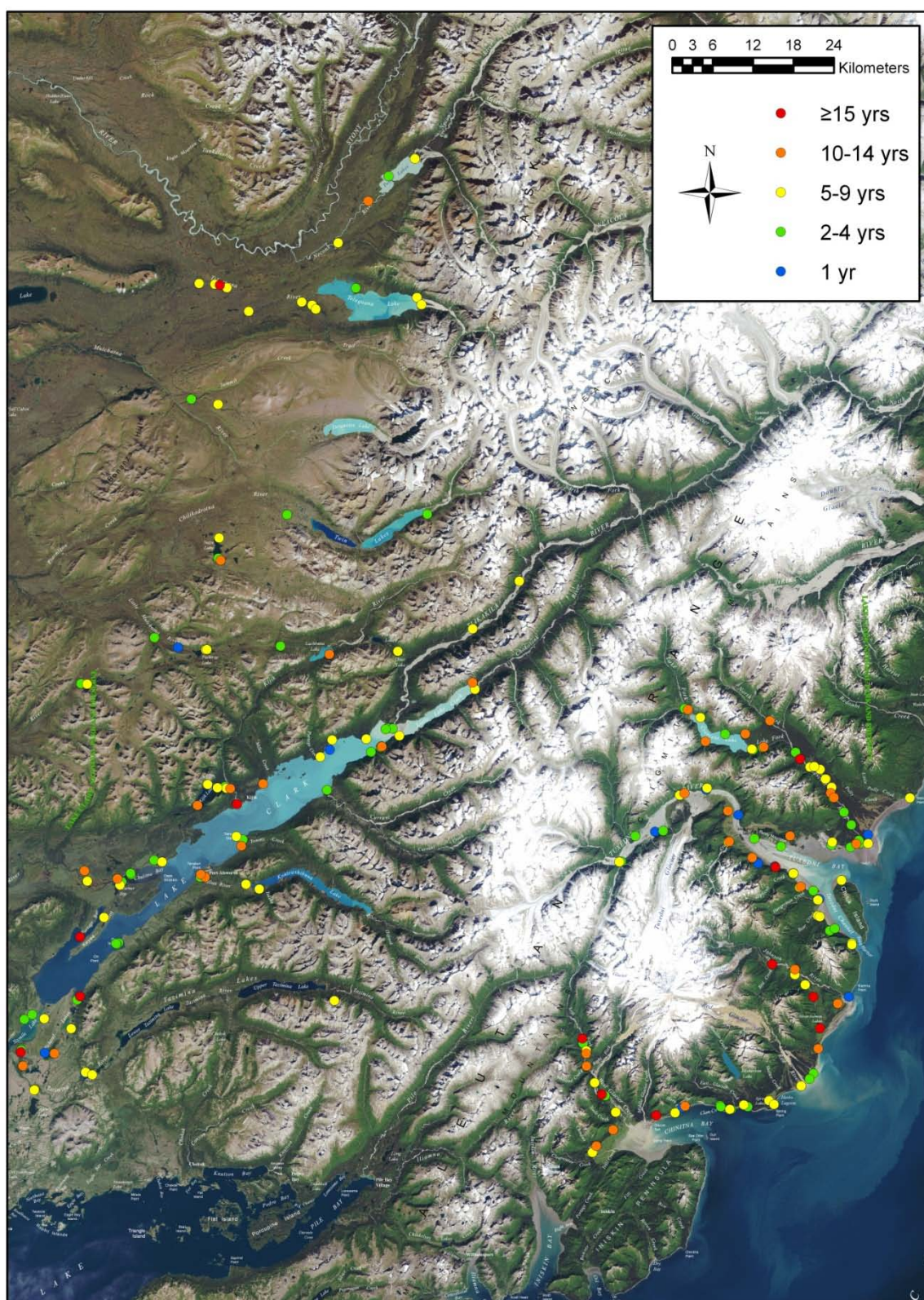


Figure 6. Locations of bald eagle nests monitored in interior and coastal LACL during 1992-2011, along with the number of years of productivity data associated with each nest.

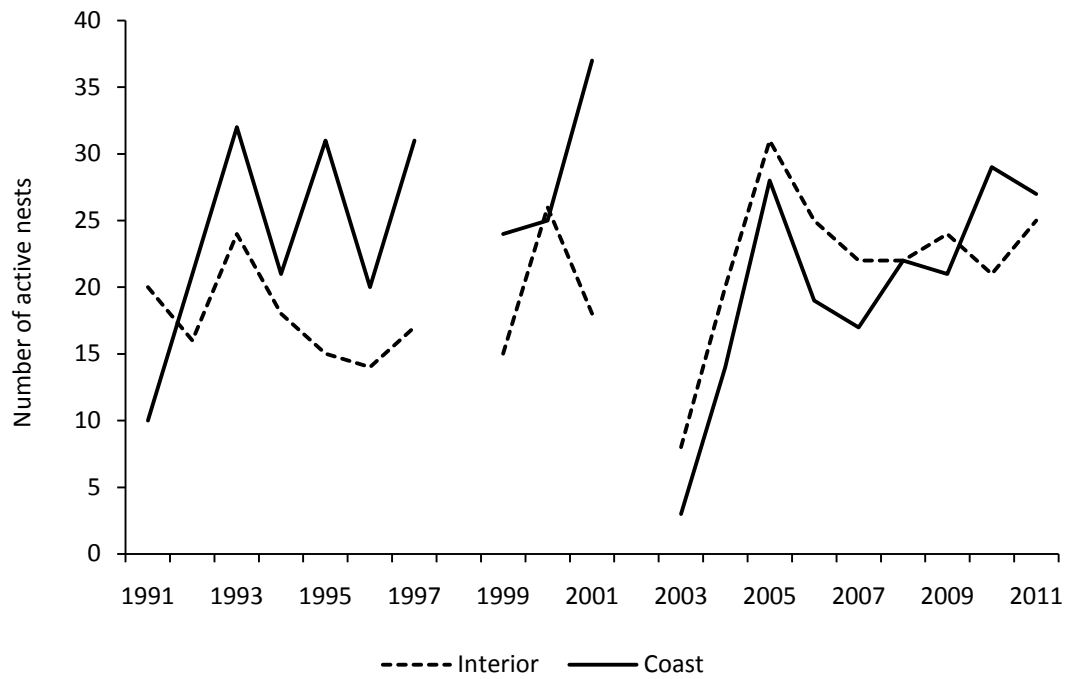


Figure 7. Number of active bald eagle nests monitored in interior and coastal LACL from 1991-2011.

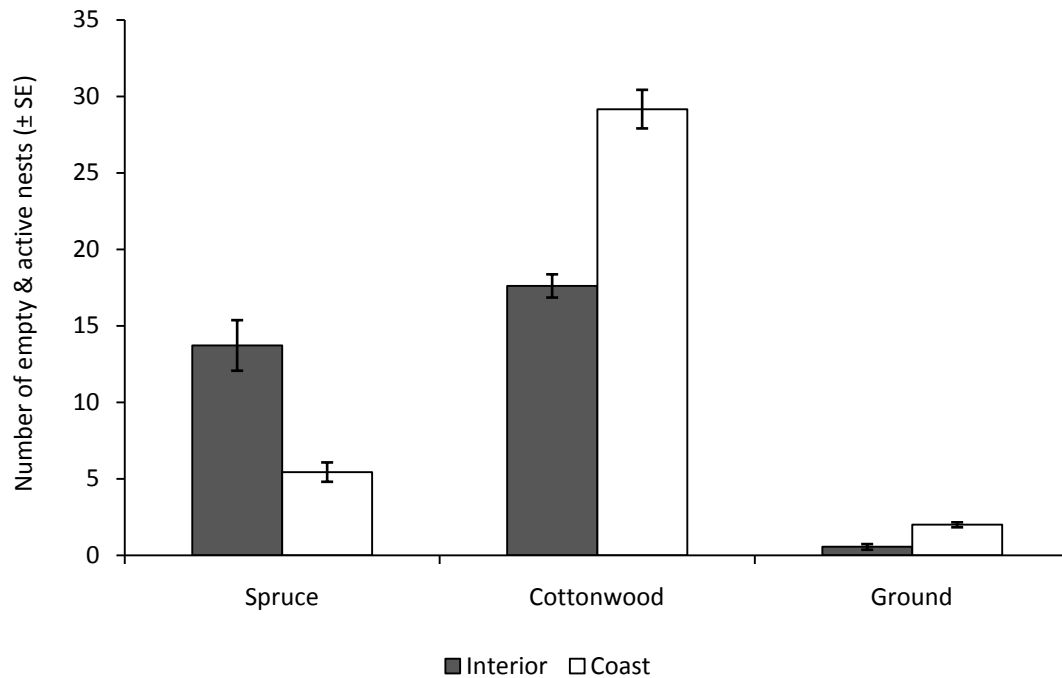


Figure 8. Bald eagle nest distribution by substrate type ($\bar{x} \pm SE$) in interior and coastal LACL from 1992-2011.

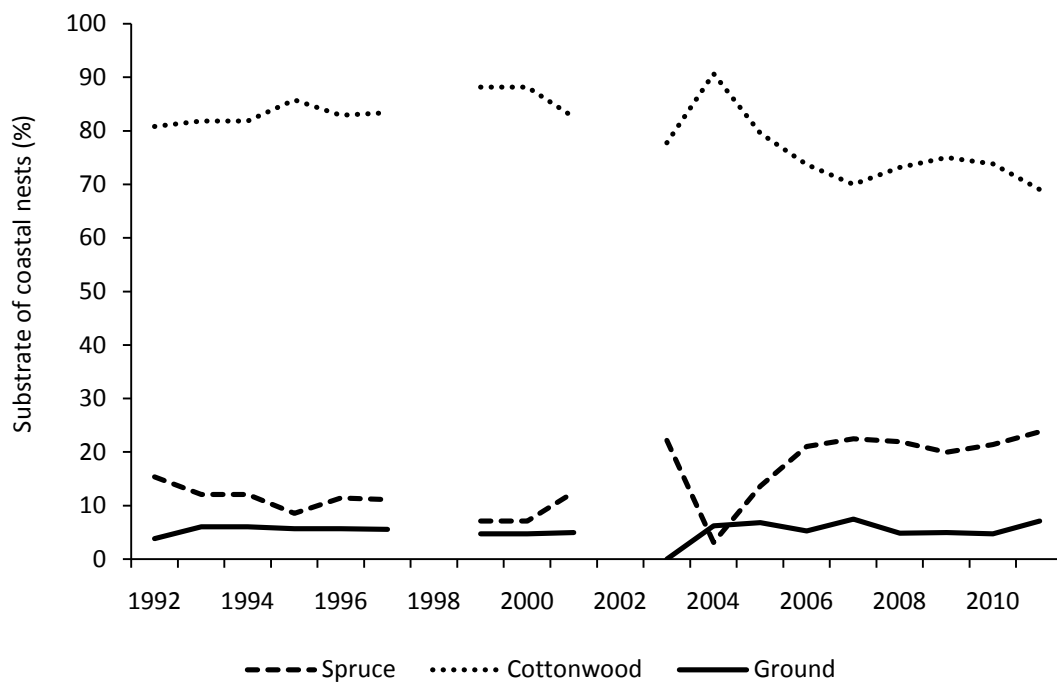


Figure 9. Bald eagle nest substrate use from 1992-2011 in coastal LACL.

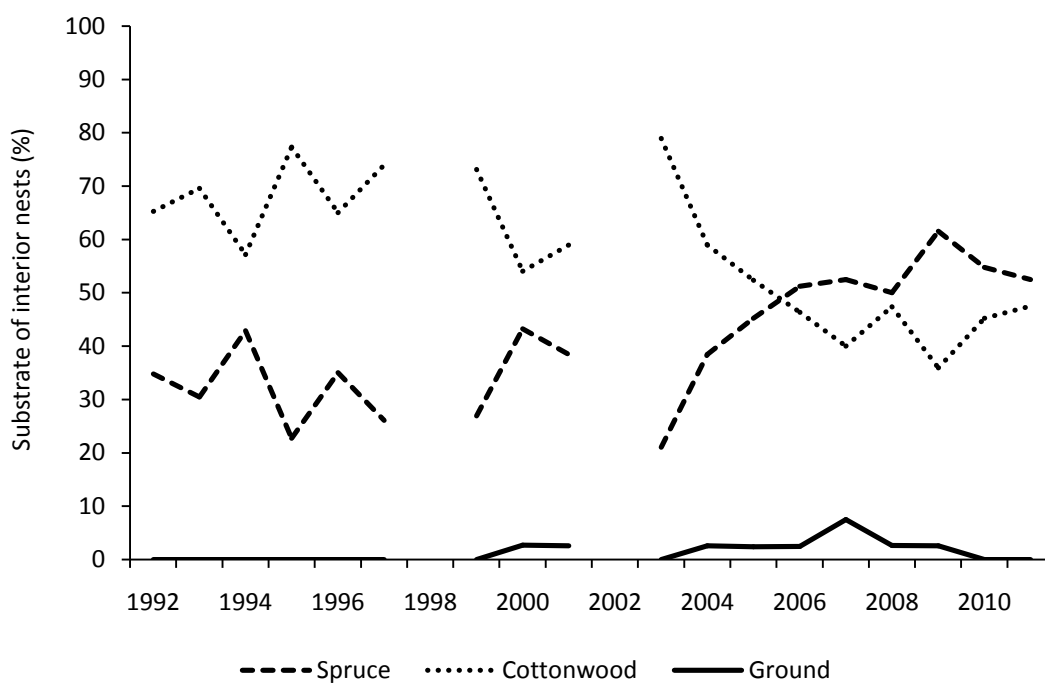


Figure 10. Bald eagle nest substrate use from 1992-2011 in interior LACL.

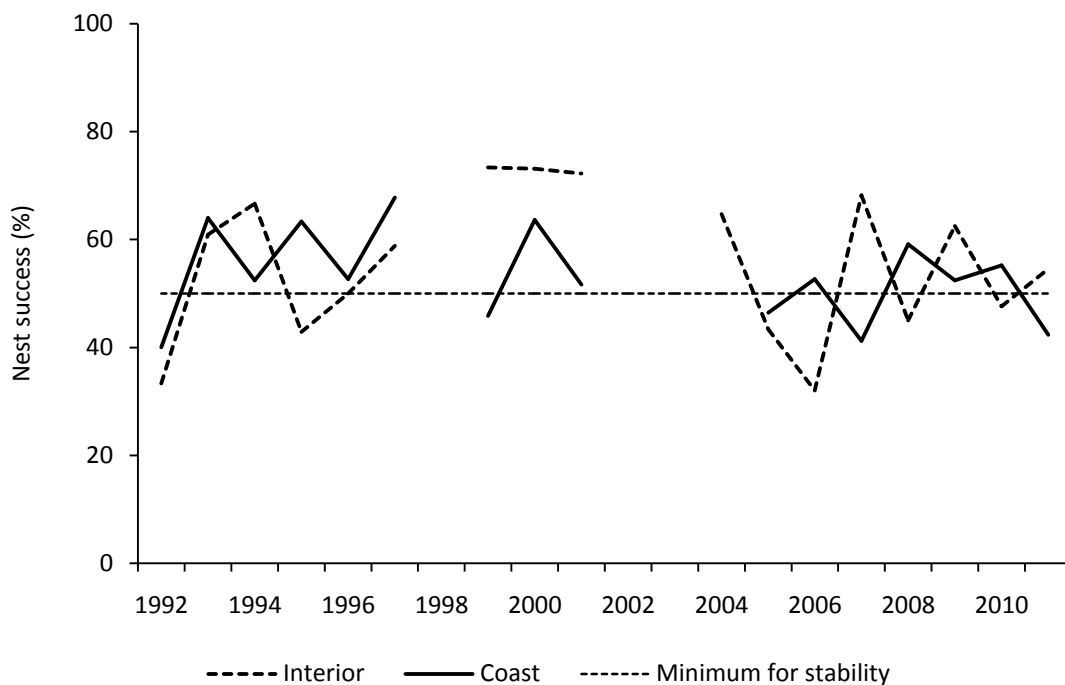


Figure 11. Percent success of active bald eagle nests in interior and coastal LACL from 1992-2011. Dashed line represents minimum needed to maintain a stable population (Sprunt et al. 1973).

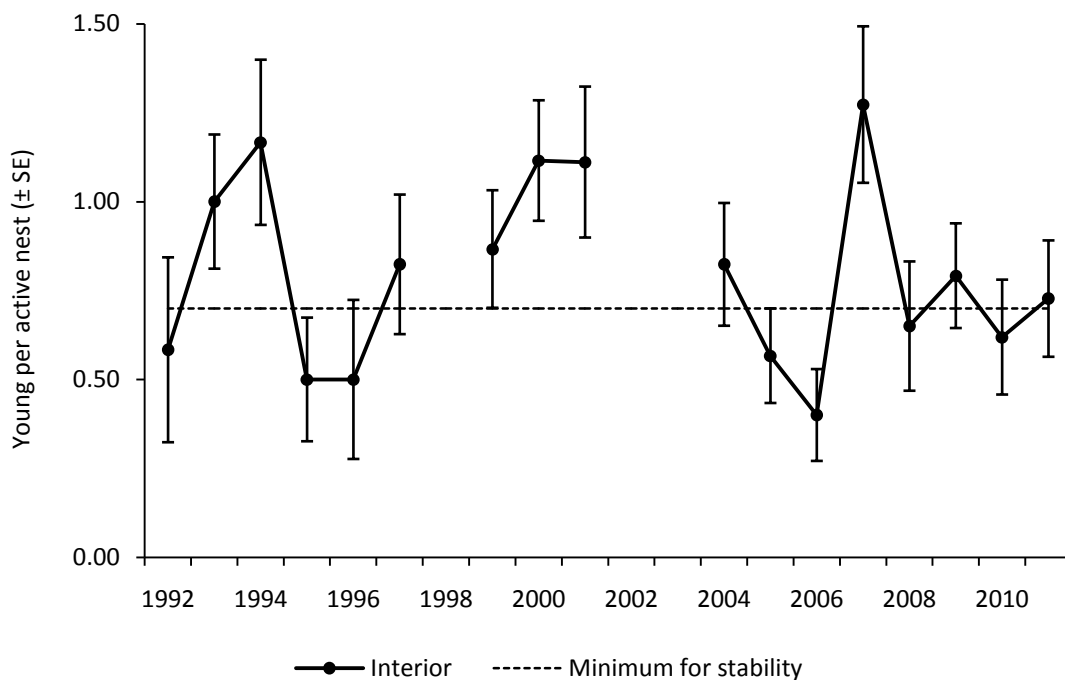


Figure 12. Mean productivity ($\bar{x} \pm SE$) of bald eagle nests in interior LACL from 1992-2011. Dashed line represents minimum needed to maintain a stable population (Sprunt et al. 1973).

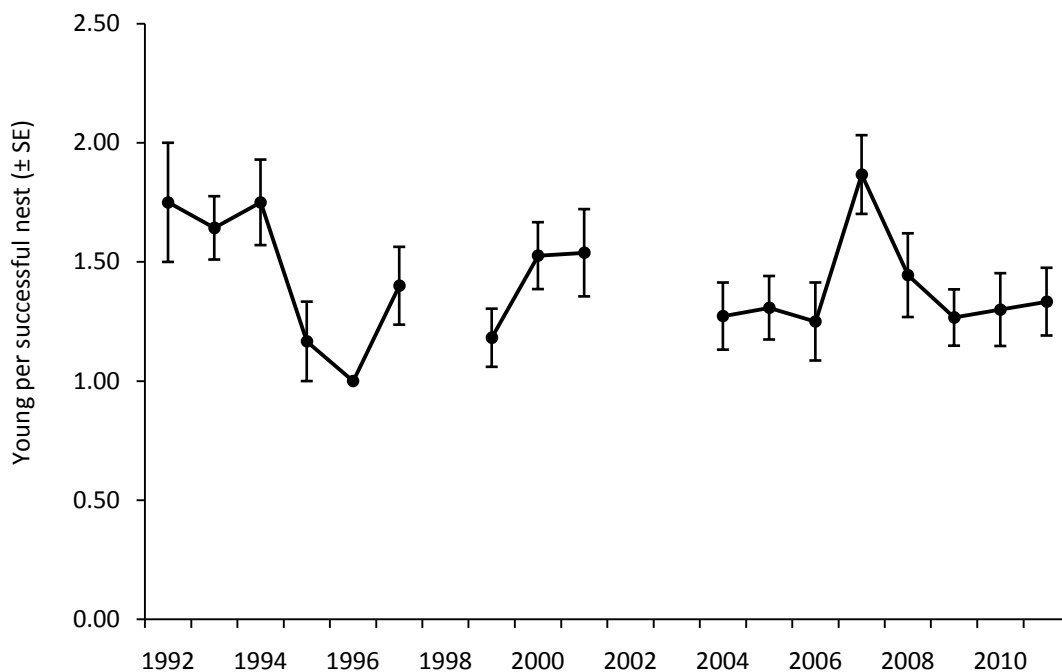


Figure 13. Mean number of eaglets fledged per successful bald eagle nest ($\bar{x} \pm SE$) in interior LACL from 1992-2011.

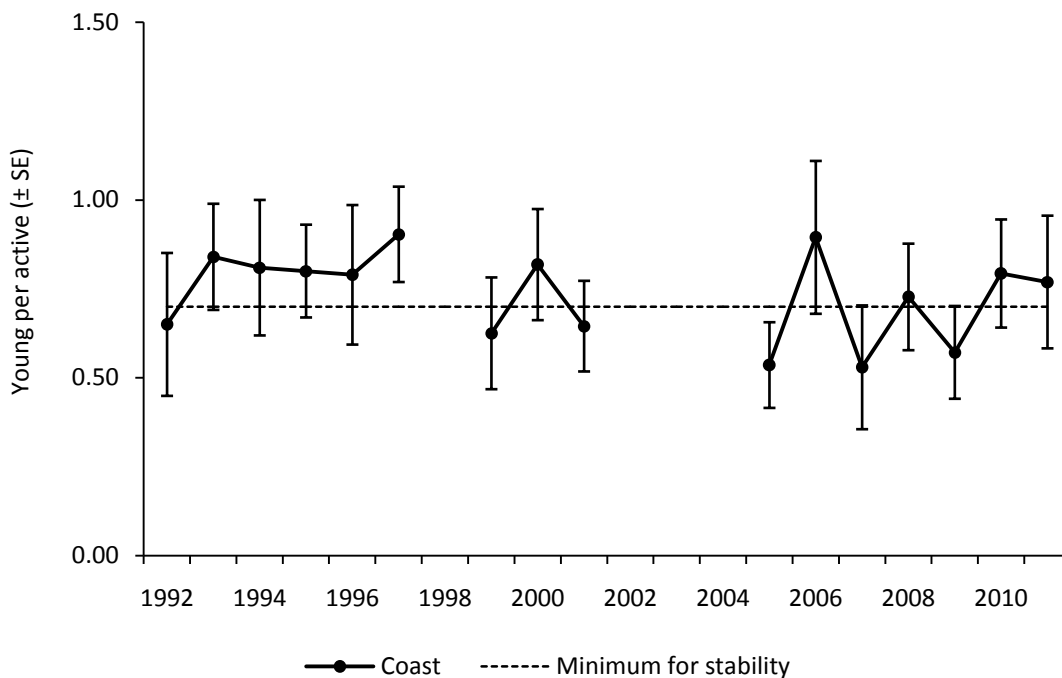


Figure 14. Mean productivity of bald eagle nests ($\bar{x} \pm SE$) in coastal LACL from 1992-2011. Dashed line represents minimum needed to maintain a stable population (Sprunt et al. 1973).

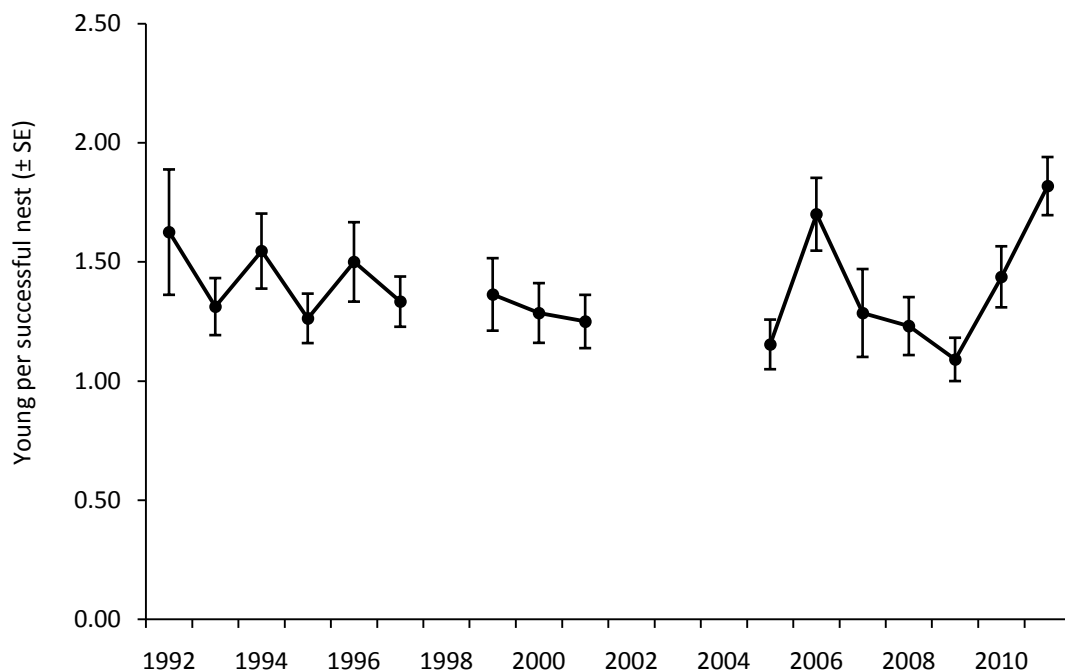


Figure 15. Mean number of eaglets fledged per successful bald eagle nest ($\bar{x} \pm SE$) in coastal LACL from 1992-2011.

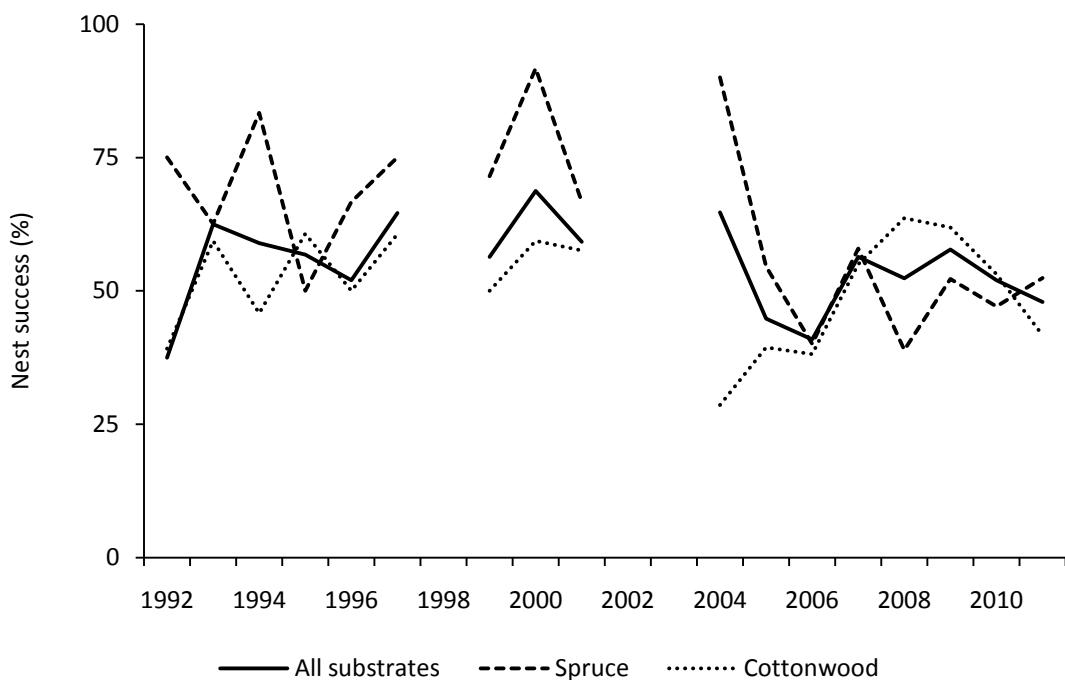


Figure 16. Percent success by substrate for active bald eagle nests in interior and coastal LACL from 1992-2011.

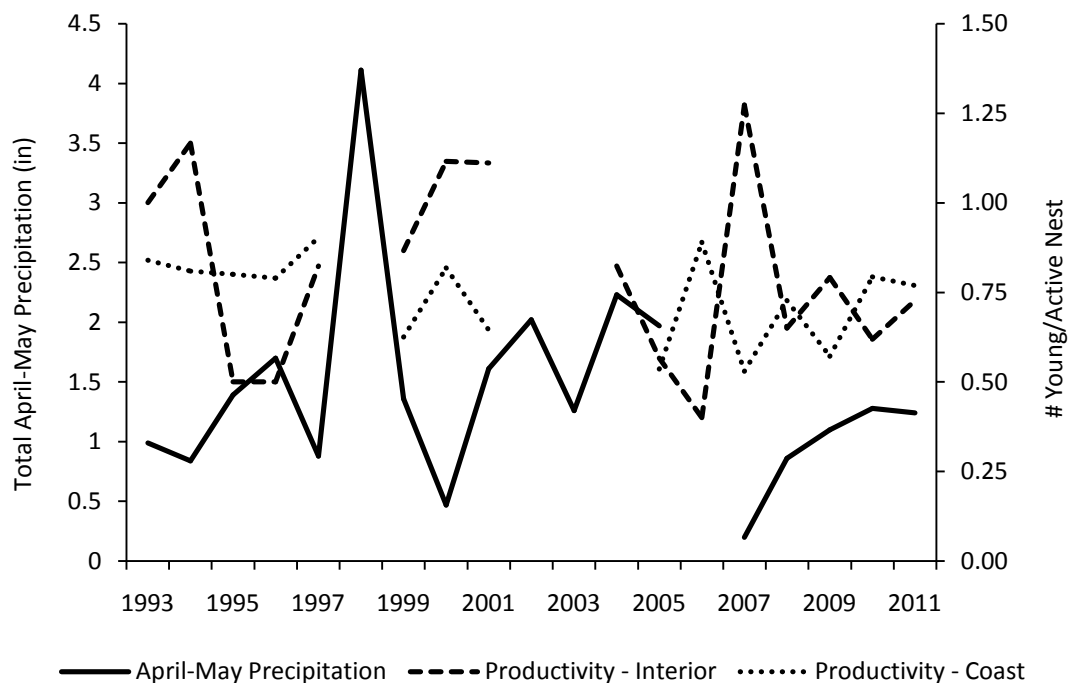


Figure 17. Trends in the mean number of young per active bald eagle nest in interior and coastal LACL, and total April-May precipitation levels from 1993-2011.

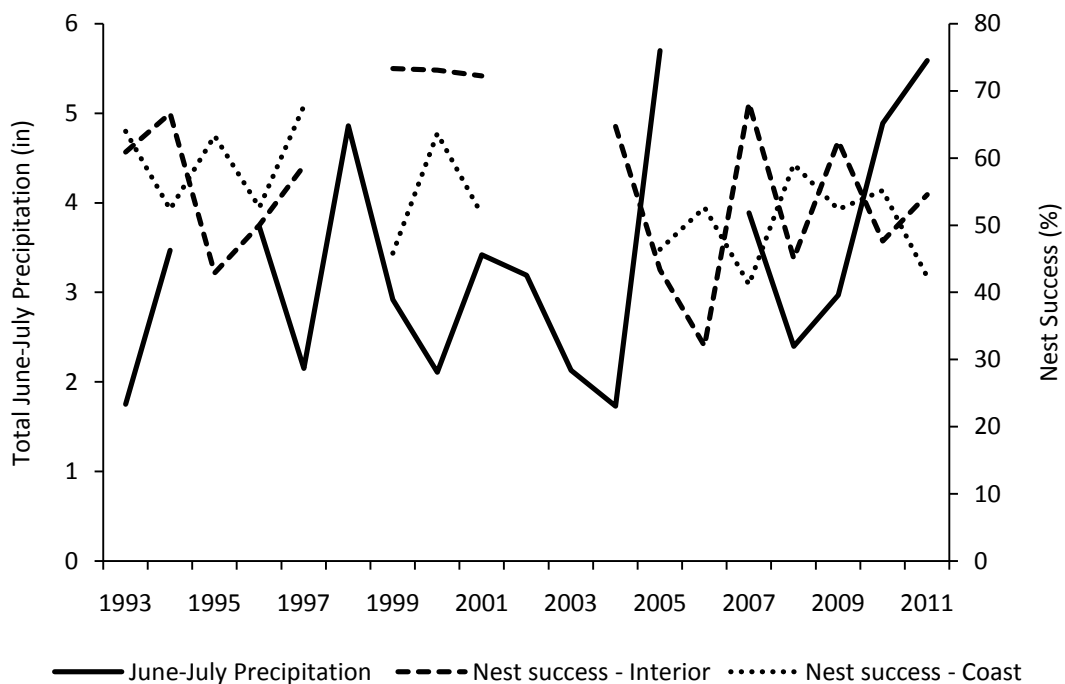


Figure 18. Trends in bald eagle nest success in interior and coastal LACL, and total June-July precipitation levels from 1993-2011.

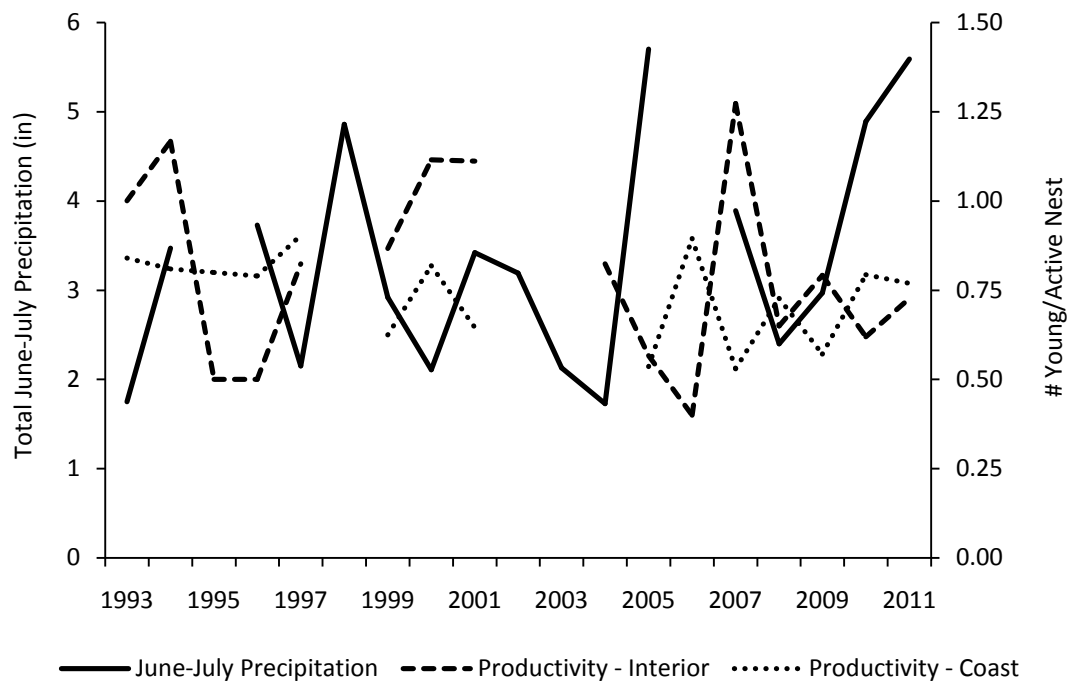


Figure 19. Trends in the mean number of young per active bald eagle nest in interior and coastal LACL, and total June-July precipitation levels from 1993-2011.

Discussion

Results of this study allowed us to meet our primary goal of building a long-term record of bald eagle population status and productivity data for LACL. Due to nearly continuous monitoring over the past 20 yrs, we have a robust data set at LACL that will allow us to explore factors affecting both year to year and long-term changes in eagle productivity. Work remains to be done, however, to standardize data collection and analysis protocols in order to maximize the usefulness of survey data for biologists and managers at LACL, and to contribute to regional and national monitoring objectives.

Productivity in 2011 was indicative of a stable bald eagle population in the interior areas of LACL. Along the coast, productivity numbers were marginal; nest success was lower and chick production per active nest higher than the minimum values necessary for stability (Sprunt et al. 1973). In both areas, productivity rates fell within the range observed in LACL in the past. Since 1992, productivity statistics are available for 17 yrs in interior LACL and 16 yrs on the coast. Nest success fell below the minimum needed for population stability in 6 and 5 yrs in interior and coastal areas, respectively. In three of these years both regions experienced low success, however in other cases coastal and interior productivity rates were dissimilar. For example, the highest recorded nest success (73.33%) in interior LACL corresponded to a year when coastal success fell below the 50% minimum. Average chick production per active nest fell below the value needed for population stability in 7 of 17 yrs in the interior, and 6 of 16 yrs in coastal LACL. In all cases, low chick production corresponded to years when nest success was near or below 50%.

Since 1992, we have observed substantial variability in annual nest success and productivity in LACL, with few trends being evident. We have limited understanding of factors influencing these fluctuations. Weather conditions are one natural factor that affects eagle productivity in other areas (Gende et al. 1997). Heavy spring rains can cause nest failure, and reproductive parameters of eagles nesting in KEFJ have been found to be negatively correlated with cumulative rainfall during April-May (Tetreau 1996). Heavy rains during June-July were hypothesized as detrimental to eagle productivity in KATM (Savage 1994). We found measures of productivity and nest success negatively correlated with both April-May and June-July precipitation in LACL. Historic weather data are available from few locations (Port Alsworth and Stoney weather stations) within LACL; however, additional automated weather stations were installed beginning in 2008. Weather data from these locations will be useful in future analyses of eagle productivity as they will allow us to explore the influence of localized weather conditions on nest success. Weather and climatic variables have also been implicated as factors in recent outbreaks of spruce bark beetle throughout the Alaska Peninsula, including areas of coastal LACL during the 1990s (Sherriff and Berg 2011). Although no substantial changes in nest substrate use by eagles have been noted to date, continued monitoring of linkages between bark beetle outbreaks and use of spruce nests by eagles in LACL is warranted. Understanding the influence of weather and climate on eagle productivity is particularly important in the context of global change occurring throughout the Arctic (IPCC 2007).

Availability of prey during egg laying and incubation is another important determinant of eagle productivity (Gende and Wilson 1997, Gende et al. 1997, Elliot et al. 1998, Anthony 2001).

Population numbers and escapement of salmon, as well as other anadromous fish, may be linked to bald eagle breeding success (Anthony 2001). Data on the diet of bald eagles within LACL, especially during the important nest initiation phase, is lacking. The timing of arrival of migratory waterfowl may be important if eagles use them as prey during this time. Availability of salmon carcasses may also be important. A rough idea of diet could be obtained in the future by visiting nests post-fledging and examining prey remains (Kozie 1993) or by conducting nest observations during the nestling phase to document prey being delivered by adults (Martin 1996).

In addition to weather and prey availability, competition with non-breeding eagles is a natural factor affecting productivity (Hansen 1987). Potential human-related factors affecting bald eagle breeding success include pollution/contaminants, habitat modification, and increased visitation/disturbance near nesting areas (Wiemeyer et al. 1993, Anthony et al. 1994, Gende et al. 1997). Efforts should be put forth to determine the causes of widely varying annual bald eagle nest occupancy and success in LACL as changes in productivity trends over time may indicate attention needs to be paid to broader natural or human-caused changes occurring within LACL ecosystems.

Bald eagles have been selected as a vital sign for long-term monitoring of ecosystem health within SWAN parks, including LACL. Data collection and analysis methodology, however, is not consistent between the three parks (KATM, KEFJ, and LACL) that have current bald eagle monitoring programs. In 2009, work began in KEFJ to field test a protocol for monitoring eagle productivity based on dual-frame sampling with a double-observer component to correct for biases in nest sightability (Haines and Pollock 1998, Thompson et al. 2009, USFWS 2009, Sauer et al. 2011). An initial survey of all potential nesting habitat was completed for areas of interest within KEFJ. Thereafter, randomly selected segments of coast and shoreline were selected to be surveyed on an annual or semi-annual basis. Nest occupancy and productivity within these segments will be used to extrapolate parkwide trends.

The current LACL protocol (Putera 1999a) recommends a combination of intensive and routine surveys to monitor eagle productivity. Intensive surveys involve flying all coastal and shoreline habitat to check the status of existing nests and locate new nests, while routine surveys only monitor the status of existing nests that were occupied within the previous 3 yrs. Although the protocol suggests intensive surveys be conducted annually on a rotational basis in three survey areas (Lake Clark drainage, northern interior, and coast), intensive surveys have not been conducted since 2005 (Mangipane and Putera 2005a). Since that time, routine surveys have been supplemented with ad hoc coverage to examine areas that previously had nests/territories to see if new nests were present (Mangipane 2008, 2009). The expanded search area resulted in an increase in new nests discovered with little change in search time (Mangipane 2008, 2009). This methodology, however, does not provide a systematic sample of eagle habitat throughout the park, is unlikely to capture expansion into additional habitat areas in the event of a population increase, and does not currently incorporate an estimate of nest sightability.

We recommend the adoption of survey methodology similar to that in KEFJ. Annual or semi-annual sampling of a random selection of eagle habitat within all three regions of LACL may prove more time and cost effective than intensive surveys. Additionally, this will yield a

representative sample of eagle habitat throughout the park and provide a broader metric than a nest census or ad hoc sample conducted in a limited area. In order to maintain continuity with the valuable long-term data on known eagle nests within LACL, known nests both within and outside of random survey segments could continue to be monitored through routine surveys as in the past. These known nests represent the “list frame” in a dual-frame sampling context, while random survey segments within potential habitat make up the “area frame” (Haines and Pollock 1998, USFWS 2009, Thompson and Phillips 2011). The dual-frame approach combines data from the two frames to estimate the total number of occupied nests in an area of interest, and has been shown to detect a larger number of occupied nests with greater precision than monitoring list or area frames on their own (USFWS 2009). The double-observer component allows for estimation of the total number of occupied nests in an area by calculating detection probabilities for each observer to account for nests missed during the survey (Thompson 2004, USFWS 2009). This can easily be implemented in LACL, with the pilot and passenger each acting as an observer during occupancy survey flights. While surveying the area frame, each observer simply waits until a detected nest is out of view of the other observer before announcing that a nest has been seen. Nest detections are assumed to be independent between observers.

Adoption of similar terminology to define nest occupancy and productivity, as well as collection of a standardized set of nest attribute data, will further facilitate comparison of LACL productivity trends with those of other eagle populations within SWAN. Attributes and terminology are currently very similar between KATM, KEFJ, and LACL, and can easily be standardized with only minor modifications. Additional attribute data (Appendix B) to be collected in future LACL surveys includes number and behavior of adult eagles detected at/near nests during occupancy surveys, along with information on the status and form of nest trees. Classification of nests during the occupancy survey can be simplified to three categories: empty, incubating, and not applicable (Thompson and Phillips 2011, Witter and Anderson 2011). “Incubating” includes nests with an adult eagle present in an incubating posture, eggs present, or chicks present. “Empty” includes nests where no adults/eggs/chicks are present, as well as nests where adults are present, but there is no sign that reproduction has occurred. Changed terminology is an attempt to clarify and standardize nest status descriptions. The terms “occupied” and “active” were used in the past, but were inconsistently defined and applied.

Users at KATM, KEFJ, and LACL are also collaborating to determine key features for a computerized data collection application. KEFJ used an ArcPad application in the past, but found problems with computer speed. This has not been a problem at KATM or LACL, but the application was simplified compared to the KEFJ version. Simplicity, speed, and ease of use are critical for an application used in the challenging data collection environment of aerial surveys. Discussion is ongoing over the development of an ArcPad or similar ArcMobile application that could be used in all SWAN units, facilitating data/database management, analysis, and comparison between parks. We anticipate implementation of a standardized application in 2012 nest surveys.

By standardizing survey methods, measures of bald eagle productivity at LACL can be compared with eagle data from other SWAN parks as well as other geographic regions. This will help us gain insight into factors affecting bald eagle populations and driving trends over time. Bald eagles play an important ecological role as apex predators of seabirds and fish in LACL. Their

reproductive success thus serves as a critical indicator of the broader health of both freshwater and marine ecosystems.

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Appendix A: Available documentation for bald eagle surveys 1984-2011, LACL.

Summary of bald eagle surveys conducted from 1984-2011 in LACL.

Year	Dates	Type	Area	Documentation*
1984	Unknown	Occupancy	Coast & interior	Marked up paper map.
1987	Jun 15, 18	Occupancy	Coast & interior	Paper data sheets & map.
1988	Jun 15, 17, 20, 21	Occupancy	Coast & interior	Paper data sheets & map.
1989	Jun 12-14	Occupancy	Coast & interior	Paper data sheets & map.
1990	May 31-Jun 5 Jul 19	Occupancy Productivity	Coast & interior	Memos & map.
1991	May 24-Jun 6	Occupancy	Coast & interior	Paper data sheets & map; Access database.
1992	Unknown	Occupancy Productivity	Coast & interior	Access database.
1993	May 17-Jun 7 Jul 14-Aug 20	Occupancy Productivity	Coast & interior	Bennett 1993; Access database.
1994	May 19-26 Jul 25-27	Occupancy Productivity	Coast & interior	Bennett 1994; Access database.

1995	Jun 1-2 Jul 25-27	Occupancy Productivity	Coast & interior	Bennett 1995; Access database.
1996	May 10 (coast); Jun 12 (interior) Aug 7 (coast); Jul 26 (interior)	Occupancy Productivity	Coast & interior	Bennett 1996; Access database.
1997	May 22-23 Aug 2, 5	Occupancy Productivity	Coast & interior	Terenzi 1997; Access database.
1999	May 4-7, 11 Jul 27-28	Occupancy Productivity	Coast & interior	Putera 1999b; Access database.
2000	May 1 (coast); May 2 (interior) Aug 3, 6	Occupancy Productivity	Coast & interior	Putera 2000; Access database.
2001	May 8 (coast); May 7, 14 (interior) Aug 1 (coast); Aug 2, 4 (interior)	Occupancy Productivity	Coast & interior	Kasemodel & Putera 2001; Access database.
2003	May 16 (coast), May 15 (interior)	Occupancy	Coast & interior	Access database.
2004	May 3 (coast); May 4-5 (interior) Jul 29 (interior); no coastal productivity survey.	Occupancy Productivity	Coast & interior	Mangipane & Putera 2005b; Access database.
2005	May 3 (coast); May 4-5 (interior) Aug 6 (coast); Aug 8-9 (interior)	Occupancy Productivity	Coast & interior	Mangipane & Putera 2005a; Access database.
2006	May 10 Jul 27 (coast); Jul 28 (interior)	Occupancy Productivity	Coast & interior	Mangipane & Putera 2006; Access database.
2007	May 3 Aug 7 (coast); Aug 7-8 (interior)	Occupancy Productivity	Coast & interior	Mangipane & Putera 2007; Access database.
2008	May 22 (coast); May 27 (interior) Aug 7 (coast); Aug 10 (interior)	Occupancy Productivity	Coast & interior	Mangipane 2008.

2009	May 16 (coast); May 24 (interior) Aug 7 (coast); Aug 10 (interior)	Occupancy Productivity	Coast & interior	Mangipane 2009.
2010	May 14 (coast); May 15 (interior) Aug 2 (coast); Jul 27 (interior)	Occupancy Productivity	Coast & interior	Excel database.
2011	May 19, 24 Aug 7 (coast); Aug 6, 8 (interior)	Occupancy Productivity	Coast & interior	Witter & Mangipane 2011.

* Paper maps, data sheets, memos, and Access and Excel databases are available at Port Alsworth field headquarters, LACL.

Appendix B: Modified attribute data to be collected during future bald eagle occupancy & productivity surveys in LACL.

Attribute	Codes	Description
Nest ID	N/A	A unique number assigned to each nest as it is detected. During post-processing nests are given unique ID codes based on the numeric code of the 1:63,360 USGS quadrangle in which they are located.
Observer (front)	0 (not detected), 1 (detected)	Whether or not nest is detected by front-seat observer/pilot during occupancy survey.
Observer (rear)	0 (not detected), 1 (detected)	Whether or not nest is detected by rear-seat observer during occupancy survey.
Number of adults (occupancy)	0, 1, 2, N/A	Number of adult eagles seen at or in close vicinity of the nest during occupancy survey. Eagles may be present, but nest classed as "empty" if eagles are not in an incubating posture and eggs/chicks are not present.
Behavior (occupancy)	N (nesting), F (flying), P (perching), NF (nesting and flying), NP (nesting and perching), FP (flying and perching), N/A (not applicable)	Behavior of adult eagles observed at/in vicinity of a nest during occupancy survey. Two letter codes apply when two adult eagles are present.
Nest occupancy	E (empty), I (incubating), N/A (not applicable)	Status of detected nest. "Incubating" includes nests with an adult eagle present in an incubating posture, eggs present, or chicks present. "Empty" includes nests where no adults/eggs/chicks are present, as well as nests where adults are present, but there is no sign that reproduction has occurred.
Nest substrate	S (spruce), C (cottonwood), G (ground), N/A (not applicable)	Tree species or substrate where the nest is located. "Ground" includes cliffs, hilltops, sea stacks (in coastal areas), and any other forms of ground nests.
Tree status	L (live), D (dead), LD (live with large dead branches), N/A (not applicable)	Status of tree where nest is located. "N/A" if nest is located on the ground.
Tree form	NT (normal complete top), AT (abnormal complete top), BL (broken live top), BD (broken dead top), N/A (not applicable)	Further detail on form of tree where nest is located. "N/A" if nest is on the ground.
Nest productivity status	S (success), F (fail), ND (not determined), NF (not found), NC (not checked)	Status on revisitation of incubating nests found during the initial survey. "Success" includes nests with chicks present. "Fail" includes empty nests, as well as nests where adults are present without chicks. "Not determined"

		includes nests where foliage, shadows, or other obstructions to visibility prohibit the determination of nest status.
Number of young (productivity)	0, 1, 2, 3, N/A	Number of chicks seen at the nest.
Chick stage	1a (small 1 st down), 1b (large 1 st down), 2 (2 nd down), 3a (early contour), 3b (late contour), 3c (contour with down), 3d (complete contour), ND (not determined), N/A.	Stage of chick development based on Carpenter (1990).
Number of adults (productivity)	0, 1, 2, N/A	Number of adult eagles seen at or in close vicinity of the nest during productivity survey.
