AN ABSTRACT OF THE THESIS OF

Deborah Lyn Holte for the degree of Master of Science in Wildlife Science presented on March 31, 1988. Title: Nest Site Characteristics of the Western Pond Turtle, *Clemmys marmorata*, at Fern Ridge Reservoir, in West Central Oregon.

Abstract approved: ______________________
Bruce Coblentz

A census of Western Pond Turtle nest sites was conducted in five nesting areas at Fern Ridge Reservoir, in West Central Oregon. Baseline data about soils, vegetation, landform structure, and hydrological environment were collected through measurement of slope, aspect, straight-line distance from water, soil compaction, overstory cover, percent vegetative ground cover, vegetation height, and period of inundation between June, 1995 and August, 1997. Nest chamber temperature was recorded at 10 nest sites during 1996. Measurements of slope, aspect, and straight-line distance from water of Fern Ridge nest sites had been collected during 1993 and 1994, and were combined with data from this study. Climatological data were collected during all 5 years. Anecdotal information was collected on nest success, clutch size, hatchling emergence dates and post-emergence movements, nesting frequency, and nest site philopatry.

Nest sites were typified by low slopes, southern aspects, and wide ranges of straight-line distance from water. Nest area soils were very compact and dry during the nesting season and period of incubation, but were often saturated or inundated between November and April, when hatchlings overwinter in the nest. Vegetation was relatively dense; dominated by various low forbs and grasses. None of the nest sites had overstory cover.

Successful nest sites tended to have more vegetative ground cover, and were exposed to less precipitation and more growing degree days during the period of incubation than unsuccessful nest sites. Successful nest sites were also inundated for shorter periods of time during the winter.

Nest Site Characteristics of the Western Pond Turtle, *Clemmys marmorata,* at Fern Ridge Reservoir, in West Central Oregon.

By

Deborah Lyn Holte

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APPROVED:

Major Professor, representing Wildlife Science

Chair of Department of Fisheries and Wildlife

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Deborah Lyn Holte, Author

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Nest Site Characteristics of the Western Pond Turtle, *Clemmys marmorata,* at Fern Ridge Reservoir, in West Central Oregon.

INTRODUCTION

The western pond turtle (*Clemmys marmorata)* is one of two species of freshwater turtle native to the West Coast, and is the only native turtle south of the Willamette River drainage in Oregon. The western pond turtle (WPT) is nominally covered by state law throughout its range, currently listed as Sensitive-Critical in Oregon (Holland and Bury In Press).

WPTs have a disjunct distribution from Puget Sound, Washington, through Northern Baja, California-Norte (Holland 1991a, 1994; Iverson 1986, cited in Holland and Bury In Press; Bury 1970; Stebbins 1954); however, few populations remain in the periphery of this range (Buskirk 1990).

The Willamette Valley supports two of the remaining populations of WPTs thought to have relatively normal size and age distributions (Holland 1994), yet is one of the most heavily altered ecosystems on the West Coast. Prior to settlement by Euro-americans, the Southern Willamette Valley was comprised of a network of braided waterways and seasonally flooded grasslands interspersed with savanna, woodlands dominated by Oregon White Oak (*Quercus garryana*), and mixed riparian gallery forests. Only remnants of these native ecosystems exist today. The conversion of this once dynamic and complex system through agricultural, urban, and industrial development has caused severe fragmentation and homogenization of the terrestrial and aquatic habitats to which the WPT is obligately tied (Holland 1994). The alteration of historical patterns of river flow, and the severance of the linkages between aquatic and upland ecosystems by perturbations such as damming, channelization, stream incision, and conversion of upland areas to agriculture, may have resulted in the dissolution of, and hence the restriction of gene flow between remaining populations of WPTs.

The current population size of WPTs in the Willamette River drainage has been estimated to be only two to four percent of the number of turtles present in this area 150 years ago (Holland 1994). The decline in turtle populations has been synchronous with the growth of the human population, and the concurrent increase in activity, development, and recreational use in and around WPT habitats (Holland 1994, Garber and Burger 1995).

In addition to the overall declines observed in WPT populations, most remaining populations range-wide are thought to be adult biased, with negligible recruitment (Holland 1992). This apparent failure in recruitment may be due to an array of complex and interrelated factors, including loss of nesting areas (Brattstrom 1988), decreased genetic variation between populations (Gray 1995, Sausman 1984), and excessive predation of hatchlings, primarily due to the introduction of exotic species such as bull frogs (*Rana catesbeiana)* and large mouth bass (*Micropterus salmoides)* (Holland 1994).

Characterized by slow growth (Holland and Bury In Press) and a potential life span of 40 to 50+ years (Holland 1994), WPTs are considered an indicator species for the health of the waterways and wetland ecosystems they inhabit, as well as the Willamette Valley as a whole. The current status of WPTs, as well as the potential loss of this species, reflects the continuing degradation and alteration of the native ecosystems of the Willamette Valley.

Research on WPTs has, to a limited extent, documented natural history (Storer 1930, Holland 1991a, Bury 1970, Holland and Bury In Press), home range, short and long term movements, thermal ecology (Bury 1972a, Avery 1982, Holland 1985a), sexual dimorphism, geographic variation (Seeliger 1945, Holland 1992, Holland and Bury In Press), feeding ecology (Bury 1986a), aggression (Bury and Wolfheim 1973), and habitat destruction (Brattstrom 1988). Relatively few studies have focused on reproduction and nesting ecology (Buskirk 1990, Holland 1991a, and Holland and Bury In Press), and there has been no systematic research on the relationship between the physical environment and the survivorship of these turtles. While a comprehensive understanding of the ecology of this species is imperative, certain aspects of research may presently be more critical for short term management practices than others. Research priorities include reproduction, nesting behavior and success, and nest site habitat requirements (Holland and Bury In Press). Identification of nest site characteristics selected by WPTs will play an instrumental role in identifying both active and potential nesting areas, and in making informed management decisions regarding the protection and restoration of these areas.

Although the reproductive ecology of the WPT is poorly understood, considerably more information exists on this topic than just a few years ago (Rathbun et al. 1992). As with many freshwater turtles, WPTs appear to select nesting habitat based primarily on local vegetative cover and landform structure (Ortleb and Sexton 1964, cited in Heatwole 1981; Sexton 1958; Holland 1994). The limited number of known WPT nesting areas have all been typified by having relatively low slopes, ranging from 0 to 60 degrees; the majority found on slopes < 25 degrees. Most nest sites have been located in areas of sparse vegetative cover, usually short grasses and forbs (Holland 1994), and have had either southern, south-eastern, or south-western aspects (pers observ). WPT nest sites have been predominately excavated in dry, compact soils, with a high silt or clay fraction (Holland 1994).

Nest site selection may be especially critical to WPTs because they exhibit pattern 1a temperature-dependent sex determination (TSD), which occurs only in turtles (Ewert and Nelson 1991, Ewert et al 1994), and is characterized by producing males at low temperatures and females at high temperatures (Bull 1980, 1983; and Bull and Charnov 1988). Although ambient temperatures around nests vary during the 90 to 130 days of development from oviposition to hatching, the slope, aspect, and vegetative cover at the site remain relatively stable (Bull and Vogt 1979, Janzen 1994). These nest site characteristics may therefore significantly alter the sexual bias of each clutch, as well as hatching success, by influencing incubation temperatures. Pivotal incubation temperatures for WPTs, those which yield 1:1 sex ratios (Wibbels et al 1991), tend to display a geographical trend, increasing with both latitude and longitude. In Oregon, the pivotal temperature for WPTs has been determined to be 30 degrees Celsius (Ewert et al 1994).

Several questions remain regarding TSD in this species. Temperature shift studies, which ascertain the critical period of gonadal sex determination during incubation have not involved WPTs (Janzen and Paukstis 1991). Most studies of turtle nest sites have shown that thermal conditions within the nest chamber vary on both a daily and seasonal basis (Janzen and Paukstis 1991). It is important to have an understanding of the natural conditions of nest sites, which are undoubtedly influenced by random and diel fluctuations in ambient temperature, general seasonal trends in ambient temperature (Ewert et al. 1994), and prevailing amounts of shading by vegetation (Janzen 1994).

Similarly, moisture conditions within the nest during incubation may significantly alter sex ratios (Janzen and Paukstis 1991), yet have rarely been monitored or controlled in incubation studies (Wibbels et al. 1991, Janzen 1994, pers observ). Hatchling snapping turtles (*Chelydra serpentina)*, for example, incubated artificially under moist, cool conditions were uncoordinated, lacked buoyancy control, and had lower hatching success and post-hatching survival and growth than turtles incubated under warmer, drier conditions (Bobyn and Brooks 1994). Western Pond Turtle eggs which were exposed to significant amounts of water during the period of incubation, both in the field and in laboratory studies, either failed to develop, or had lower overall rates of hatching success (Holland 1991b, Feldman 1982). The critical period of sexual differentiation and the normal hydric environment of natural WPT nests remain unknown, yet appear to have a direct impact on the success and sexual composition of each clutch. Nest site selection criteria may directly affect hatching success, post-hatching survival and growth, and the sex ratio of future WPT populations by influencing the physical conditions of the nest chamber.

Additional nest site characteristics, such as soil type, may also be of critical importance in determining hatching success. In hard-shelled turtle eggs, the calcareous matrix surface and the dense boundary layer of the shell work together to prevent water loss, while an interior "aerating layer" facilitates gas exchange (involving water, carbon dioxide, and oxygen). Water diffuses more quickly through the shell layers than either carbon dioxide or oxygen (Congdon and Gibbons 1985). Eggs laid in poorly drained or highly compact soils which may become inundated during periods of high or frequent rainfall, may break from internal water pressure, or cause developing embryos or hatchlings to suffocate (Feldman 1982). Soil compaction and drainage may therefore influence clutch mortality.

Previous studies have indicated that female WPTs may demonstrate nest site fidelity from year to year (Ehrenfeld 1979, pers observ), further emphasizing the importance of terrestrial nesting habitat identification, protection, or restoration. Comparisons of nest site maps at Fern Ridge Reservoir in the Willamette Valley between 1992 and 1995 reveal roughly the same number of females nesting each year, and nest sites in approximately the same location within each nesting area. During 1995, one permanently marked female at Fern Ridge Reservoir nested within 0.5 meters of her 1993 nest site (pers observ).

While size, and presumably age of WPTs at first reproduction vary geographically (Holland and Bury In Press) and possibly altitudinally (Holland 1994), secondary sexual characteristics and the development of the gonads are apparent throughout the range by 110 mm Carapace Length (CL). The onset of egg development in most females appears to occur between 8 and 10 years of age, or approximately 120 mm CL (Holland and Bury In Press).

The reproductive output of WPTs requires further study. Nesting frequency appears to vary with age of the female, geographic location, and environmental conditions, such as seasonal temperature and resource availability. Data collected range-wide between 1987 and 1994 indicate that most females oviposit in alternate years (Holland 1991a). In some areas, such as Southern and Central California, however, WPTs may lay every year, and some may even lay two clutches in one year (G. Rathbun pers comm, cited in Holland and Bury In Press). Several female WPTs at Fern Ridge Reservoir have been gravid during two successional years (pers observ).

The clutch size of WPTs is positively correlated with the carapace length of the female, and generally ranges from 1 to 13 eggs. Average clutch size in the Willamette Valley is approximately 7 eggs (Holland 1994).

Oviposition generally occurs during June and July, although nesting forays have been observed as early as April in parts of Southern and Central California (Rathbun et al.

1993). Female WPTs typically leave the water in late afternoon, choose a nesting site in an adjacent upland habitat, and return to water around midnight. It is not uncommon for females to leave water, search for a nesting site, and return to water one or more times before actually choosing a nest site. On these test forays, the female may or may not dig test scrapes or holes. Once a nesting site has been chosen, the female empties her bladder contents onto the soil, and then excavates a light-bulb shaped nest chamber with her hind legs (pers observ). Nest chambers generally range in depth from 90 to 125 mm as measured from the surface of the ground to the bottom of the nest chamber (Holland 1994). After depositing the eggs, the female then scrapes mud and vegetation from the ground immediately surrounding the hole to form a nest plug.

Hatching rates of WPTs average approximately 70 percent. Complete failure of nest sites; however, is not uncommon (Holland 1994). The period of incubation for WPT eggs ranges from 80 to 106 days (Bull and Vogt 1979, Janzen 1994, Holland 1994).

Further research is also required on the timing of hatchling emergence, hatchling behavior and post-emergence movements, and identification of suitable hatchling habitat. Selection for delayed emergence is known to be greater for species in less predictable environments (Hartweg 1944, 1946; Gibbons and Nelson 1978), and a lower incidence of hatchling overwintering occurs in riverine systems than in lacustrine systems (Jackson 1994). Overwintering of hatchlings in the nest has been reported for species in at least six Chelonian Families (Gibbons and Nelson 1978), and all known instances in Northern California and Oregon indicate that hatchlings remain in the nest over the winter and emerge the following spring (Holland 1994, pers observ). A limited amount of data on hatchling emergence was recorded at Fern Ridge Reservoir, Oregon in 1995. Hatchlings were observed emerging from 3 1994 nest sites on 02 and 03 March, 1995.

Relatively few studies (Burger 1976, Gibbons and Nelson 1978, Noble and Breslau 1938, Butler and Graham 1993, Jackson 1994) have documented the behavior of freshwater hatchlings from the initiation of hatching through nest emergence and their subsequent movements into wetland habitats. None have involved WPTs. Factors known to affect hatchling emergence behavior of other freshwater species may also influence WPTs. These mechanisms include geotaxis (Noble and Breslau 1938; Parker

1922, cited in Burger 1976), the brightness pattern of the sky over water (Mrosovsky and Boycott 1966, cited in Burger 1976), orientation by visual and/or audible landmarks, following natural or man-made pathways (Carroll and Ehrenfeld 1978), and the openness of the horizon (Parker 1922 and Anderson 1958 cited in Burger 1976). Although olfactory orientation is thought to play a dominant role in the homing abilities of adult aquatic turtles (Baldaccini et al 1974 and Papi et al 1974 cited in Carroll and Ehrenfeld 1978), as does celestial navigation (Carroll and Ehrenfeld 1978), these mechanisms presumably do not influence hatchling post-emergence movements. Innate recognition of their environment upon emergence is possible, however, hatchlings are most likely unfamiliar with smells encountered in their new environment, and are too close to their wetland destination to rely on celestial activity (Noble and Breslau 1938).

Post-emergence terrestrial movements of WPT hatchlings are essentially unknown. While observation of these movement patterns, descriptions of habitat use, and documentation of survivorship would help determine the effectiveness of future management tools, telemetry practices required to obtain this information have not been conducted on turtles smaller than 52 mm CL (Brewster and Brewster 1991). Tracking methods such as fluorescent pigment and radio isotope tracking have had complications. Fluorescent pigment has been used to track *C. blandingi* in Massachusetts, but the trails were very hard to follow (Butler and Graham 1993). Similar use of fluorescent pigment, however, has been used successfully in tracking various small mammals (Duplantier et al. 1984), salamanders (Butler and Graham 1993), lizards and young tortoises (Fellers and Drost 1989). Fluorescent pigments have low toxicity and have shown no evidence of increased predation of hatchlings due to their enhanced conspicuousness (Butler and Graham 1993). Radio isotope tracking is very expensive and requires special training.

Although undocumented, hatchling WPTs are widely thought to travel directly to an aquatic habitat after emergence from the nest. The increase in hatchling activity levels after emergence presumably increases nutrient intake requirements. Although WPTs are capable of capturing food terrestrially, they have only been observed swallowing food while submerged (Bury 1986a). Hatchlings may need to reach an aquatic habitat to feed. Feeding competition appears to be low between adults and hatchlings, and is unlikely to inhibit hatchlings from moving directly into adult aquatic habitat. Alternatively, hatchlings likely maximize foraging success and reduce the probability of encountering large fish or other predators by limiting their activities to water near shore (Congdon et al 1992). Hatchlings are predominantly carnivorous, most likely due to their higher metabolic demands for energy and growth (Bury 1986a), while adults show a stronger tendency toward herbivory, and feed on larger prey (Clark and Gibbons 1969, cited in Bury 1986a). Aggression over basking sites, has been extensively documented between age and sex classes of WPTs (Bury and Wolfheim 1973), and may influence hatchling dispersal. Nevertheless, hatchlings of other freshwater species have been observed basking with adults on the same basking substrate. The observance of adult and hatchling painted turtles (*Chrysemys picta)* basking together, for example, is a common occurrence (Martins 1993).

OBJECTIVES

This project was initiated to establish a quantitative description of various characteristics of nest sites chosen by WPT within five known nesting habitats at Fern Ridge Reservoir, Oregon. Baseline data on vegetation, soils, and the hydrological environment of these nest sites were recorded and analyzed to provide guidelines for identification of nesting areas, as well as a foundation for subsequent research by suggesting relationships between habitat attribute selection and nest site success.

Measurements of slope, aspect, straight-line distance from water, soil compaction, percent vegetative ground cover, percent overstory cover, vegetation height, and period of inundation were collected and compared among successful and unsuccessful nest sites, nesting areas, among nest sites from different years, and among attempted, depredated, and intact nest sites. These same measurements were further compared among actual nest sites, and randomly chosen non-nest sites from both active and inactive quadrats of potential nesting habitat within each of the five nesting areas during 1996 and 1997. Anecdotal information was collected on nest success, clutch size, nest chamber temperature, climatological data, hatchling emergence and post-emergence movements, nesting frequency , and nest site philopatry.

NULL HYPOTHESES

Based on existing literature and observations made in 1993 and 1994, the following null hypotheses were made regarding WPT nest site selection at Fern Ridge Reservoir, Oregon.

1. There are no differences in nest site characteristics among successful and unsuccessful nest sites located between 1994 and 1997.

2. There are no differences in nest site characteristics among different nesting areas between 1994 and 1997.

3. There are no differences in nest site characteristics among different years; 1994 through 1997.

4. There are no differences in nest site characteristics among intact, attempted, and depredated nest sites between 1994 and 1997.

5. There are no differences in nest site characteristics among actual nest sites, and randomly chosen non-nest sites within active quadrats of potential nesting habitat in each nesting area during 1996 and 1997.

6. There are no differences in nest site characteristics among actual nest sites, and randomly chosen non-nest sites within inactive quadrats of potential nesting habitat in each nesting area during 1996 and 1997.

STUDY AREA

Fern Ridge Reservoir is a wide, shallow, multi-purpose impoundment located in West Central Oregon, approximately 10 km west of the Eugene/Springfield metropolitan area. The lake was formed by an earthfill dam at the confluence of the Long Tom River (a tributary to the Willamette River), and Coyote Creek (a tributary to the Long Tom River). Fern Ridge dam crosses the Long Tom River 38.1 km above its confluence with the Willamette River in Lane County, Oregon. The reservoir covers 4,087 surface hectares and is 7.6 meters at deepest point when full. The major tributaries of the reservoir, Coyote Creek and the Long Tom River, drain over 777 square km of the Eastern Coast Range.

The reservoir was constructed primarily for flood control, and secondarily for irrigation and provision of downstream flows. Annual drawdowns of the reservoir in the fall provide flood control storage. The reservoir is lowered to 107.6 meters above mean sea level starting in mid-October, and outflows are reduced each year after 01 February to fill the lake to approximately 113.8 meters above mean sea level by 15 April.

Emergent vegetation, dominated by bulrush (*Scirpus acutus*), reed canary grass (*Phalaris arundinacaea*), and cattail (*Typha latifolia*), is abundant around islands and along the entirety of the shoreline.

The temperate maritime climate of the Willamette Valley results in wet, mild winters, and warm, dry summers. An average annual rainfall of 141 centimeters is recorded at the headwaters of the Long Tom Basin. Due to mild temperatures and an extensive frost-free period, a lengthened growing season often lasts nearly 200 days per year in the valley.

As a result of a preliminary study at Fern Ridge in 1992, five WPT nesting areas; South Applegate, Tripass, North Applegate, South Marsh, and Kirk (Figure 1) were identified by finding predator excavated WPT nest sites in upland habitats . Each of the nesting areas range in elevation between 116 and 119 meters above mean sea level.

The first nesting area, Kirk Pond (K), is a large borrow pit created during construction of the dam (Figure 2). It is located at T17S R5W sec 3, at the north end of the reservoir.

Figure 1. Fern Ridge Reservoir

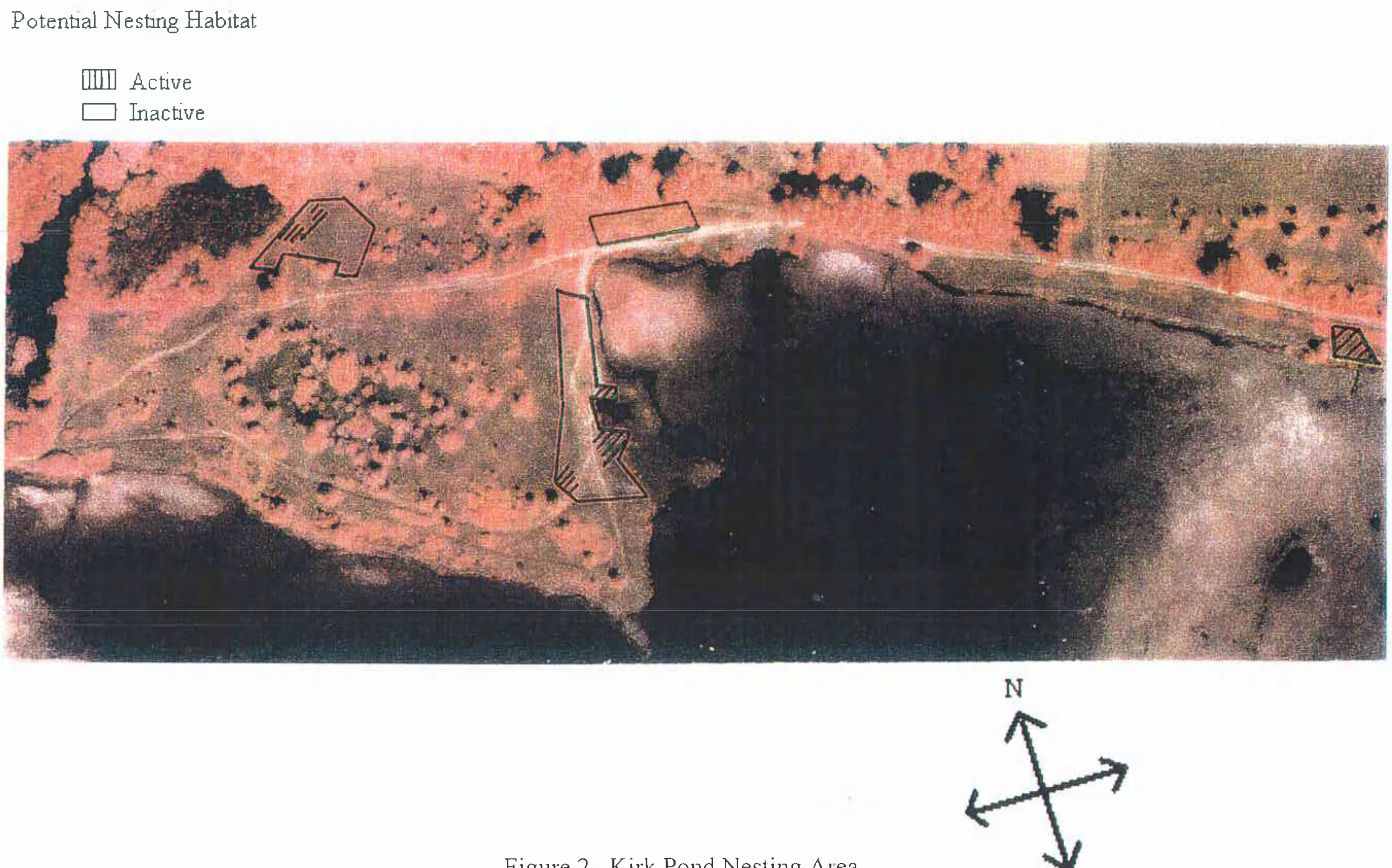


Figure 2. Kirk Pond Nesting Area

The pond is immediately downstream from the dam, and to the east of the spillway gates. This shallow, warm pond, is approximately 22.7 ha in size, and has been estimated to support approximately 40 WPTs (Leatham 1993). It receives a constant flow of water from the dam and spills into Coyote Creek, its only outlet. The water level does not fluctuate during the year. Kirk Pond is heavily infested with exotic water milfoil (*Myriophyllum spicatum*) and supports a large population of bullfrogs (*Rana catesbeiana).* The adjacent nesting area is a small, upland, grassy meadow with scattered woodland shrubs. Dominant vegetation includes rushes (*Juncus spp.)*, sedges (*Carex spp.)*, various grasses, forbs, wild rose (*Rosa pisocarpa)*, hawthorn (*Crataegus spp.)*, and Oregon Ash (*Fraxinus latifolia).* Natroy silty clay, a deep, poorly drained soil predominates throughout the nesting area. The permeability of this soil is very low, and runoff is very slow. A high water table exists from 0.3 meters above the ground surface to 0.3 meters below between November and May (SCS 1987).

North (NA) and South (SA) Applegate are relatively small prairies, together covering approximately 8 ha (Figures 3 and 4). These remnant native wetland prairies, dominated by tufted hairgrass (*Deschampsia caespitosa*), camas (C*amassia quamash*), and various short grasses and forbs, are currently under encroachment by wild rose, Oregon Ash, hawthorn, Ponderosa Pine *(Pinus ponderosa),* and blackberries (*Rubus spp.*). Both nesting areas are mapped as being dominated by Dayton silt loam, clay substratum, and thus have relatively poorly drained soil. This soil has very slow permeability and a high water table exists from 0.3 meters above the ground surface to 0.5 meters below between November and May. The soil has high shrink-swell potential (SCS 1987). Both areas were historically used for agricultural purposes, and irrigation furrows are still evident. These prairies are located at T17S R5W sec 19, on the southwest shoreline of the reservoir, just west of the mouth of the Old Long Tom Channel within the reservoir. The Old Long Tom Channel is a slow, warm, meandering river which is backed up by the reservoir in the summer (Figure 5). Numerous adjacent ponds are isolated from the river by thick stands of reed canary grass, which are usually inundated by 2 to 100 centimeters of water depending on the pool level of the reservoir. The ponds range from 10 to 20 meters wide, and from 30 to over 300 meters long. Most range in depth from 1 to 3

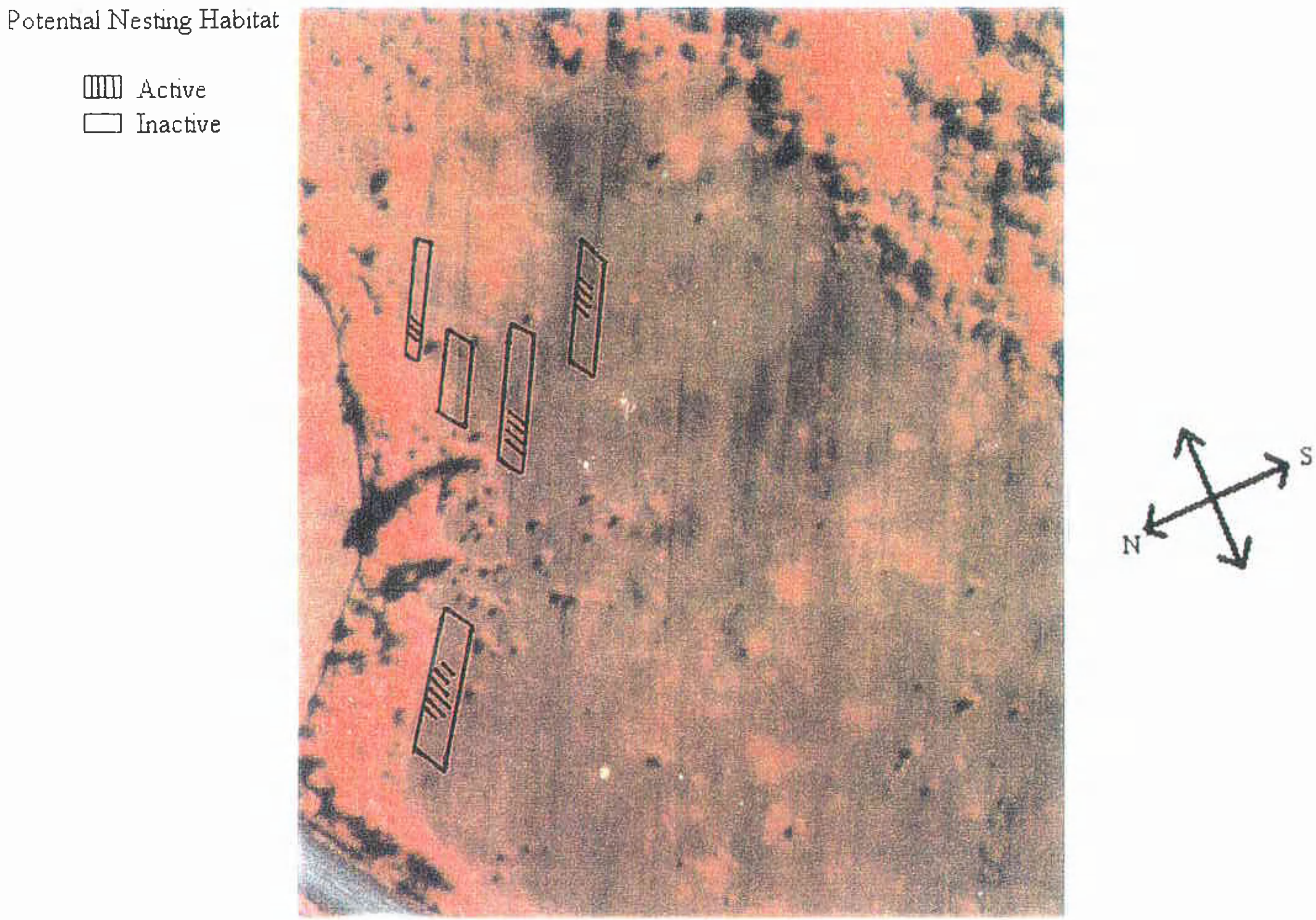


Figure 3. North Applegate Nesting Area

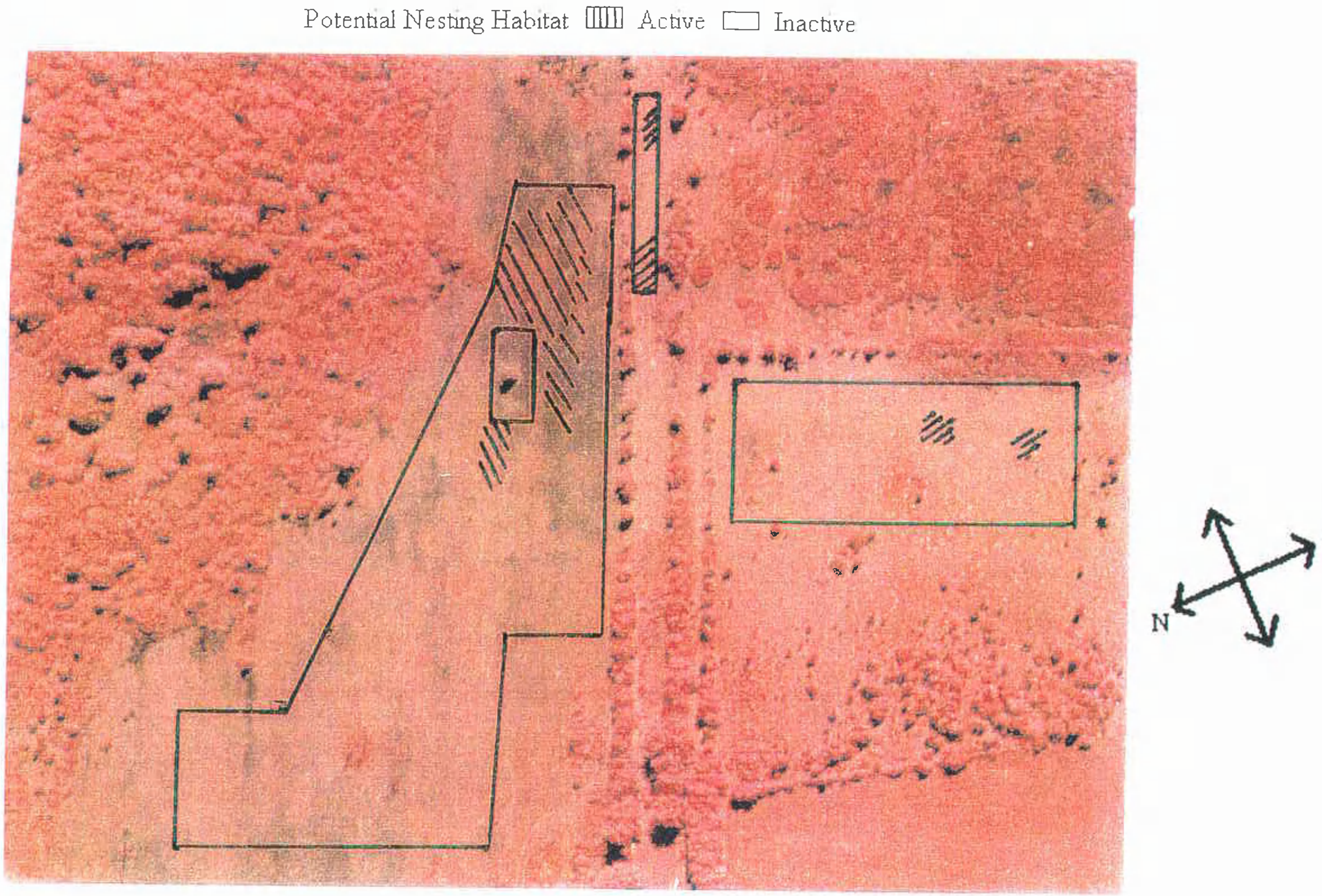


Figure 4. South Applegate Nesting Area

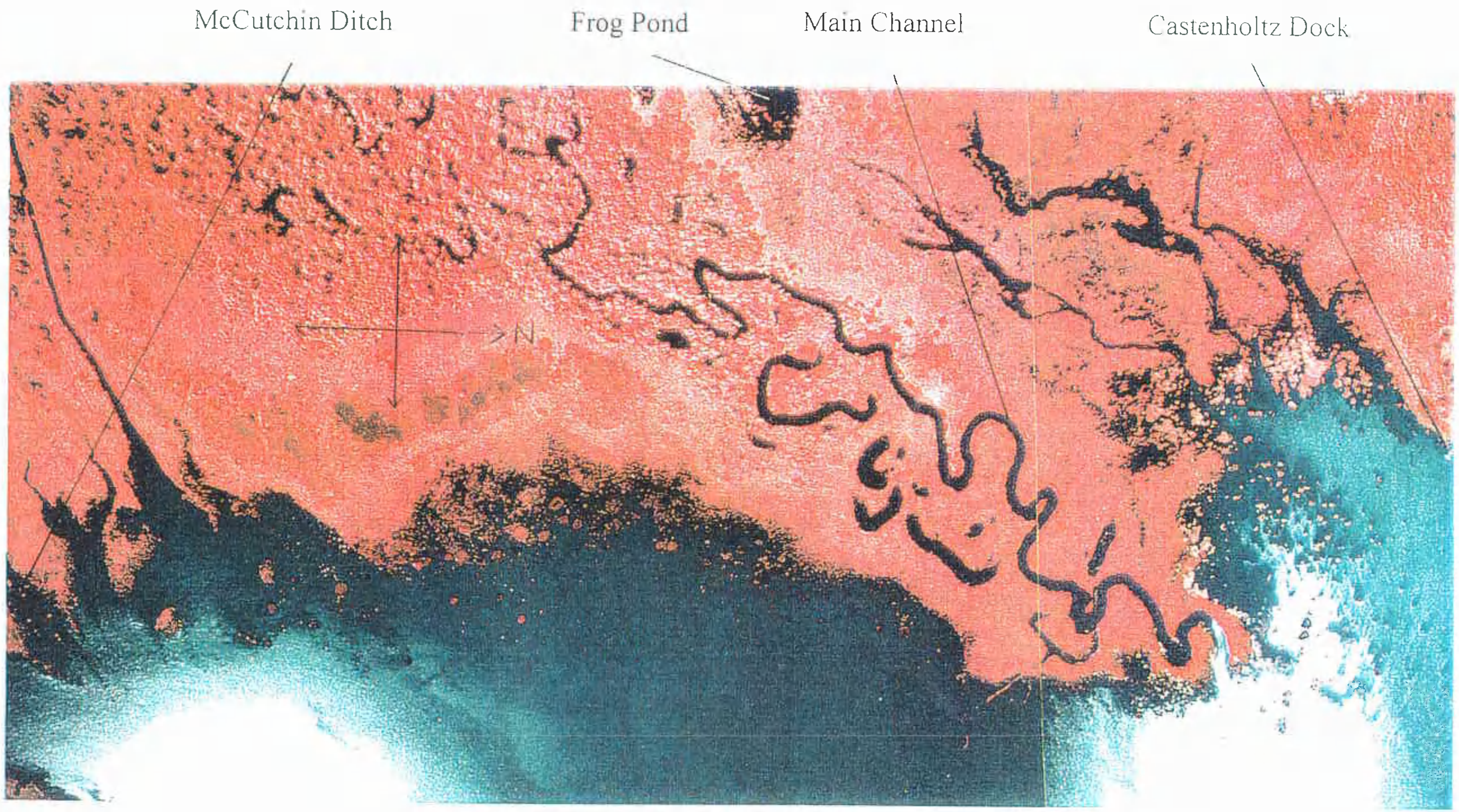


Figure 5. Old Long Tom Channel and Adjacent Ponds

meters, although water levels fluctuate all year long. Woody debris is abundant in the ponds and provides shelter and basking structure for WPT populations. This portion of the Old Long Tom Channel and its adjacent ponds support the largest population of WPTs at Fern Ridge. Mark-recapture analysis during 1993 resulted in a mean estimate of 122 individuals by the Lincoln-Peterson index, and a mean estimate of 104 by the Schnabel method (Unpubl. Data). South Applegate, the nesting area closest to the Old Long Tom Channel receives more nesting activity than the other four areas, presumably as a result of its close proximity to this population. The Applegate nesting areas are licensed to the Oregon Department of Fish and Wildlife (ODFW) for wildlife management purposes, and are cooperatively managed by the state and the US Army Corps of Engineers (USACE) Fern Ridge Office.

The fourth area, Tripass (T), is a small upland area located near Tripass Ski Club on the Northwest corner of the reservoir at T17S R5W sec 5 (Figure 6). This 2 ha meadow lies on the north shore of Tripass Cove. The field was formerly part of the Agriculture Leasing Program, but has since been leased to the Eugene school district for environmental education purposes. Prior to 1994, the field was mowed yearly. The field was left unmowed for two years, and yearly mowing and maintenance were again implemented in Spring 1996. The predominant soil type, Linslaw loam, is a deep, poorly drained soil which is frequently saturated between November and May because of a high water table (SCS 1987). The meadow, primarily consisting of various short grasses and forbs, is bordered to the north by a privately owned parcel of land managed for hay and cattle. This adjacent field is cut and plowed yearly, and the owners have sighted turtles in the field during the nesting season. Willows *(Salix spp.),* Oregon Ash, scattered Oregon White Oak, Douglas Fir *(Pseudotsuga menziesii),* Ponderosa Pine, and blackberries border the periphery of this meadow on three sides.. Although turtles are frequently observed basking in Tripass Cove, population size has not been estimated.

Potential Nesting Habitat

Active
Inactive

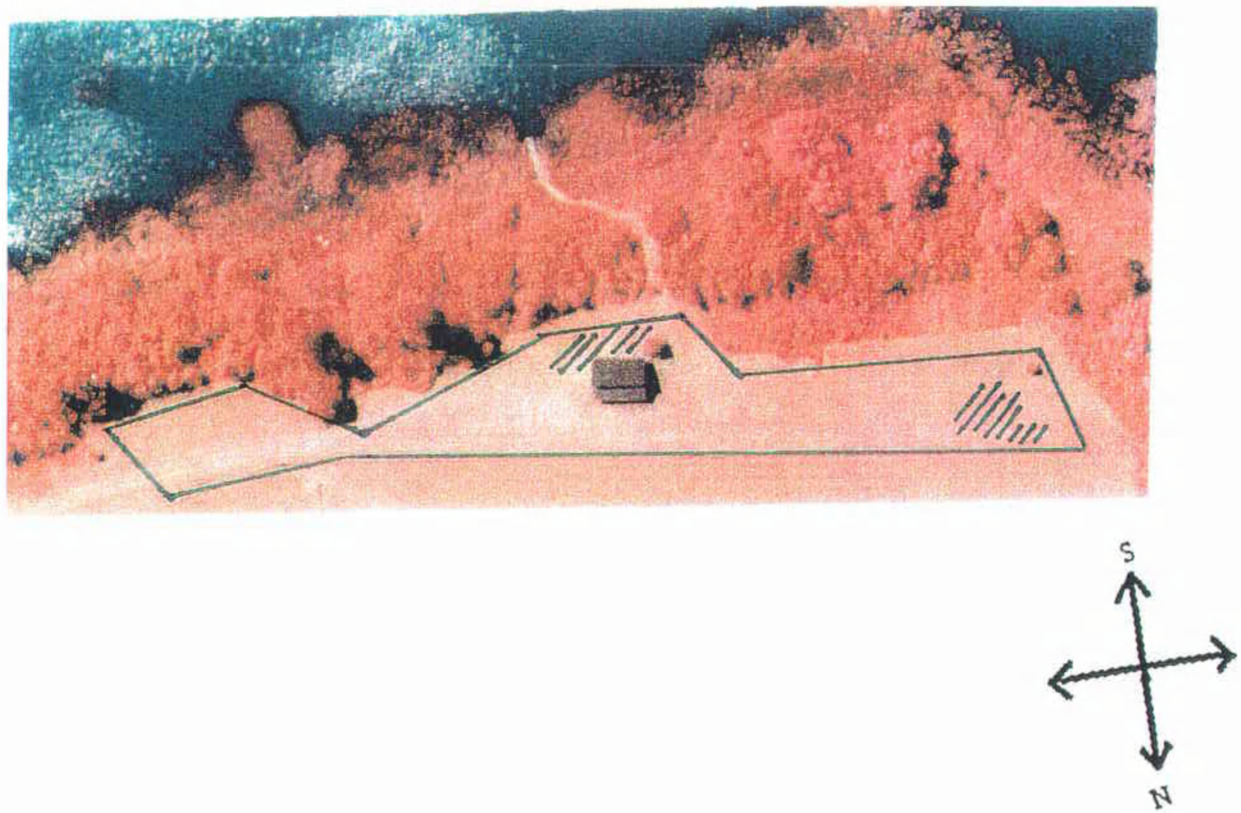


Figure 6. Tripass Nesting Area

The last nesting area at Fern Ridge, South Marsh (Figure 7), is located on the deep, poorly drained soils of an artificial embankment at T18S R5W sec 8, on the West Fork of Job Swale Creek which flows into the South end of Fern Ridge Reservoir. South Marsh nesting area lies approximately two miles further south of the lakeshore, and is partially separated from the rest of the reservoir by Highway 126. The creek underwent "channel improvement" in the 1960's, and drop structures were placed by the Soil Conservation Service, now the Natural Resource Conservation Service (NRCS), to enhance drainage of private lands near the reservoir. The land is privately owned. I was granted access to one half acre, which accounts for approximately one fourth of the total South Marsh nesting area. The banks of the creek are fairly steep, with slopes ranging from 5 to 30 degrees. Although much of the soil in this area is bare, sedges and various short grasses dominate vegetated areas. Dominant soil type is Natroy Silty Clay (SCS 1987). Population size of WPTs in this area have not been estimated.

Kirk Pond, South Applegate, North Applegate, and Tripass have been designated as Environmentally Sensitive Areas by USACE, and plans are under way to implement control measures aimed at preventing the invasion and succession of woody species. All five WPT nesting areas at Fern Ridge Reservoir are surrounded by agricultural fields, suburban and residential developments, and roadways.

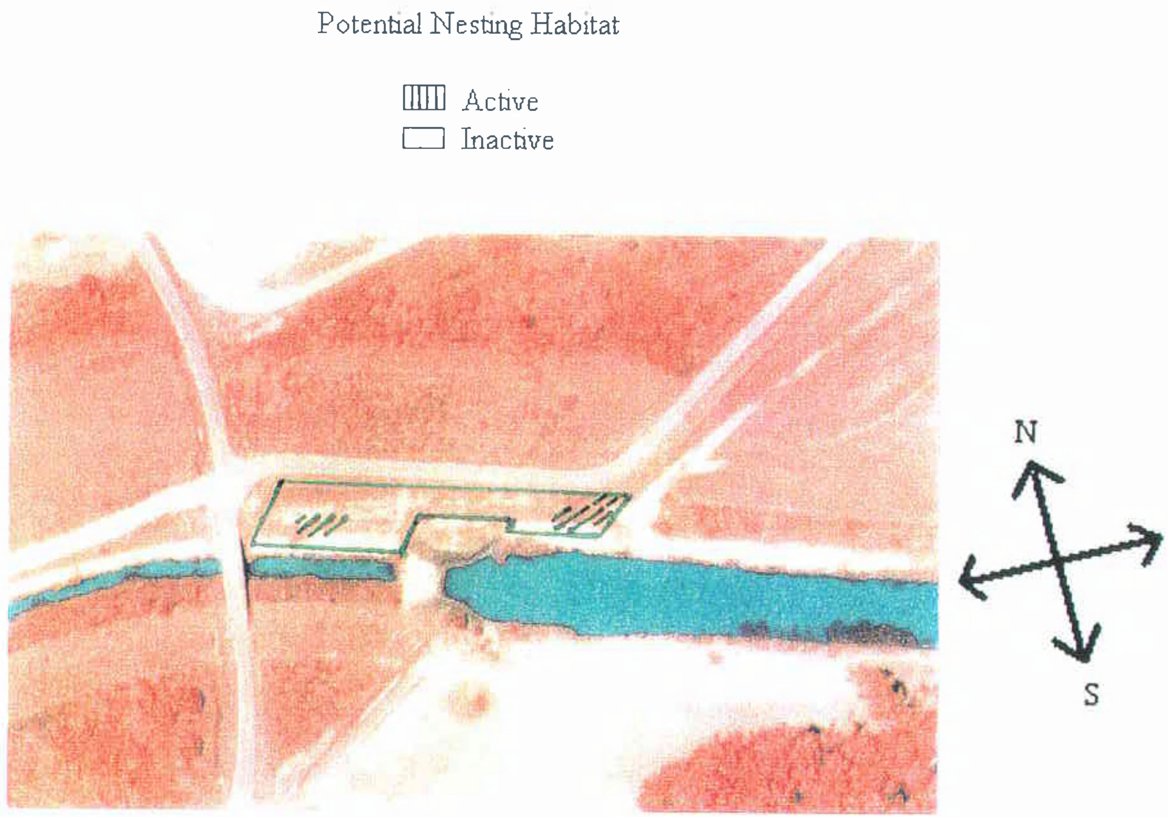


Figure 7. South Marsh Nesting Area

METHODS AND DESIGN

Capture Techniques and Objectives:

Attempts were made to capture a minimum of 20 gravid female WPTs during 1995 and 1996. Trapping efforts focused on the Old Long Tom Channel and adjacent ponds located within the southwest corner of Fern Ridge Reservoir. Trapping was conducted from 01 May through 31 May 1995, and from 25 March through 30 May in 1996. Fourteen modified Legler traps, collapsible, hoop-style, net traps with entrances at both ends (Figure 8), were dispersed throughout the Old Long Tom Channel, and set perpendicular to the shore line on the edges of ponds and inlets. All traps were tied securely to logs, or densely matted vegetation, with one eighth to one fourth of the trap above water to ensure access to the surface by captured turtles. The traps were checked daily by foot or canoe depending on the pool level of the reservoir. One open can of oil-packed sardines was placed in each trap every other day.

The portion of the Old Long Tom Channel and adjacent ponds within the reservoir were divided into five trapping sections. Traps were moved from section to section every two weeks in response to trapping success or failure. Turtles were also captured by hand during nesting forays. Additional trapping sessions were conducted during August, September, and October of 1997 to recapture transmittered turtles.

Marking Techniques and Data Collection:

All turtles captured were given permanent identification numbers by filing notches into the marginal scutes of the carapace according to a numbering system developed by Dr. Dan Holland (Figure 9). Turtles captured for this study were assigned numbers between 9001 and 9100 (Codes assigned by ODFW). Several of the turtles were recaptures from a 1993 WPT study at Fern Ridge, and had already been given permanent

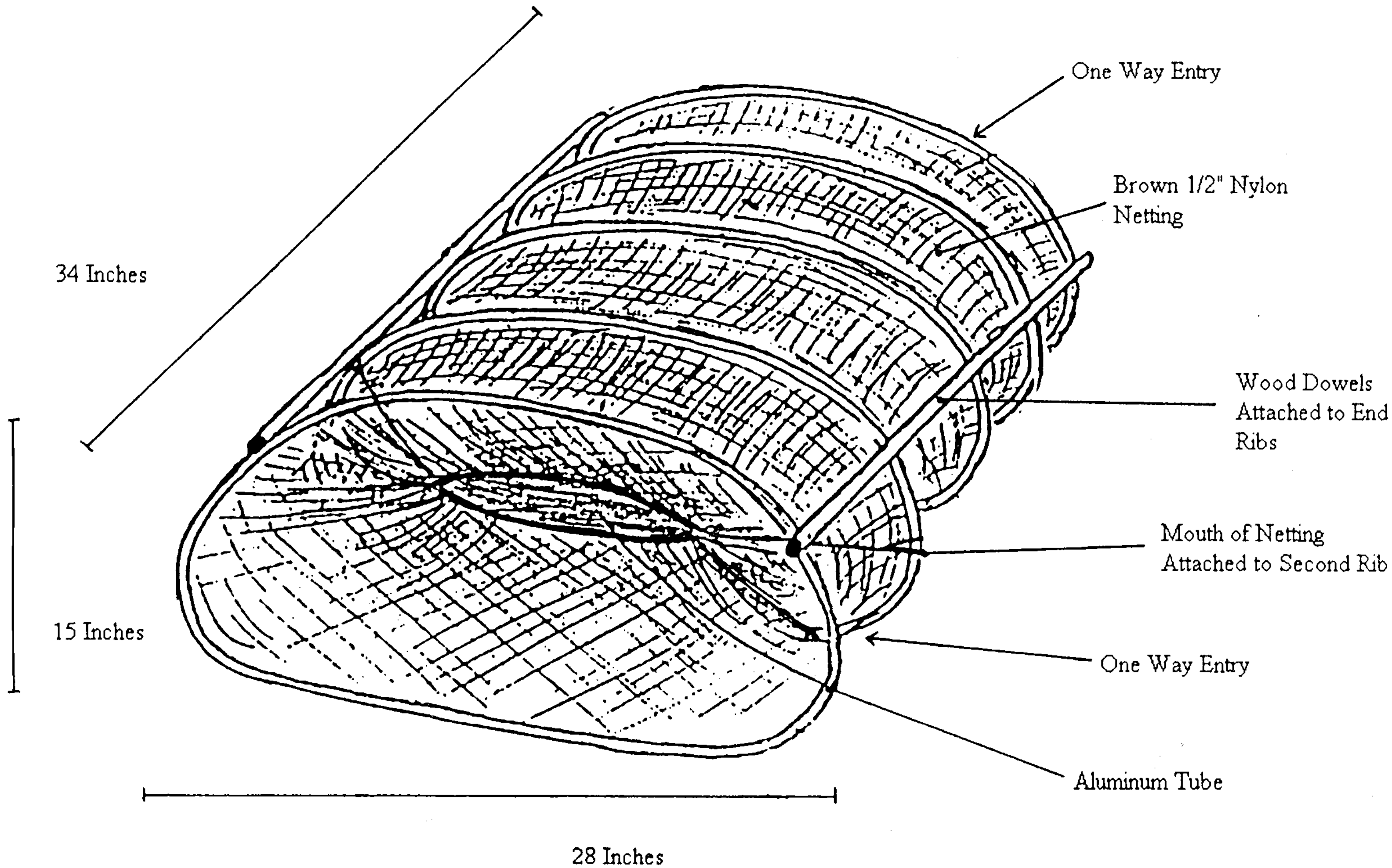


Figure 8. Modified Legler Trap

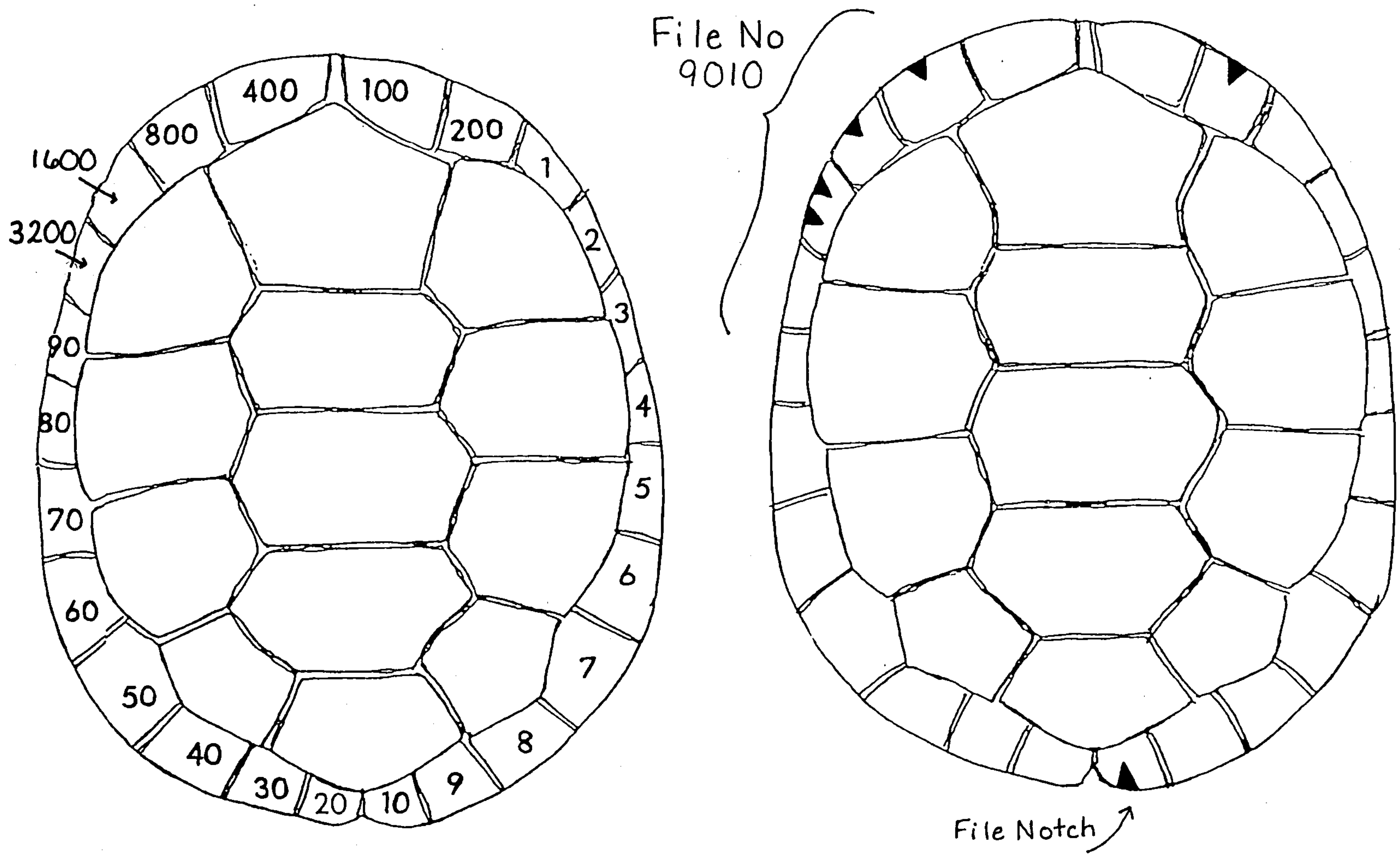


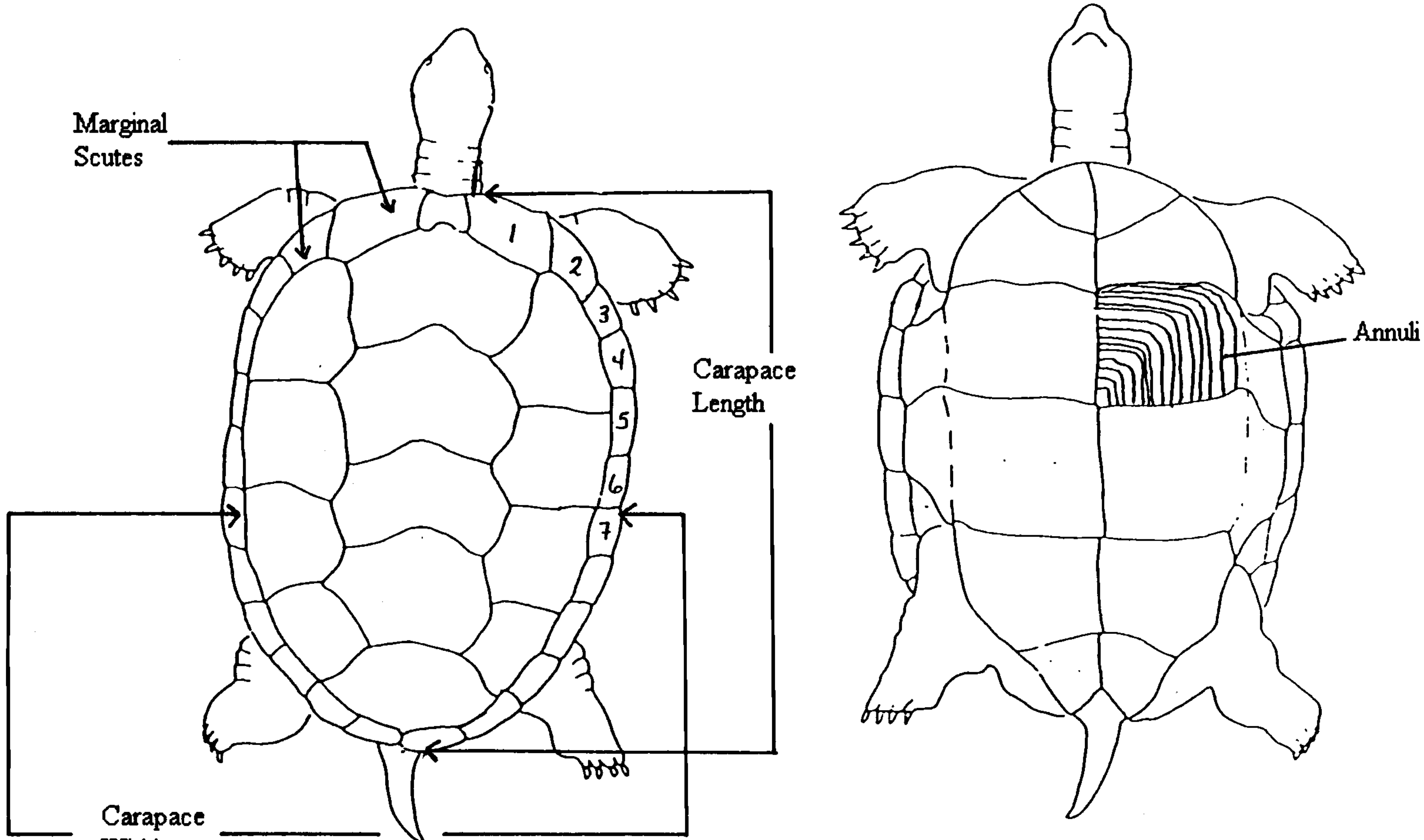
Figure 9. Western Pond Turtle Permanent Marking System

file numbers. As a result, some of the file numbers used in this study deviated from the designated range. I recorded each turtle's mass to the nearest gram (the scale went to a maximum of 1,000 grams), carapace length (CL) and carapace width (CW) to the nearest millimeter, gender, number of plastral annuli, and general condition. CL was measured from the marginal scutes nearest the head to those nearest the tail, and CW was measured at the seventh marginal scute, usually the broadest point of the carapace (Figure 10). Counting plastral annuli is considered a reliable aging technique for WPTs to approximately 7 to 10 years. Annuli of most adults become crowded, worn, and difficult to count. Annuli of Fern Ridge turtles also may become stained and difficult to see because of high tannin content of the lake water, especially in the vicinity of the Old Long Tom Channel. WPTs hatch with 1 annuli, so age is determined by subtracting 1 from the annuli count.

All female turtles were palpated to detect the presence of eggs. Trapping began as early as March, and because it is unknown how quickly turtle eggs "shell up" and are thus detectable, all females of reproductive size and age, in addition to those determined to be gravid by palpation, were affixed with radio transmitters. Although reproductive maturity generally occurs at approximately 115 mm CL, all gravid females captured at Fern Ridge Reservoir between 1993 and 1995 ranged from 160 and 175 mm CL. Transmitters were initially applied to females over 140 mm CL, as well as gravid females. During 1997, transmitters were applied to any female larger than 130 mm CL due to relatively poor trapping success in 1996.

Transmitter Application:

I applied Sm 1-H type, M-Module custom radio transmitters (AVM Instrument Co.) to the carapace of each turtle. Each transmitter weighed approximately 14 grams, and had a predicted life span of 17 to 21 months. The transmitters were applied by tacking the transmitter to the center of the carapace with five minute epoxy to temporarily hold it in



Dorsal View / Carapace

Ventral View / Plastron

Figure 10. Western Pond Turtle Measurements

place, and covering the entire package with PC-7 epoxy. The transmitter antenna was wrapped along the marginal scutes of the carapace and similarly covered with PC-7. Each turtle was left in a five gallon bucket, in a quiet, undisturbed location, for 24 hours while the bonding agent was allowed to cure. All transmitter frequencies were in the 151 mH band. Transmitters were chosen for each turtle so that there was at least .01 mH (10kH) frequency difference between other transmitters in use. Transmitter frequencies were verified before releasing each turtle.

Adult Telemetry Techniques:

All transmittered females were tracked from June, 1995 through July, 1997, to locate nest sites for characteristic measurements, determine yearly reproductive output per female, and determine degree of nest site fidelity. The turtles were tracked by foot or canoe, depending on the pool level of the reservoir, using a TRX-1000S receiver and hand-held folding Yagi directional antenna (Wildlife Materials, Inc). All radioed females were tracked on a daily basis from the date of capture through the end of the nesting season, approximately 01 August, each year. Tracking continued on each turtle after they had nested to detect the possibility of multiple clutches. Daily tracking took place early in the morning from the water to avoid disturbing the nesting areas. Transmitter frequencies were also checked each evening from the edge of the nesting areas. When a frequency was picked up, the area was not searched, and the transmittered female was located and tracked through her nesting foray.

After the nesting season ended, all transmittered females were tracked once a week through the rest of the year to monitor their movements and record overwintering locations.

Nesting Area Searches:

Potential nesting habitat within each nesting area at Fern Ridge Reservoir was searched daily from 25 May through 25 July during 1995, 1996, and 1997. Potential nesting habitat was categorically defined as open field; portions of nesting areas dominated by shrubs, trees, or tall, dense vegetation were known to be unsuitable for WPT nesting sites and were not searched (Figures 2, 3, 4, 6, and 7). Nesting areas were searched by walking North/South and East/West transects approximately 3 meters apart, scanning the ground for intact, attempted, and depredated nest sites. Nest sites were located by searching the nesting areas, or by tracking a female to her nest site. Holes resembling attempted nest sites were recorded as such only if the female was actually observed digging the hole before abandoning the site, and predated nest sites were recorded as such only if intact eggs or egg shell fragments were present. All intact, attempted, and depredated nest sites were marked with stakes identifying the nesting area, nest site number, and the year. All intact nest sites were covered by wire-mesh cages to exclude predators. None of the exclosed nests were damaged by predators.

Nest Site Characteristics:

Several characteristics were measured and recorded at each nest site located at Fern Ridge Reservoir between 1993 and 1997. All nest site characteristics were measured immediately after nest completion, or the following morning if nesting occurred very late at night. Due to the changing goals of WPT studies at Fern Ridge Reservoir over the years, different characteristics were measured for nest sites located during different years (Table 1).

Table 1. Nest Site Characteristics Measured Each Year, Fern Ridge Reservoir, Oregon, 1993 - 1997.

Nest Site Characteristics	1993	1994	1995	1996	1997
Slope	✓	✓	✓	✓	✓
Aspect	✓	✓	✓	✓	✓
Straight-Line Distance from H2O	✓	✓	✓	✓	✓
Soil Compaction				✓	✓
% Vegetative Ground Cover				✓	✓
% Overstory Cover				✓	✓
Vegetation Height				✓	✓
Period of Inundation			✓	✓	

Slope (SL) was determined at each nest site by placing a clinometer near the ground directly over each nest plug. I held the clinometer slightly above the ground to eliminate errors due to surface irregularities and debris.

Aspect (AS) was determined at each nest site using a compass with bearings based on true north. The compass was held directly over the nest plug. Nest sites having southern aspects, or no aspect (0 degree slope) both had 100 percent sun exposure, and were combined in data analysis.

Straight-line distance from water (SLD) of each nest site was directly measured using a meter tape. When dense vegetation prevented straight-line measurements from the nest plug to the nearest significant body of water (Fern Ridge Reservoir in South Applegate, Tripass, and North Applegate; Kirk Pond in Kirk; and Job Swale Creek in South Marsh), a right triangle was constructed using the nest plug and the nearest point of water as two corners, and two straight lines were measured from these points to form a right angle around the vegetation. The Pythagorean theorem was then used to determine the length of the straight line from the nest site to the water (Figure 11).

Soil compaction (SC) at each nest site was determined by pressing a Lang penetrometer needle into the ground. The number on the penetrometer was subtracted from one, multiplied by 33.198, and then multiplied by 0.179 to get kilograms per square centimeter. A penetrometer reading was taken at each of the four cardinal points 10 cm

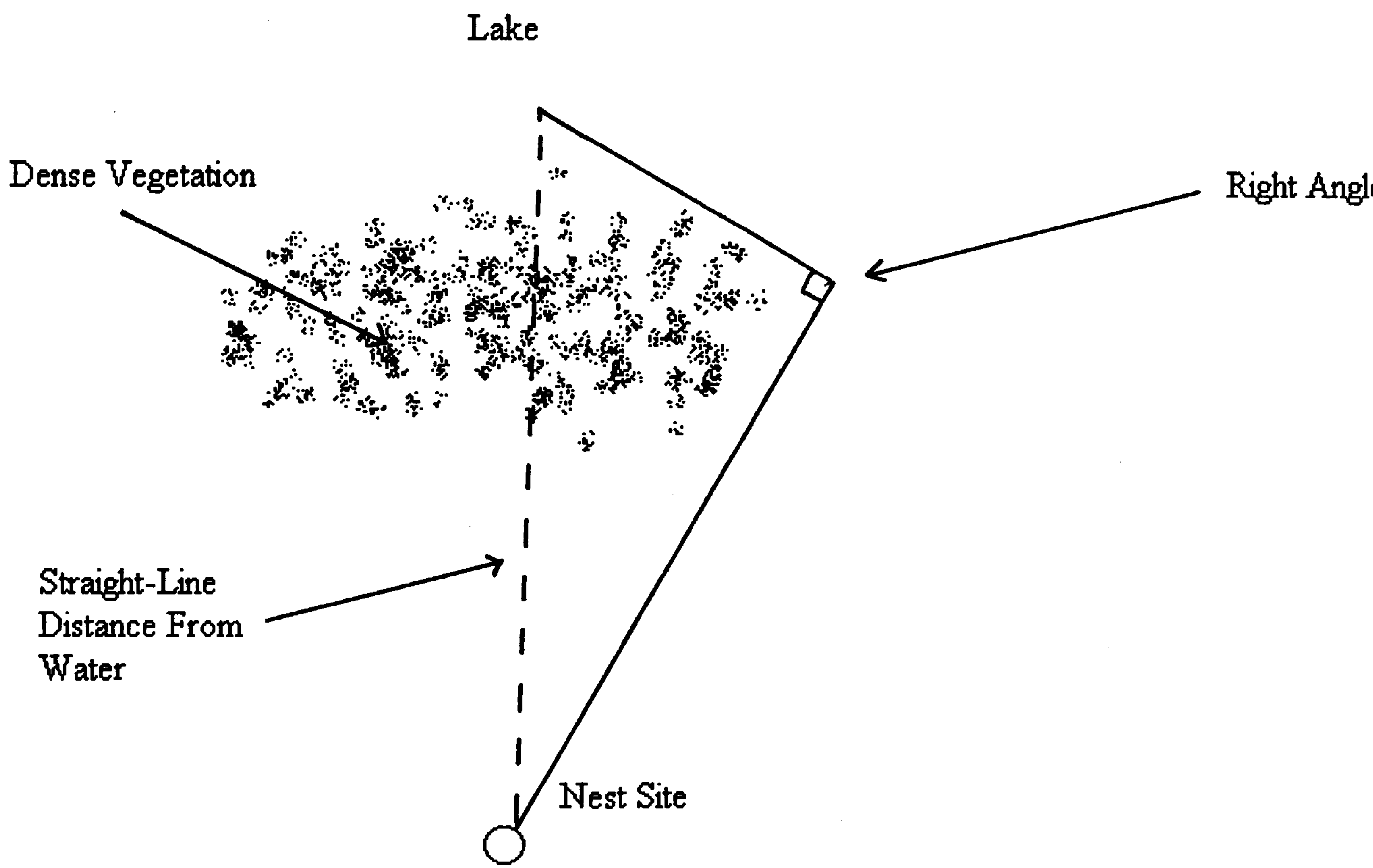


Figure 11. Derivation of Straight-Line Distance From Water Measurements in Areas of Dense Vegetation

away from the nest plug. An average of the four readings was computed to give a single value for each nest site.

Percent vegetative ground cover (% VGC) was determined by placing a 10 x 10 decimeter grid over each nest site, and counting the number of squares containing vegetation. Vegetative cover included moss.

Percent overstory cover (% OSC) was measured at each nest site using a model C design spherical densiometer; a concave mirror engraved with 24 one fourth inch squares on the surface. This allowed me to view the same degree of arc overhead regardless of time of day or weather conditions. The densiometer was placed on the ground directly over the nest plug. Each square in the grid was mentally divided into four smaller squares, and the number of small imaginary squares which did not reflect overstory were counted. The result was multiplied by 1.04 to give the percent of overhead area not occupied by canopy, or the percent of sun exposure to that particular spot.

Vegetation height (VH) was determined at each nest site by standing a graduated, barred, pole perpendicular to the ground, while I laid with my chin on the ground (turtle height), at a distance of 0.3 m from the nest plug, and estimated the greatest height at which the vegetation obstructed approximately twenty-five percent of a single bar. Vegetation height was determined at each of the four cardinal points, and an average of the four readings was computed to give a single value for each nest site.

Period of inundation (P of I) was the number of consecutive days each nest site was inundated by water. P of I was estimated for each nest site by constructing 20 water wells (Figure 12). Holes measuring 12 cm in diameter were drilled to a depth of 0.5 m. A length of 6 cm diameter perforated PVC pipe was inserted into each hole and back filled with pea gravel allowing water to move freely through the pipe. The number of water wells constructed in each nesting area was proportionate to the number of nest sites previously located there. In October, 1995, nine wells were constructed in South Applegate, 4 in South Marsh, 3 in Kirk, 2 in Tripass, and 2 in North Applegate. The wells were constructed in random directions, 1.5 meters from randomly chosen nest sites in each of the five areas. The patterns of ground water fluctuation in each well were measured by using one meter of graduated twine affixed with a small fishing

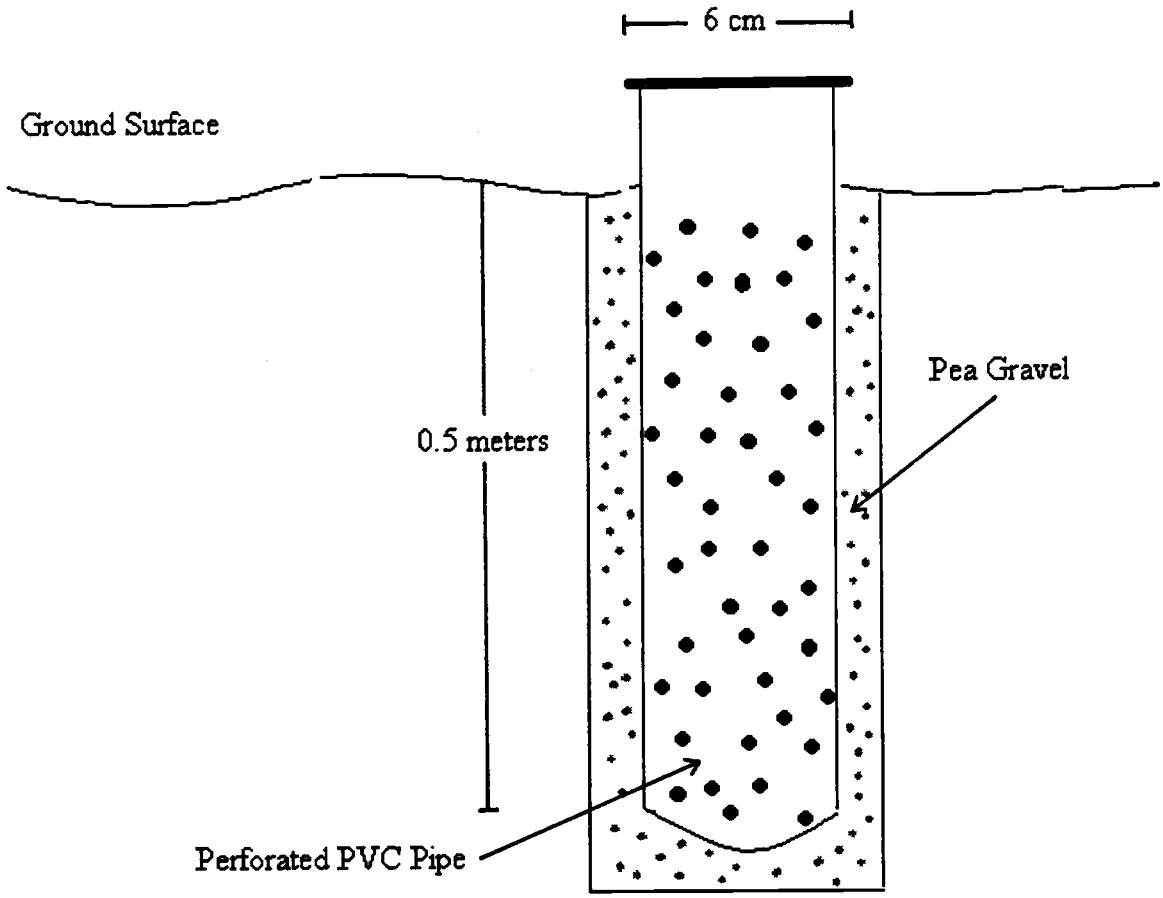


Figure 12. Water Well Design

bobber to determine the depth of the subsurface water. Nest chambers generally range in depth from 9 to 12.5 cm below the surface of the ground. Nest chambers were considered to be inundated when water levels in the wells rose to within 12.5 cm of the ground surface. Water levels in each hole were monitored daily from 15 October, 1995 through May, 1997

Nest Temperature:

Nest chamber temperatures were recorded in ten nest sites during 1996 using Stow-Away data loggers with external probes from Onset Company (Table 2).

Table 2. Nest Sites Monitored by Stow-Away Data Loggers, Fern Ridge Reservoir, Oregon, 1996.

Nesting Site Stake No	Nesting Area	Date Initiated	Data Logger ID
01-08-96	South Applegate	26 June 96	0094
01-10-96	South Applegate	26 June 96	5052
02-01-96	Tripass	28 June 96	5055
04-05-96	South Marsh	02 July 96	0096
01-12-96	South Applegate	04 July 96	0092
01-13-96	South Applegate	11 July 96	0093
01-04-96	South Applegate	11 July 96	0095
02-03-96	Tripass	11 July 96	5056
05-11-96	Kirk	12 July 96	5051
01-15-96	South Applegate	15 July 96	5053

Immediately after nest completion, each nest plug was carefully removed, the external probe inserted into the chamber, and the nest plug quickly replaced. The data loggers were placed outside the nest chamber, and camouflaged with vegetation and leaf litter.

Nest temperature was measured every hour from oviposition through 30 April, 1997. Data were downloaded in the field every two months, tabulated, and graphed (Figure 13). Maximum, minimum, and mean nest temperatures were calculated for the estimated period of incubation, day of emergence, month of emergence, and total period. Temperatures calculated differed depending on fate of nest site (Table 3). The period of incubation was estimated as 94 days from oviposition, which is the mean period of incubation for WPTs in the Northwest. The total period was calculated from oviposition through emergence for successful nest sites, and through 12 March (the mean emergence date of all successful nest sites at Fern Ridge Reservoir) for unsuccessful nest sites.

Table 3. Nest Temperatures Calculated at Successful and Unsuccessful Nest Sites Monitored by Stow-Away Data Loggers, Fern Ridge Reservoir, Oregon, 1996.

	Period of Incubation			Day of Emergence			Mo of Emergence			Total		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
U	✓	✓	✓							✓	✓	✓

Climatological Data:

Precipitation, barometric pressure, and growing degree days were monitored for each nest site located between 1993 and 1997. Local climatological data were received from Oregon State University from measurements taken at Malon Sweet Airport, located 8 km Northeast of the nesting areas at Fern Ridge Reservoir. The maximum, minimum, and mean of each climatological measurement were determined for the day of nesting, estimated period of incubation, day of emergence, month of emergence, and total period from oviposition through hatching were calculated for all successful nest sites. The

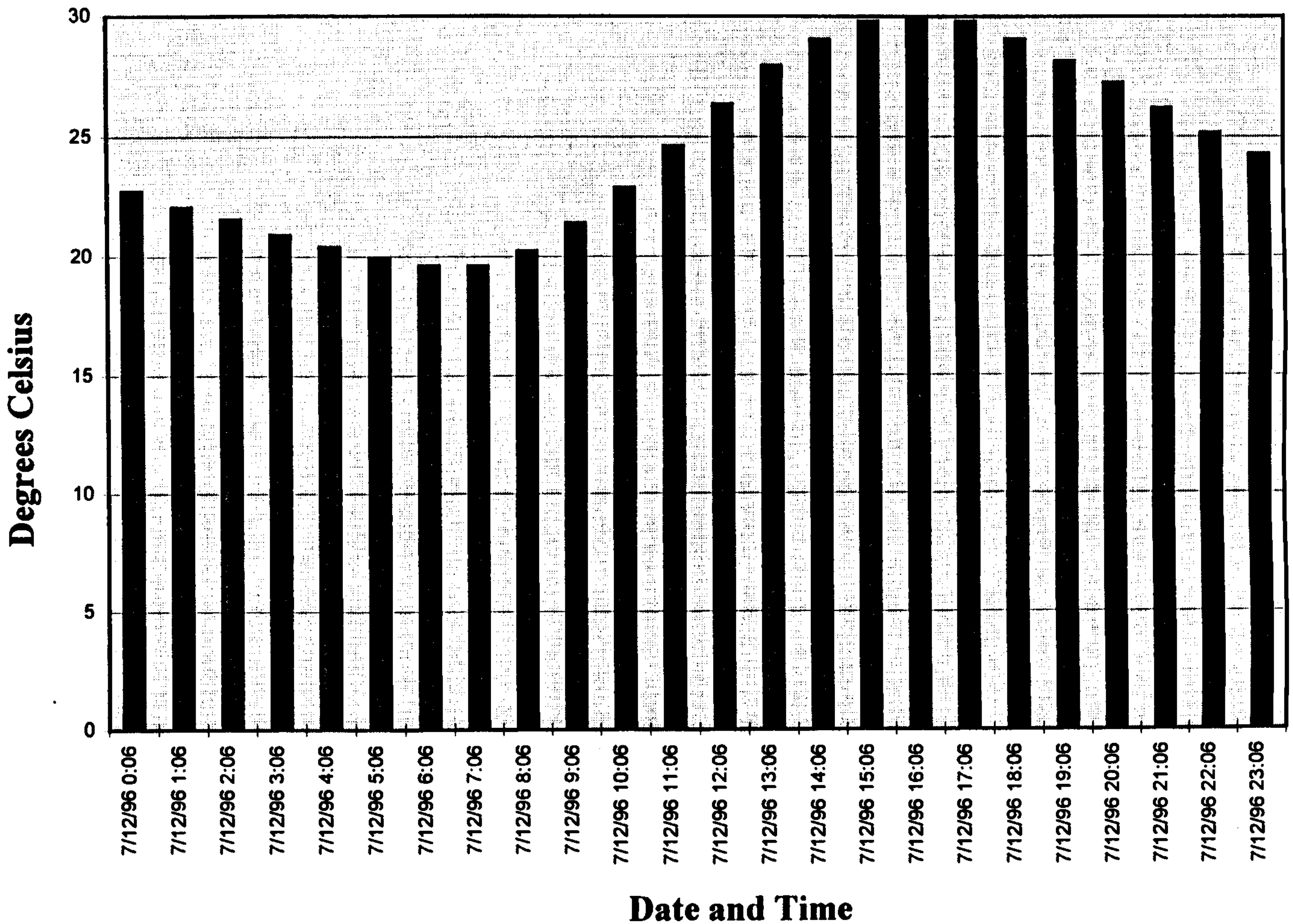


Figure 13. Graph of Nest Temperature Measurements Recorded By Stow-Away Data Logger, Nest Site Number 01-08-96, Fern Ridge Reservoir, Oregon, 1996

maximum, minimum, and mean were determined for the day of nesting, estimated period of incubation, and total period from oviposition through 12 March were calculated for unsuccessful nest sites.

Nest Exclosure Monitoring:

All intact nest sites were monitored daily from oviposition through 01 November of each year to detect possible fall hatchling emergence, and again from 01 January through 15 April of the following year to detect spring hatchling emergence. Nest plugs were examined for any sign of disturbance, and all vegetation and duff surrounding the nest plug were searched carefully for hatchlings which had emerged. If a nest showed any sign of hatchling emergence, the predator exclosure was removed, the tracking equipment set up, and the nest observed until all of the hatchlings had left the nest chamber. The date, time, weather conditions, and each hatchling's weight, CL, CW, and CD were recorded. All nest sites were classified as 1) successful - no detectable infertile eggs, partially developed embryos, or dead hatchlings, 2) partially successful - one or more infertile eggs, partially developed embryos, or dead hatchlings, 3) unsuccessful - all infertile eggs, partially developed embryos, and/or dead hatchlings, 4) unknown - nest sites vandalized or depredated, or 5) excavated by ODFW - nest sites which were excavated, the eggs incubated artificially, and the hatchlings entered into a Head Start Program through a previous arrangement between ODFW and USACE.

Hatchling Telemetry Techniques:

All hatchlings were tracked using fluorescent powder (visible by ultraviolet light in darkness). A 1 cm thick circular line of powder was placed around each nest, forcing hatchlings to crawl through the powder upon leaving the nest. Plastic stake wire flags recording the date, time, nest site number, and hatchling number were placed at the beginning and end of each tracking run. Additional rings of powder were placed around hatchlings that were subsequently located to give them a second dusting.

Hatchlings which emerged after 16 March, 1997, or for which locations were still known after this date, were also tracked using a Schonstedt Magnetic Locator. A small metal washer, weighing approximately 0.11 grams was affixed to the carapace of each hatchling with Skin Bond (TM), a latex cement used for the attachment of colostomy appliances in humans. The washers were labeled with nesting area number, nest site number, and a hatchling number.

Five hatchlings were additionally tracked using Model LB-2 radio transmitters (Holohil Systems Ltd). Each transmitter weighed 0.44g, had an expected life span of 10 to 14 days, and was attached to the carapace of each hatchling with Skin Bond (TM). The transmitter and the bonding agent weighed less than ten percent of each hatchling's body weight.

Hatchlings were tracked as continuously as possible during the first 12 hours following emergence (hatchlings emerged in multiple nesting areas on the same day). Hatchlings were tracked every four hours, day and night, during the following week, and then once daily until their locations were no longer known. Rate and direction of movement, use of cover types, and general behavior were recorded for each hatchling.

Sampling Design:

Prior to the 1996 nesting season, the potential nesting habitat in each nesting area was divided into active and inactive quadrats based on the presence or absence of current and/or prior nesting activity (Figures 2, 3, 4, 6, 7). Non-nest sites from both active and inactive quadrats were selected by overlaying aerial photographs of each nesting area with a numbered grid transparency, and randomly drawing grid numbers which corresponded to 1 by 1 meter sites in each nesting area. As each actual nest site (intact, attempted, and depredated) was located during 1996 and 1997, four randomly drawn non-nest sites were selected from that nesting area: two from an active quadrat, and two from an inactive quadrat. Slope, aspect, straight-line distance from water, soil compaction, percent vegetative ground cover, percent overstory cover, and vegetation height were measured at each of the four non-nest sites at the same time they were measured for the actual nest site. Nest site characteristics were compared among actual nest sites, non-nest sites from active quadrats, and nest sites from inactive quadrats.

Data Presentation and Analysis:

Slope, aspect, straight-line distance from water, soil compaction, percent vegetative ground cover, percent overstory cover, vegetation height, and period of inundation measurements from each nest site were analyzed to identify differences among nest sites which were successful (S) and unsuccessful (U), from different nesting areas from different years, and among those which were intact (I), attempted (A), or depredated (P), between 1994 and 1997 (Table 4). In data analysis, nest sites were considered to be successful if any hatchlings emerged. Nest site characteristics of nest sites located during 1993 were reported, but not compared to the other four years due to a presumed bias in data collection methods.

With the exception of period of inundation, the same nest site characteristics were compared among actual nest sites and non-nest sites from both active and inactive quadrats of potential nesting habitat in each nesting area during 1996 and 1997 (Table 5 and 6).

A census of the five nesting areas between 1994 and 1997 resulted in a large amount of data; however, sample sizes became relatively small once sorted by nest status (intact, attempted, depredated), nesting area, year, and fate (successful, unsuccessful, vandalized, excavated by ODFW). ODFW nest sites were excavated after the estimated period of incubation, and were therefore included in comparisons among successful and unsuccessful nest sites. Vandalized and depredated nest sites were not included in comparisons among successful and unsuccessful nest sites.

Table 4. Sample Sizes and Comparisons of Nest Site Characteristics Among Different Nest Sites, Fern Ridge Reservoir, Oregon, 1994 - 1997.

Compared among: ⇩		*Slope n =*	*Aspect n =*	*SLD n =*	*Soil Comp n =*	*% VGC n =*	*% OS n =*	*Veg Ht n =*	*Per of Inund n =*
Success	S	23	23	23	12	12	12	12	09
Unsuccess	U	57	57	57	10	10	10	10	23
Nesting Areas	SA	54	54	54	31	31	31	31	17
	T	12	12	12	08	08	08	08	04
	NA	16	16	16	09	09	09	09	05
	SM	27	27	27	12	12	12	12	09
	K	27	27	27	18	18	18	18	04
Years	97	36	36	36	36	36	36	36	--
	96	42	42	42	42	42	42	42	18
	95	29	29	29	--	--	--	--	14
	94	29	29	29	--	--	--	--	--
Intact	I	122	122	122	59	59	59	59	--
Attempt	A	23	23	23	18	18	18	18	--
Predated	P	20	20	20	01	01	01	01	--

Table 5. Sample Sizes and Comparisons of Nest Site Characteristics Among Actual Nest Sites and Non-Nest Sites from Both Active and Inactive Quadrats of Potential Nesting Habitat Within Each Nesting Area, Fern Ridge Reservoir, Oregon, 1996.

	Comparisons of Nest Site Characteristics Measured		
	Actual Nest Sites n =	Non-Nest Active n =	Non-Nest Inactive n =
South Applegate	15	30	30
Tripass	03	06	06
North Applegate	05	10	10
South Marsh	06	12	12
Kirk	13	26	26

Table 6. Sample Sizes and Comparisons of Nest Site Characteristics Among Actual Nest Sites and Non-Nest Sites From Both Active and Inactive Quadrats of Potential Nesting Habitat Within Each Nesting Area, Fern Ridge Reservoir, Oregon, 1997.

	Comparisons of Nest Site Characteristics Measured		
	Actual Nest Sites	Non-Nest Active	Non-Nest Inactive
	n =	n =	n =
South Applegate	16	32	32
Tripass	05	10	10
North Applegate	04	08	08
South Marsh	06	12	12
Kirk	05	10	10

Neither Two Way or Three Way Analysis of Variance tests were applicable due to small sample sizes and unbalanced data. One Way Analysis of Variance was used to analyze balanced data with normal distributions and equal variances. Differences among groups were isolated using the Tukey Test for all pairwise multiple comparison procedures.

The nonparametric test, Kruskal-Wallis One Way Analysis of Variance on Ranks, was used to analyze data from non-normal populations with unequal variances. Differences among groups were isolated using the Dunn's Method of all pairwise multiple comparison procedures when sample sizes were unequal, and the more conservative nonparametric Student-Newman Keuls Method of all pairwise multiple comparisons was used when sample sizes were equal. The Student-Newman-Keuls Method was more likely to find a difference between the two groups being compared.

Chi-Square Analysis of Contingency Tables, Fisher Exact Test, was used to compare the distributions of aspect. One Way Analysis of Variance and Kruskal-Wallis One Way Analysis of Variance on Ranks were used to analyze nest chamber temperatures and climatological data. Sigma Stat Statistical Software Package, Version 2.0 for Windows 95 (Jandel Scientific) was used for all statistical comparisons.

RESULTS

Nesting Area Survey Results:

The five nesting areas at Fern Ridge Reservoir, Oregon, were searched for a total of 1,226 hours over 264 days, between 1993 and 1997. The number of search hours varied daily among nesting areas depending on the number of people searching, weather conditions, and the number of nest sites located. Search time in each area was further biased by known probability of finding nest sites. A breakdown of search hours in each nesting area is provided in Table 7.

Table 7. Search Effort in Each Nesting Area,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

Nesting Area	# of Days	# of Hrs	# Nest Sites Located	Ave Hrs / Nest Site Located
South Applegate	264	368	65	5.7
Tripass	264	184	20	9.2
North Applegate	264	245	21	11.7
South Marsh	264	184	32	5.8
Kirk	264	245	27	9.1

Nest searches resulted in the location of 165 WPT nest sites between 1993 and 1997. South Applegate received the most nesting activity, accounting for 65 nest sites. Twenty nest sites were located in Tripass, 21 in North Applegate, 32 in South Marsh, and 27 in Kirk (Table 8).

Of the 165 nest sites located, 122 were intact, 23 were attempted, and 20 were depredated (Table 9).

Table 8. Number of Nest Sites Located in Each Nesting Area,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

	South Applegate	Tripass	North Applegate	South Marsh	Kirk
1993	11	8	5	5	0
1994	9	3	3	10	4
1995	14	1	4	5	5
1996	15	3	5	6	13
1997	16	5	4	6	5
Total	65	20	21	32	27

Table 9. Number and Status of All Nest Sites,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

	1993	1994	1995	1996	1997
Intact/Exclosed	20	20	24	29	30
Attempted ①	00	00	05	12	06
Predated ②	09	09	00	01	00
Total	29	29	29	42	36

① Attempted nests were not recorded during 1993 and 1994.

② Number of predated nest sites does not reflect predation rates or pressure.

The nesting season at Fern Ridge Reservoir started between 02 June and 04 June, during 1994 through 1997 (Figures 14, 15, 16, 17, 18). Although the nesting season appears to have begun on a much later date in 1993 (14 June), this was the first year nest area searches were conducted at Fern Ridge Reservoir, and we were not yet familiar with the physical attributes of the nest sites or how best to search for them. Nest searches were not initially done daily, and the first five nests located during 1993 were depredated. During all five years the nesting season ended between 16 and 21 July.

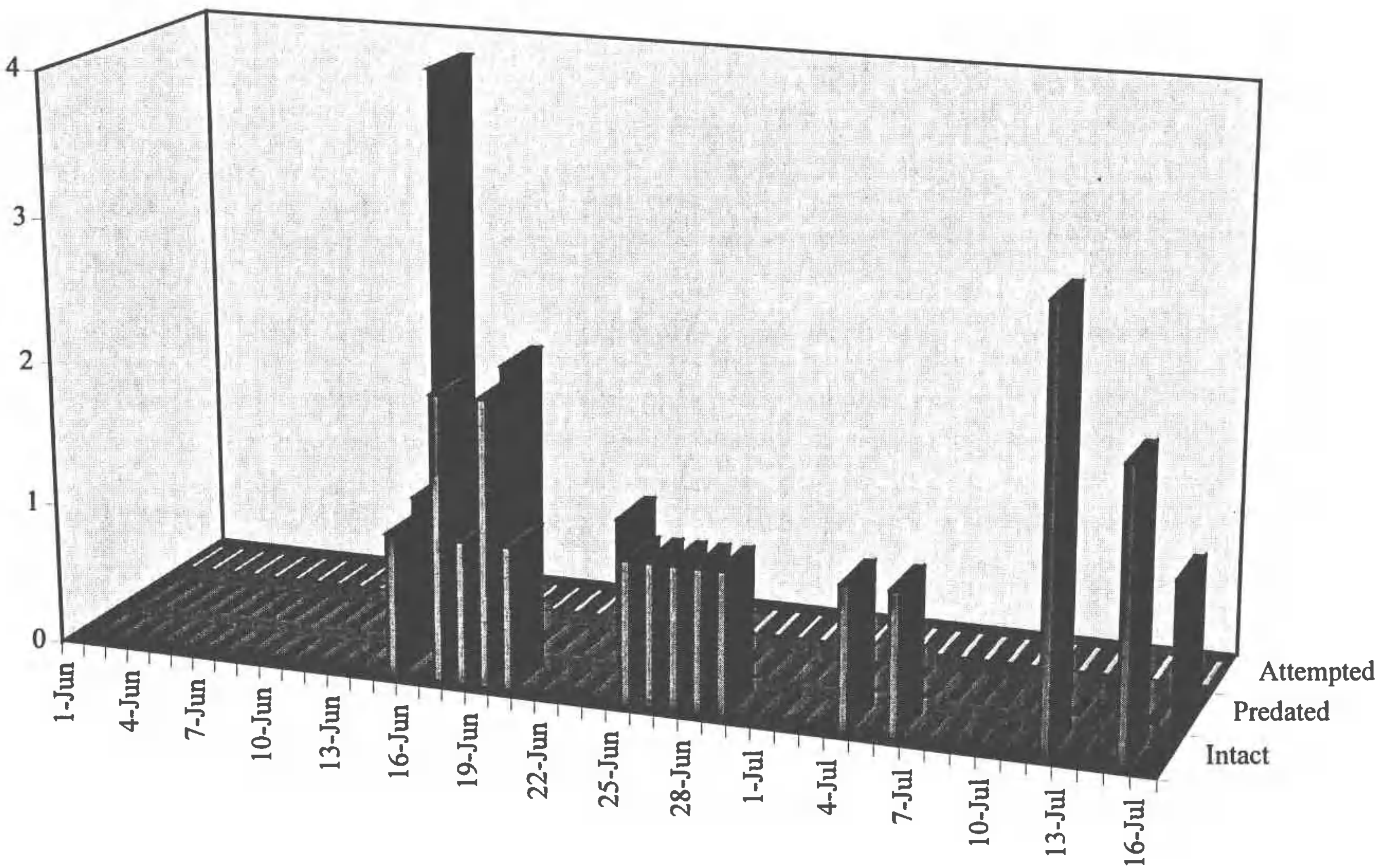


Figure 14. Nesting Dates of All Nest Sites, Fern Ridge Reservoir, Oregon, 1993

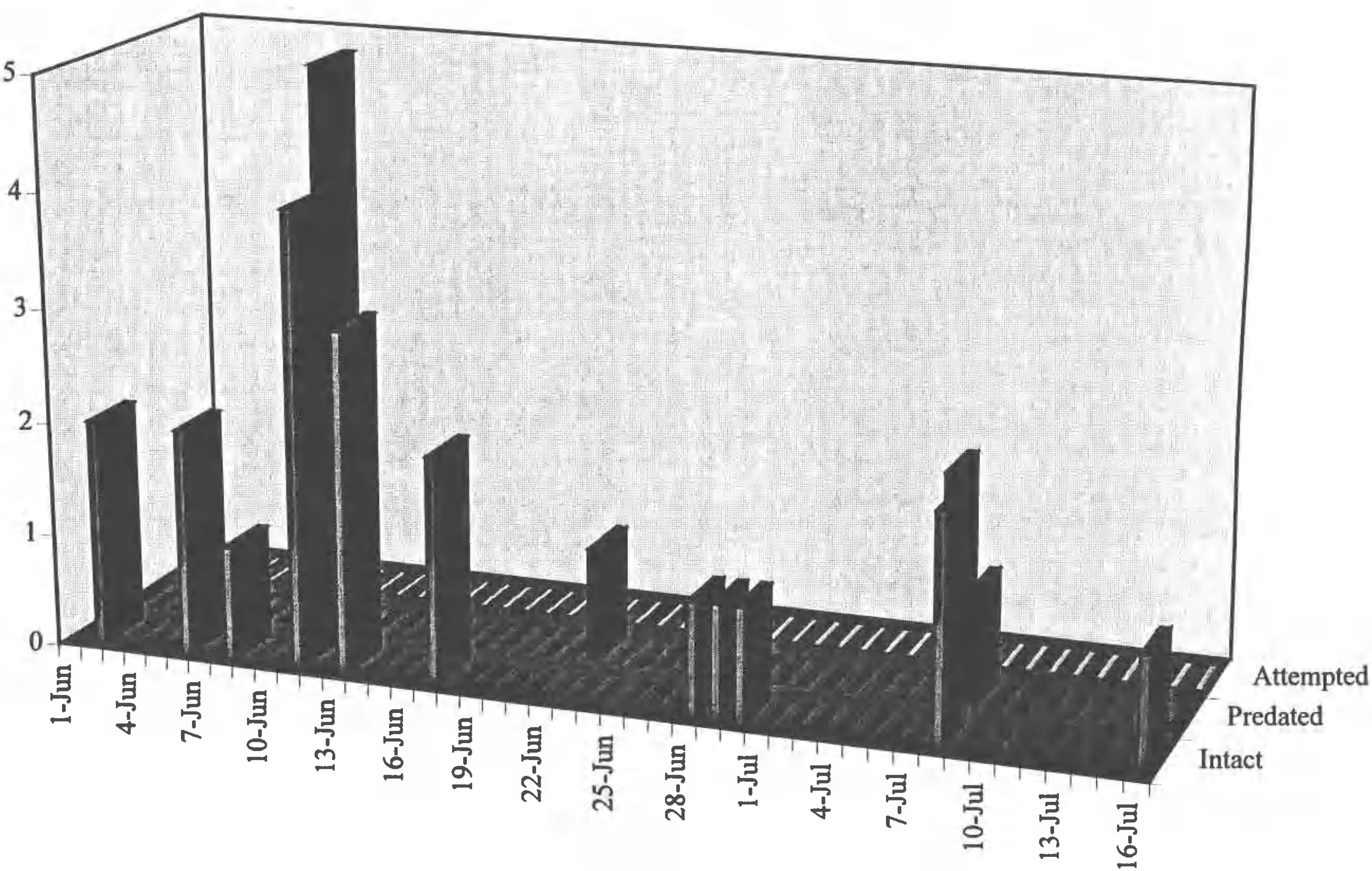


Figure 15. Nesting Dates of All Nest Sites, Fern Ridge Reservoir, Oregon, 1994

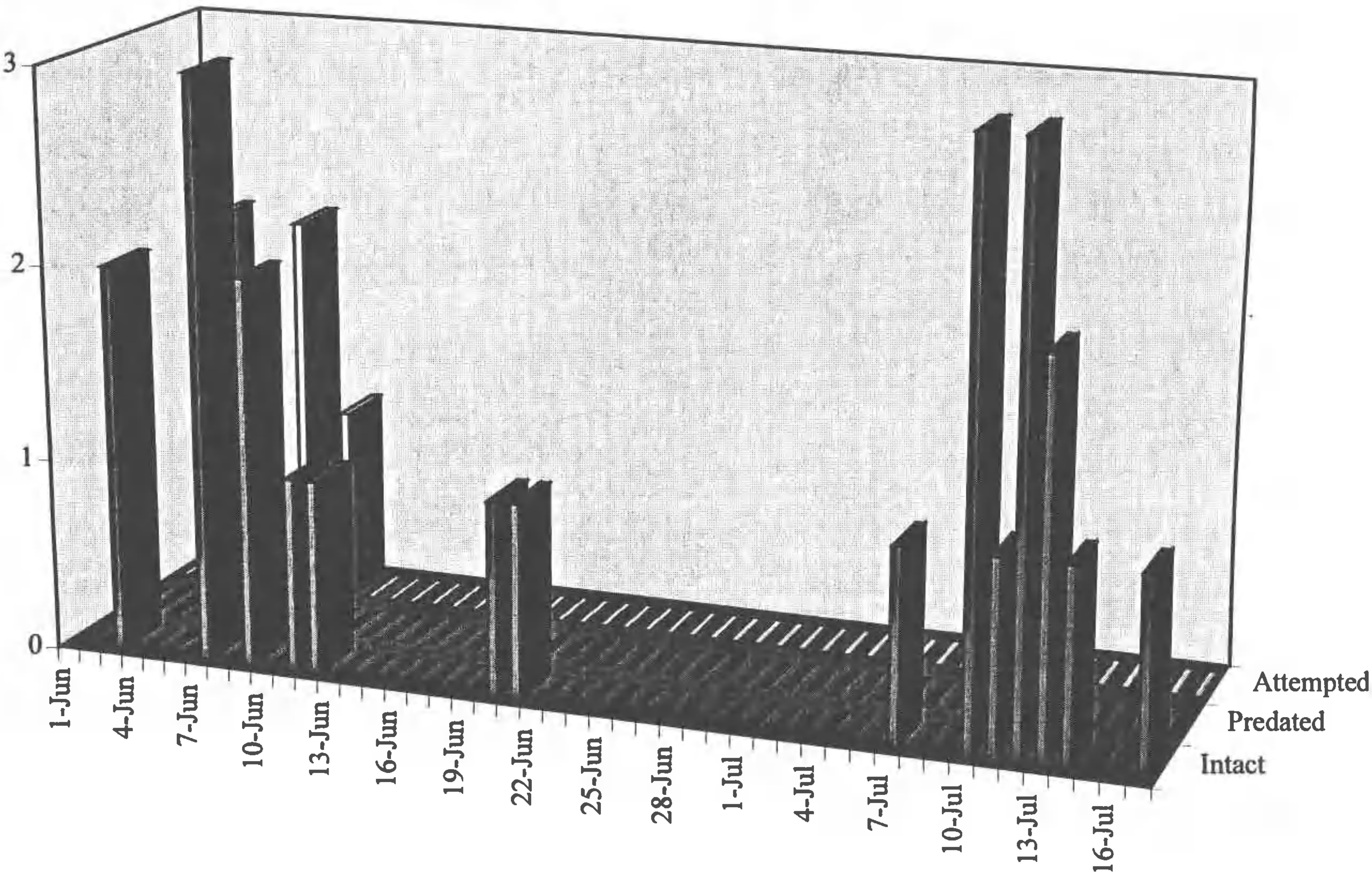


Figure 16. Nesting Dates of All Nest Sites, Fern Ridge Reservoir, Oregon, 1995

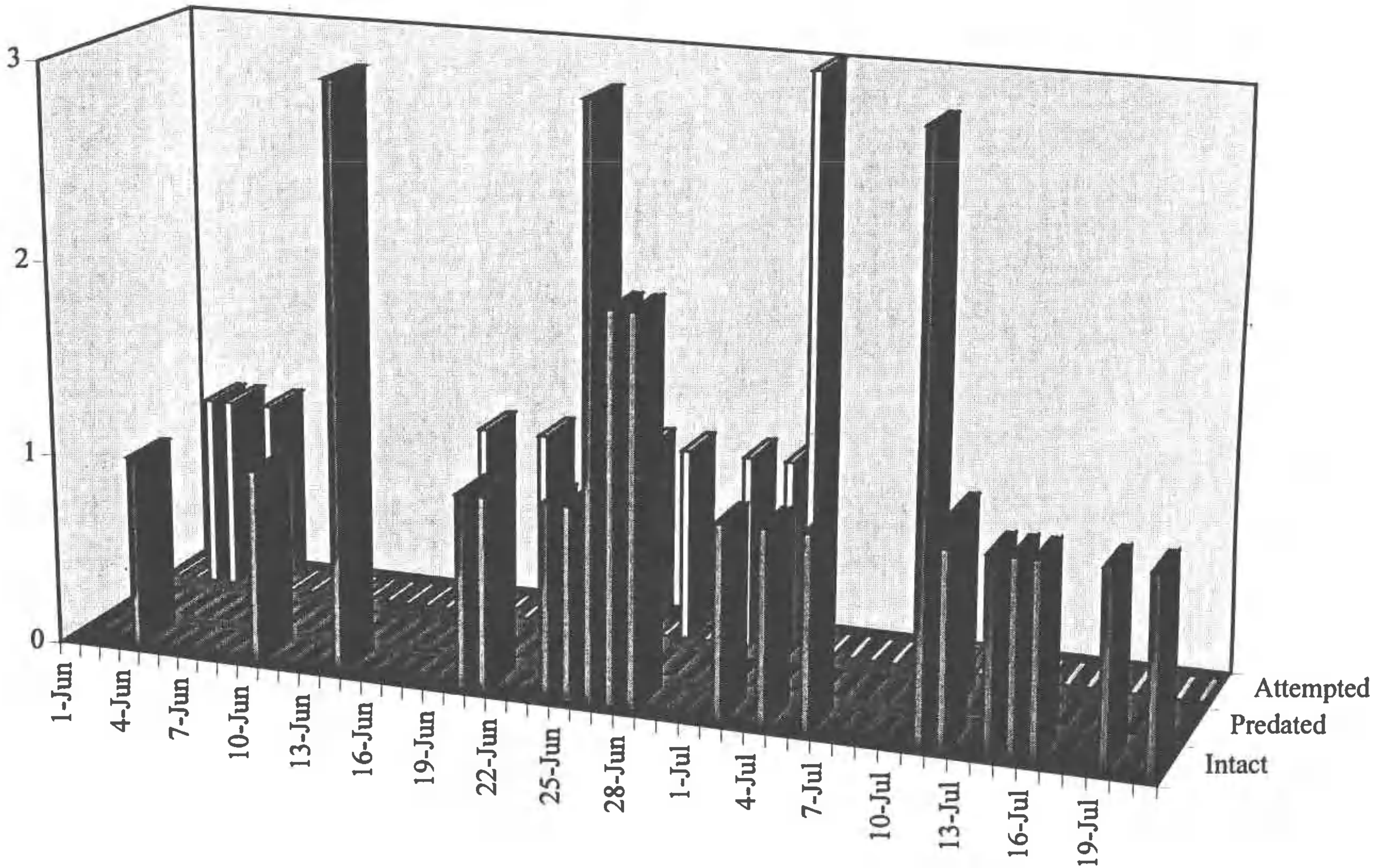


Figure 17. Nesting Dates of All Nest Sites, Fern Ridge Reservoir, Oregon, 1996

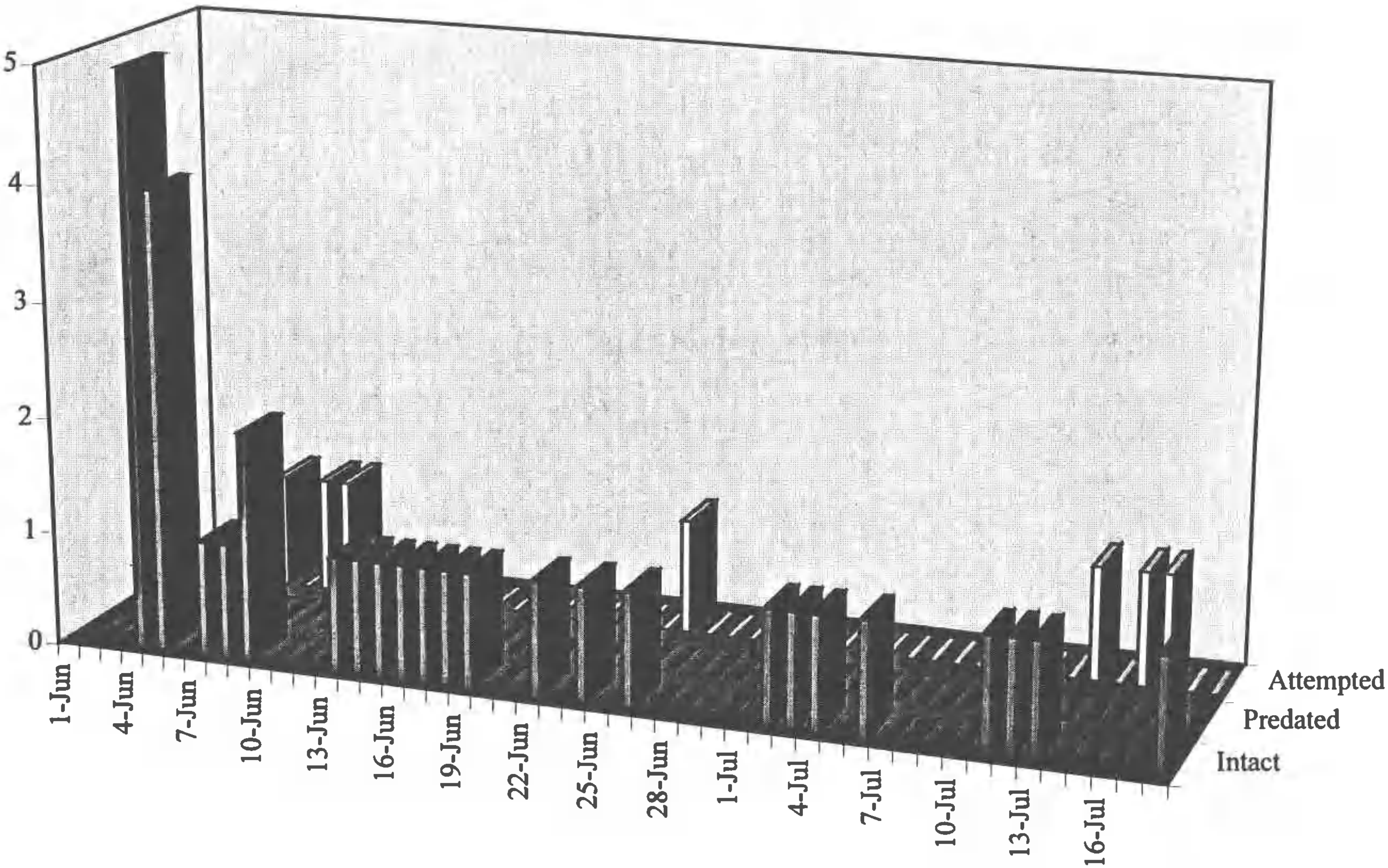


Figure 18. Nesting Dates of All Nest Sites, Fern Ridge Reservoir, Oregon, 1997

Nest Success and Clutch Size:

Of the 122 intact nest sites located at Fern Ridge Reservoir between 1993 and 1997, 10 were 100 percent successful and 13 were partially successful (Table 10). In 1993 and 1995 all nest sites were unsuccessful. Of the 29 nest sites located during 1994, 3 were successful and hatchlings emerged naturally in March, 1995. Of the 42 nest sites located during 1996, 9 were successful and hatchlings emerged naturally in March, 1997.

Table 10. Fate of All Nest Sites, Fern Ridge Reservoir, 1993 - 1997

FATE	1993	1994	1995	1996	1997
SUCCESSFUL / EMERGED	00	03	00	05	00
PARTIALLY SUCCESSFUL / EMERGED	00	00	00	04	00
UNSUCCESSFUL / FAILED TO EMERGE	17	08	14	09	00
INTACT / UNKNOWN	00	00	00	00	12
ATTEMPTED	00	00	05	12	06
UNSUCCESSFUL / DEPREDATED	09	10	00	01	00
UNSUCCESSFUL / VANDALIZED	00	00	05	06	00
EXCAVATED / ODFW - SUCCESSFUL	00	08	00	03	00
EXCAVATED / ODFW - UNSUCCESSFUL	03	00	05	01	00
EXCAVATED / ODFW - UNKNOWN	00	00	00	01	18

Comparisons of nest site success among the different nesting areas was difficult due to the loss of nest sites in some areas to predation and vandalism. Of the 25 intact nest sites covered with predator exclosures in South Applegate between 1993 and 1997, 16 percent were successful. Of the 14 intact nest sites in Tripass, 29 percent were successful, and of the 14 in South Marsh, 29 percent were successful. There were no successful nest sites in North Applegate (n = 11) or Kirk (n = 8). The fate of predator exclosed nest sites and those excavated by ODFW in each nesting area are listed in Tables 11 through 15.

Table 11. Fate of Intact Nest Sites, South Applegate Nesting Area,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Predator Exclosed Nests			ODFW Excavated Nests			Total
	S	U	Unk	S	U	Unk	Intact
1993	00	05	00	00	00	00	05
1994	00	04	00	04	00	00	08
1995	00	08	00	00	05	00	13
1996	04	04	00	00	01	01	10
1997	00	00	00	00	00	14	14

Table 12. Fate of Intact Nest Sites, Tripass Nesting Area,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Predator Exclosed Nests			ODFW Excavated Nests			Total
	S	U	Unk	S	U	Unk	Intact
1993	00	07	00	00	01	00	08
1994	02	01	00	01	00	00	04
1995	00	01	00	00	00	00	01
1996	02	01	00	00	00	00	03
1997	00	00	00	00	00	04	04

Table 13. Fate of Intact Nest Sites, North Applegate Nesting Area,
Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Predator Exclosed Nests			ODFW Excavated Nests			Total
	S	U	Unk	S	U	Unk	Intact
1993	00	02	00	00	02	00	04
1994	00	02	00	01	00	00	03
1995	00	03	00	00	00	00	03
1996	00	02	00	00	00	00	02
1997	00	00	02	00	00	00	02

Table 14. Fate of Intact Nest Sites, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Predator Exclosed Nests			ODFW Excavated Nests			Total
	S	U	Unk	S	U	Unk	Intact
1993	00	03	00	00	00	00	03
1994	01	00	00	00	00	00	01
1995	00	01	00	00	00	00	01
1996	03	01	00	00	00	00	04
1997	00	00	05	00	00	00	05

Table 15. Fate of Intact Nest Sites, Kirk Pond Nesting Area, Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Predator Exclosed Nests			ODFW Excavated Nests			Total
	S	U	Unk	S	U	Unk	Intact
1993	00	00	00	00	00	00	00
1994	00	02	00	02	00	00	04
1995	00	01	00	00	00	00	01
1996	00	00	00	03	00	00	03
1997	00	00	05	00	00	00	05

Clutch size was determined in 57 of the 165 nest sites. Of these, hatchlings emerged naturally from 13, 27 were excavated by ODFW, and 17 were unsuccessful. The unsuccessful nest sites were excavated on 15 April each year to determine clutch size and degree of hatchling development.

Mean clutch size was 7 eggs per clutch (± 2.0, range 2 - 12). Half of all nest sites (n = 57) contained 5 to 8 eggs. Nesting females were located at 5 of the 57 nest sites. Each female was weighed and measured immediately after nest completion (Table 16).

Table 16. Clutch Size and Measurements of Nesting Females at Five Nest Sites, Fern Ridge Reservoir, Oregon, 1996.

Turtle No	CL (mm)	CW (mm)	Wt (g)	# of Annuli	Clutch Size
9014	180	147	> 1,000	> 15	07
8934	165	134	700	> 19	04
9015	164	143	690	--	08
9009	153	119	600	14	05
8971	137	110	620	15	08

<u>Nest Site Characteristics</u>:

Slope:

Mean slope at nest sites located in the five nesting areas at Fern Ridge Reservoir between 1993 and 1997 (n = 165) was 10.33 degrees (± 8.4, range 0 - 40 degrees). Half of all nest sites had slopes between 4 and 17 degrees.

No difference in median values of nest site slope was found among successful (n = 23) and unsuccessful (n = 57) nest sites located between 1994 and 1997 (p = 0.577, Kruskal-Wallis One Way Analysis of Variance on Ranks). Mean slope of successful nest sites was 8.15 degrees (± 8.27), and mean slope of unsuccessful nest sites was 8.08 degrees (± 7.56).

Differences were not found in median values of slope among nest sites located in different nesting areas (p = 0.236, Kruskal-Wallis One Way Analysis of Variance on Ranks).

There were no differences in mean slope among 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36); nest sites (p = 0.221, One Way Analysis of Variance, Tukey Test, Table 17).

Table 17. Mean, Median, and Range of Slope, All Nest Sites, Fern Ridge Reservoir, Oregon, 1993 - 1997.

Year	n =	Mean Slope (degrees)	Median Slope (degrees)	25 - 75% Range	Range
1997	36	6.2	5.0	2 - 10	0 - 20
1996	42	7.7	5.0	0 - 15	0 - 25
1995	29	9.6	9.0	5 - 14	3 - 23
1994	29	9.2	10.0	5 - 11	3 - 30
1993	29	21.3	20.0	18 - 22	10 - 40

One Way Analysis of Variance did not detect a difference in the mean slope among intact (n = 122), attempted (n = 23), and depredated (n = 20) nest sites (p = 0.126).

With the exception of mean slope among actual nest sites and non-nest sites from active quadrats in North Applegate during 1996 (P = 0.020, One Way Analysis of Variance, Tukey Method), there were no differences in mean slope among actual nest sites, and non-nest sites from both active and inactive quadrats during 1996 and 1997 (Table 18 and 19). In North Applegate during 1996, non-nest sites from active quadrats had greater mean slope than actual nest sites.

Table 18. Comparisons of Mean Slope Among Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-Nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1996.

	Actual Nest Sites		Non-Nest Sites Active		Non-Nest Sites Inactive	
	Mean Slope	n =	Mean Slope	n =	Mean Slope	n = -
SA p = 0.401	4.2	15	5.7	30	5.0	30
T p = 0.509	3.3	03	2.0	06	2.0	06
NA p = 0.020	0.0	05	4.6	10	3.0	10
SM p = 0.260	13.7	06	9.4	12	7.0	12
K p = 0.053	13.3	13	6.2	26	7.2	26

Table 19. Comparisons of Mean Slope Among Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1997.

	Actual Nest Sites		Non-Nest Sites Active		Non-Nest Sites Inactive	
	Mean Slope	n =	Mean Slope	n =	Mean Slope	n =
SA p = 0.643	4.5	16	4.1	32	4.9	32
T p = 0.995	4.0	05	3.0	10	2.9	10
NA p = 0.952	4.0	04	3.3	08	3.1	08
SM p = 0.544	11	06	7.3	12	7.8	12
K p = 0.096	10	05	4.1	10	6.0	10

Aspect:

Of all nest sites located between 1993 and 1997 (n = 165), 99.9 percent had either southern aspect or no aspect.

No difference in aspect was detected among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.998, Chi Square Analysis, Fisher Exact Test).

There were no differences in aspect among nest sites located in different nesting areas (p = 0.952), among 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36) nest sites (p = 0.897), or among intact (n = 122), attempted (n = 23), and predated (n = 20) nest sites (p = 0.914, Chi Square Fisher Exact Test).

Differences in aspect were found among actual nest sites, and non-nest sites from both active and inactive quadrats in all five nesting areas during 1996 and 1997 (p = 0.003, Chi Square Analysis, Fisher Exact Test). Of all actual nest sites located during 1996 and 1997, 93 percent had southern slopes or no slope. Of all non-nest sites from active quadrats (n = 156), 62 percent had southern slopes or no slope, and of all non-nest sites from inactive quadrats (n = 156), 59 percent had southern slopes or no slope.

Straight-Line Distance From Water:

Between 1994 and 1997 all nesting females at Fern Ridge Reservoir chose nest sites within 215 meters straight-line distance from water (mean = 81 ± 7.39 meters, n = 136). While nest sites ranged from 0.8 to 215 meters straight-line distance from water, 75 percent were located within 150 meters of the water.

Mean straight-line distance from water among successful nest sites and unsuccessful nest sites was not different (p = 0.020, One Way Analysis of Variance, Tukey Test).

Differences were found in median values of straight-line distance from water among nest sites from different nesting areas (p = 0.001, Kruskal-Wallis One Way Analysis of Variance, Dunn's Method, Table 20).

Table 20. Straight-Line Distance From Water of Nest Sites Located in Different Nesting Areas, Fern Ridge Reservoir, Oregon, 1994 - 1997.

	n =	Mean SLD (m)	Standard Deviation (m)	Median SLD (m)	Range of SLD (m)
SA	54	132.9	± 52.2	141.8	27.3 - 145.07
T	12	48.2	± 6.6	47.9	37.5 - 58.4
NA	16	171.1	± 30.9	160.6	125 - 212
SM	27	5.6	± 1.5	5.7	3 - 8.3
K	27	5.3	± 4.1	4.1	0.8 - 22

A difference was detected in mean straight-line distance from water among 1995 (n = 29) and 1996 (n = 42) nest sites (p = 0.033, One Way Analysis of Variance, Dunn's Method). On average, nest sites located during 1995 were further from the water than 1996 nest sites. Although mean straight-line distance from water differed among the years, the ranges were quite similar (Table 21).

Table 21. Straight-Line Distance From Water of Nest Sites Located During Different Years, Fern Ridge Reservoir, Oregon, 1993 - 1997.

		Straight-Line Distance From Water (meters)			
Year	n =	Mean	Standard Deviation	25 - 75% Range	Range
1997	36	64.45	± 105.6	8.58 - 94.45	0.80 - 194.70
1996	42	58.59	± 110.9	4.50 - 94.00	2.50 - 199.50
1995	29	113.90	± 87.1	6.70 - 198.25	2.40 - 215.00
1994	29	77.58	± 81.5	4.98 - 155.18	3.00 - 212.00
1993	29	109.51	± 76.4	42.85 - 168.25	3.40 - 214.50

There was no difference found in median values of straight-line distance among intact (n = 122), attempted (n = 23), or depredated (n = 20) nest sites (p = 0.097, Kruskal-Wallis One Way Analysis of Variance on Ranks).

In South Applegate, mean straight-line distance from water differed among actual nest sites (n = 78) and non-nest sites from both active (n =156) and inactive (n = 156) quadrats during 1996 and 1997 (p < 0.001, p < 0.001; One Way Analysis of Variance, Dunn's Method, Table 22 and 23). Non-nest sites in both active and inactive quadrats were further from water than actual nest sites.

Table 22. Mean Straight-Line Distance From Water of Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-Nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1996.

	Actual Nest Sites			Non-nest Sites Active			Non-nest Sites Inactive		
	n=	Mean SLD	St Dev	n=	Mean SLD	St Dev	n =	Mean SLD	St Dev
SA	15	93.0	± 47.3	30	231.3	± 55.3	30	195.1	± 54.5
T	03	50.4	± 11.2	06	50.6	± 10.9	06	45.4	± 7.6
NA	05	162.7	± 32.6	10	160.5	± 28.6	10	155.2	± 33.5
SM	06	5.8	± 1.6	12	8.7	± 4.6	12	9.0	± 4.2
K	13	4.4	± 2.2	26	0.6	± 3.5	26	5.6	± 3.7

Table 23. Mean Straight-line Distance From Water of Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-Nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1997.

	Actual Nest Sites			Non-Nest Sites Active			Non-Nest Sites Inactive		
	n =	Mean SLD	St Dev	n =	Mean SLD	St Dev	n =	Mean SLD	St Dev
SA	16	88.3	± 23.9	32	227.7	± 60.6	32	238.9	± 54.2
T	05	47.5	± 1.1	10	40.5	± 11.5	10	39.8	± 9.5
NA	04	149.9	± 2.7	08	159.2	± 34.9	08	220.0	± 33.4
SM	06	5.1	± 1.2	12	4.7	± 2.7	12	3.3	± 2.6
K	05	7.9	± 8.7	10	11.0	± 4.8	10	9.9	± 11.0

Soil Compaction:

Mean soil compaction of the 78 nest sites located during 1996 and 1997 was 45.7 kilograms per square centimeter (± 22.2), and ranged from 26.0 to 96.5 kg/cm.

No differences were detected in median values of soil compaction among successful (n = 12) and unsuccessful (n = 10) nest sites (p = 0.581, Kruskal-Wallis One Way Analysis of Variance on Ranks).

There were differences in mean soil compaction among nest sites in different nesting areas (p < 0.001, One Way Analysis of Variance, Dunn's Method, Table 24). On average, South Applegate nest sites were located in soils less compact than those in Tripass, South Marsh, and Kirk (p < 0.001).

There were no differences in median values of soil compaction among nest sites located during different years (p = 0.397), or among intact (n = 59), attempted (n = 18), and depredated (n = 01) nest sites (p = 0.359, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Table 24. Mean Soil Compaction of Nest Sites in Different Nesting Areas, Fern Ridge Reservoir, Oregon, 1996 - 1997.

Nesting Area	n =	Mean Soil Compaction	Standard Deviation
South Applegate	31	39.0	± 9.6
Tripass	08	69.9	± 7.8
North Applegate	09	46.3	± 8.1
South Marsh	12	73.6	± 16.8
Kirk	18	66.9	± 16.7

Likewise, a One Way Analysis of Variance and Student-Newman Keuls Test did not detect a difference in mean soil compaction among actual nest sites and non-nest sites from both active and inactive quadrats in each nesting area during 1996: (Kirk $p = 0.754$, Tripass $p = 0.245$, South Applegate $p = 0.440$, North Applegate $p = 0.557$, South Marsh $p = 0.069$); and 1997: (Kirk $p = 0.250$, Tripass $p = 0.437$, South Applegate $p = 0.703$, North Applegate $p = 0.274$, South Marsh $p = 0.698$).

Percent Vegetative Ground Cover:

Mean percent vegetative ground cover for all nest sites located during 1996 and 1997 (n = 78) was 65.74 percent (± 28.7, range 0 - 100 percent). Half of all nest sites had between 50 and 87 percent vegetative ground cover.

Mean percent vegetative ground cover differed among successful (n = 12) and unsuccessful (n = 10) nest sites located during 1996 and 1997 ($p = 0.014$, One Way Analysis of Variance, Tukey Test). Successful nest sites (mean = 81.9 ± 18.7, range 35 - 100 percent) tended to have higher percentages of vegetative ground cover than unsuccessful nest sites (mean = 62.3 ± 33.4, range 0 - 100 percent).

Differences were detected in mean percent vegetative ground cover among nest sites located in different nesting areas ($p < 0.001$, One Way Analysis of Variance, Dunn's

Method). North Applegate nest sites had lower percentages of vegetative ground cover than nest sites located in Tripass and Kirk (Table 25).

Table 25. Percent Vegetative Ground Cover of Nest Sites Located in Different Nesting Areas, Fern Ridge Reservoir, Oregon, 1996 - 1997.

Nesting Area	n =	Mean % VGC	St Dev	Range
South Applegate	31	66.7	17.3	0 - 95
Tripass	08	81.9	18.8	50 - 100
North Applegate	09	29.4	28.3	0 - 80
South Marsh	12	61.9	31.5	20 - 95
Kirk	18	77.5	32.6	0 - 100

Mean percent vegetative ground cover among 1996 (n = 42) and 1997 (n = 36) nest sites were different ($p = 0.004$, One Way Analysis of Variance, Tukey Test). Nest sites located during 1996 (mean = 73.9 ± 25.7, range 0 - 100) had greater percentages of vegetative ground cover than 1997 nest sites (mean = 56.3 ± 29.5, range 0 - 90 percent). Of the 42 nest sites located during 1996, 9 had 100 percent vegetative ground cover.

There was no difference in median values of percent vegetative ground cover among intact (n =59), attempted (n = 18), and predated (n = 01) nest sites ($p = 0.271$, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Mean percent vegetative ground cover of nest sites differed among actual nest sites, non-nest sites from active quadrats, and non-nest sites from inactive quadrats during 1996 and 1997 ($p < 0.001$, $p < 0.001$; One Way Analysis of Variance, Tukey Test, Table 26 and 27).

Table 26. Mean Percent Vegetative Ground Cover of Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-Nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1996.

	Actual Nest Sites			Non-Nest Sites Active			Non-Nest Sites Inactive		
	n =	Mean % VGC	St Dev	n =	Mean % VGC	St Dev	n =	Mean % VGC	St Dev
SA p = 0.001	15	67.3	14.3	30	80.2	29.9	30	98.2	5.3
T p = 0.174	03	100.0	0.0	06	85.0	11.8	06	68.3	33.6
NA p = 0.018	05	28.0	21.7	10	27.5	33.4	10	78.0	35.8
SM p = 0.027	06	79.7	22.9	12	65.0	34.7	12	40.4	30.4
K p = 0.001	13	90.4	15.2	26	27.5	30.4	26	39.4	34.3

Table 27. Mean Percent Vegetative Ground Cover of Actual Nest Sites, Non-Nest Sites from Active Quadrats, and Non-Nest Sites from Inactive Quadrats, Fern Ridge Reservoir, Oregon, 1997.

	Actual Nest Sites			Non-Nest Sites Active			Non-Nest Sites Inactive		
	n =	Mean % VGC	St Dev	n =	Mean % VGC	St Dev	n =	Mean % VGC	St Dev
SA p = 0.001	16	88.3	23.9	32	68.1	34.2	32	85.1	24.4
T p = 0.021	05	71.0	15.1	10	91.5	10.0	10	98.0	4.8
NA p = 0.098	04	31.3	38.8	08	67.5	29.7	08	60.0	35.7
SM p = 0.111	06	44.2	30.1	12	62.1	40.6	12	47.9	41.6
K p = 0.087	05	44.0	43.3	10	58.0	34.7	10	38.5	29.9

Percent Overstory Cover:

Mean percent overstory cover for all nest sites located during 1996 and 1997 was 0. There was no difference in percent overstory cover among successful and unsuccessful nest sites, among the five nesting areas, among the years, or among intact, attempted, and predated nest sites.

There was no difference in mean percent overstory cover among actual nest sites and non-nest sites from both active and inactive quadrants during 1996 and 1997.

Vegetation Height:

Mean vegetation height of all nest sites located at Fern Ridge Reservoir during 1996 and 1997 (n = 78) was 4.8 centimeters (± 3.2, range 0 - 20 cm).

No difference was found in median values of vegetation height among successful (n = 12) and unsuccessful (n = 10) nest sites (p = 0.582, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Median values of vegetation height did not differ among nest sites located in different nesting areas (p = 0.110, Kruskal-Wallis One Way Analysis of Variance on Ranks).

No difference was found in median values of vegetation height among 1996 (n = 42) and 1997 (n = 36) nest sites (p = 0.489, Kruskal-Wallis One Way Analysis of Variance on Ranks); or among intact (n = 59), attempted (n = 18), and depredated (n = 01) nest sites (p = 0.930, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Likewise, mean vegetation height did not differ among actual nest sites (n = 78) and non-nest sites from both active (n = 156) and inactive (n = 156) quadrats during 1996 and 1997 (p = 0.174, One Way Analysis of Variance).

Period of Inundation:

Of the 39 nest sites for which period of inundation was monitored during 1995 and 1996, 11 were found to have never been inundated, and 28 were estimated to have been inundated for 70 to 157 days. Mean period of inundation was 88 days (± 58.7), and period of inundation for all nest sites occurred between November and April.

Median values of period of inundation differed among successful (n = 9) and unsuccessful (n = 30) nest sites (p = 0.011, Kruskal-Wallis One Way Analysis of Variance on Ranks, Dunn's Method). On average, unsuccessful nest sites were inundated by water for longer periods of time than were successful nest sites (Table 28).

Table 28. Mean Period of Inundation of Successful and Unsuccessful Nest Sites, Fern Ridge Reservoir, Oregon, 1995 - 1996.

	Period of Inundation (Days per Year)			
	Median	Mean	StDev	Range
Successful (n = 09)	76.0	64.0	51.5	0 - 120
Unsuccessful (n = 30)	127.5	102.7	54.2	0 - 157

Median values of period of inundation differed among nest sites located in different nesting areas ($p < 0.001$, Kruskal-Wallis One Way Analysis of Variance, Dunn's Method). Nest sites located in South Applegate and North Applegate tended to be inundated for longer periods than did nest sites located in Tripass, South Marsh and Kirk (Table 29).

Table 29. Mean Period of Inundation of Nest Sites Located in Different Nesting Areas, Fern Ridge Reservoir, Oregon, 1995 - 1996.

	Period of Inundation (Days Per Year)			
	Median	Mean	StDev	Range
South Applegate (n = 17)	131.0	126.8	29.77	114 - 140
Tripass (n = 04)	77.0	94.7	29.77	76 - 129
North Applegate (n = 05)	146.0	140.6	12.46	129 - 156
South Marsh (n = 09)	0.0	7.7	24.74	0 - 70
Kirk (n = 04)	0.0	19.7	45.61	0 - 79

There were no differences in median values of period of inundation among 1995 ($n = 22$) and 1996 ($n = 17$) nest sites ($p = 0.111$, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Nest Temperature:

Of the 10 nest sites for which nest chamber temperatures were recorded, 3 were successful, 2 were partially successful, 4 were unsuccessful, and one was destroyed by vandalism. Nest chamber temperatures were recorded during different periods depending on the fate of each nest site (Table 30).

Table 30. Nest Chamber Temperatures Calculated at Each Nest Site Monitored by a Stow-Away Data Logger, Fern Ridge Reservoir, Oregon, 1996.

Nest Site Number	Data Logger	Nest Site Fate	Period of Incubation	Day of Emergence	Month of Emergence	Total
01-08-96	0094	S	✓	✓	✓	✓
01-10-96	5052	S	✓	✓	✓	✓
02-01-96	5055	PS	✓			
04-05-96	0096	S	✓	✓	✓	✓
01-12-96	0092	U	✓			✓
01-03-96	0093	U	✓			✓
01-14-96	0095	U	✓			✓
02-03-96	5056	PS	✓	✓	✓	✓
05-11-96	5051	Unk				
01-15-96	5053	U	✓			✓
n =	--	--	09	04	04	08

Comparisons of nest chamber temperatures, ambient temperatures during 1996, and normal ambient temperatures at Fern Ridge Reservoir during the estimated period of incubation are provided in Table 31.

Table 31. Nest Chamber Temperature, 1996 Ambient Temperature, and Normal Ambient Temperature During The Estimated Period of Incubation, Fern Ridge Reservoir, Oregon, 1996.

	1996 Nest Chamber Temperatures (C)			1996 Ambient Temperatures (C) Fern Ridge			Normal Ambient Temperatures (C) Fern Ridge		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
June	--	--	--	29.1	2.2	15.3	29.4	4.8	16.8
July	38.4	14.7	25.1	37.5	6.7	21.0	34.6	7.1	19.8
August	.43.9	14.8	24.4	38.6	3.9	19.4	39.9	6.1	18.9
September	37.9	10.9	18.2	30.2	2.2	15.2	31.5	7.9	17.1
October	22.2	6.9	13.9	28.0	-1.1	11.4	29.4	-0.1	12.4
Average			20.4			16.4			16.2

Mean nest site temperature during the estimated period of incubation (n = 9) was 22.9 degrees Celsius (± 1.65, range 7.4 - 38.4). Mean nest temperature on the day of emergence (n = 4) was 10.7 (± 0.6, range 3.0 - 20.4) degrees Celsius. Mean nest temperature during the month of emergence (n = 4) was 8.7 (± 1.05, range 2.0 - 20.9) degrees Celsius. Mean nest temperature during the total period from oviposition through emergence (or through 12 March for unsuccessful nest sites) was 23.8 (± 1.5, range -8.4 - 68.6) degrees Celsius.

There was no difference in median values of nest chamber temperature during the estimated period of incubation among successful (n = 5) and unsuccessful (n = 4) nest sites (p = 0.111, Kruskal-Wallis One Way Analysis of Variance).

There was no difference in median values of nest chamber temperature during the total period from oviposition through emergence (or 12 March) among successful (n = 5) and unsuccessful (n = 4) nest sites (p = 0.232, One Way Analysis of Variance).

Climatological Data:

Different measurements of precipitation, barometric pressure, and growing degree days were calculated depending on the fate of nest sites located between 1993 and 1997 (Table 32).

Table 32. Climatological Measurements Calculated for Different Nest Sites, Fern Ridge Reservoir, Oregon, 1993 - 1997.

	Day of Nesting	Period of Incubation	Day of Emergence	Mo of Emergence	Total Period	n =
Successful	✓	✓	✓	✓	✓	12
Unsuccessful	✓	✓			✓	48
Unknown	✓	✓				12
Attempted	✓					23
Predated	✓					20
Vandalized	✓					11
ODFW	✓	✓				39
n =	165	111	12	12	60	--

Precipitation:

Mean precipitation on the day of nesting for all nest sites (n = 165) was 0.03 (± 0.08, range 0.00 - 0.41) cm per day. Differences were found in median values of precipitation among days nesting did occur (n = 97) and days nesting did not occur (n = 214) during June and July, 1993 - 1997 (p = 0.015, Kruskal-Wallis One Way Analysis of Variance on Ranks). Mean precipitation was 0.00 cm on days nesting did occur, and 0.21 cm on days nesting did not occur. One Way Analysis of Variance revealed no difference in mean precipitation on the day of nesting among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.562), or among 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n= 42), and 1997(n = 36) nest sites (p = 0.546).

Mean precipitation during the estimated period of incubation for all intact nest sites (n = 111) was 4.5 (± 2.23 , range 0.00 - 9.59) cm. Differences in mean precipitation during the period of incubation were found among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.015, One Way Analysis of Variance, Dunn's Method). Mean precipitation during the period of incubation was 7.08 cm for successful nest sites, and 9.36 cm for unsuccessful nest sites. Differences were also found in mean precipitation during the period of incubation among 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36) nest sites (p = <0.001, One Way Analysis of Variance, Tukey Test). Mean precipitation during the period of incubation was greater during 1993 (mean = 9.23 ± 0.77 cm) and 1995 (mean = 9.74 ± 1.79 cm) than during 1994 (mean = 3.84 ± 0.77 cm) ,1996 (mean = 6.41 ± 2.59), and 1997 (mean = 4.62 ± 2.31 cm).

Mean precipitation on the day of emergence for all successful nest sites (n = 12) was 0.00 cm per day. Mean precipitation during the month of emergence for all successful nest sites (n = 12) was 13.6 (± 2.51, range 11.46 - 15.71) cm. Mean precipitation during the total period from oviposition through emergence (or 12 March) of all intact nest sites (n = 60) was 122.30 (± 2.35, range 119.23 - 125.13) inches.

There were no differences in median values of precipitation during the month of emergence during 1994 and 1996 among days hatchlings emerged (n = 6), and days hatchlings did not emerge (n = 25); (p = 0.972, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Differences were not detected in mean precipitation during the total period from oviposition through emergence (or 12 March) among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.3920, or among 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36) nest sites (p = 0.886, One Way Analysis of Variance, Dunn's Method).

Barometric Pressure:

Mean barometric pressure on the day of nesting of all nest sites (n = 165) was 741.25 (± 3.5, range 726.50 - 745.75) mm of Mercury. There were no differences in median values of barometric pressure among days nesting did occur (n = 97) and days nesting did not occur (n = 214) during June and July, 1993 - 1997 (p = 0.995, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Mean barometric pressure on the day of emergence for all successful nest sites located during 1994 and 1996 (n = 12) was 743.00 (± 3.00, range 740.25 - 747.50) mm of

Mercury. There were no differences in median values of barometric pressure during the month of emergence in 1994 and 1996 among days hatchlings emerged (n = 6) and days hatchlings did not emerge (n = 25); (p = 0.972, Kruskal-Wallis One Way Analysis of Variance).

Growing Degree Days:

Mean growing degree days on the day of nesting of all nest sites (n = 165), was 12.3 (± 0.14, range 5.0 - 30.0). There were no differences in median values of growing degree days among days nesting did occur (n = 97) and days nesting did not occur (n = 214) during June and July, 1993 - 1997 (p = 0.0441, Kruskal-Wallis One Way Analysis of Variance on Ranks). One Way analysis of Variance revealed no difference in mean growing degree days on the day of nesting among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.811), or among 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36) nest sites; (p = 0.829).

Mean growing degree days during the period incubation for all intact nest sites (n = 111) was 1416 (± 81.7, range 1221 - 1596). Differences were found in mean growing degree days during the period of incubation among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.002, One Way Analysis of Variance). Mean growing degree days during the period of incubation was 1427 (range 1379 - 1441) for successful nest sites, and 1317 (range 1221 - 1496) for unsuccessful nest sites. Differences were found in mean growing degree days during the period of incubation among 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n = 42), and 1997 (n = 36) nest sites (p < 0.001, One Way Analysis of Variance, Tukey Test). Mean growing degree days during the period of incubation was greater during 1994 (mean = 1529 ± 36.9) and 1996 (mean = 1486 ± 64.83) than during 1993 (mean = 1363 ± 27.5), 1995 (mean = 1372 ± 81.1), and 1997 (mean = 1371 ± 42.2).

Mean growing degree days on the day of emergence for all successful nest sites (n = 12) was 0.22 (± 0.67, range 0.0 - 2.0). There were no differences in median values of growing degree days during the month of emergence in 1994 and 1996, among days hatchlings emerged (n = 6) and days hatchlings did not emerge (n = 25); (p = 0.354, Kruskal-Wallis One Way Analysis of Variance on Ranks).

Differences were not found in mean growing degree days for the total period from oviposition through emergence (or 12 March) among successful (n = 12) and unsuccessful (n = 48) nest sites (p = 0.349, One Way Analysis of Variance, Dunn's Method).

Hatchling Emergence and Telemetry Results:

Hatchling emergence data collected during 1992, 1994, and 1996 indicate WPT hatchlings at Fern Ridge Reservoir overwinter in the nest chamber and emerge the following spring.

In 1993, two hatchlings, presumably from 1992 nest sites, were found in terrestrial locations near Tripass Cove on 14 and 22 May. One hatchling was found basking on a small piece of vegetation in a shallow (2.5 cm) puddle near Tripass Cove. The second hatchling was located near a shallow *Juncus* wetland in a cow-hoofprint containing a small amount of muddy water. Both hatchlings were immediately transported to Theresa DeLorenzo, a Portland Rehabilitator, and raised in an artificial environment until the end of the following summer. After the hatchlings had reached approximately 70 mm CL, they were returned to Fern Ridge and released in Tripass Cove.

In 1995, 3 predator exclosed WPT nest sites located during the 1994 nesting season emerged naturally on 02 and 03 March, 1995. Two of the nest sites were in Tripass, and the other was in South Marsh. All hatchlings were immediately removed from the exclosures and transported to ODFW. After these hatchlings had reached approximately 70 mm CL, they were released back into Fern Ridge.

Of the 25 intact nest sites remaining through the winter of 1996, 9 hatched and emerged naturally in March, 1997. Two of the nest sites were in Tripass, 3 in South Marsh, and 4 in South Applegate. A total of 28 hatchlings emerged from these 9 nest sites. Two of the nest sites from South Marsh and 3 from South Applegate were 100 percent successful; accounting for 16 of the 28 hatchlings. Clutch size and percent hatching success of each nest site is provided in Table 33.

Table 33. Percent Hatching Success and Clutch Size of Naturally Emerged Nest Sites, Fern Ridge Reservoir, Oregon, 1996.

Nest Site	Nesting Area	Clutch Size	# of Live Hatchlings	% Success
04-01-96	South Marsh	04	03	75
04-04-96	South Marsh	04	04	100
04-05-96	South Marsh	02	02	100
02-01-96	Tripass	06	05	83
02-03-96	Tripass	06	02	33
01-07-96	South Applegate	05	05	100
01-03-96	South Applegate	07	02	29
01-10-96	South Applegate	02	02	100
01-08-96	South Applegate	03	03	100

Of 11 intact nest sites located in South Applegate during 1996, 4 were successful and emerged. Of 3 intact nest sites in Tripass during 1996, 2 were successful and emerged, and of 5 intact nest sites in South Marsh during 1996, 3 were successful and emerged.

Hatchling emergence was difficult to detect. Although one of the nest sites had a 2 cm diameter hole in the nest plug leading down into the nest chamber, four had 0.25 by 0.5 cm slits in the nest plug which appeared to small for a hatchling too emerge through, and four nest sites did not appear to have any opening leading into the nest chamber. With the exception of the nest site with the visible hole in the plug, all emerging nest sites were discovered during the daily examination of vegetation immediately surrounding the nest plug. Of the 28 hatchlings, 27 were found outside of the nest chamber, buried under mud, rocks, moss, and vegetation. One hatchling was found in the nest chamber sitting in approximately 4 cm of water with its head slightly above the surface. Mean CL of all hatchlings (n = 28) was 29.3 mm (range 26.4 - 32.3), and mean weight was 5.7 grams (range 3.7 - 6.8).

Table 34. Hatchling Data, South Applegate Nesting Area,
Fern Ridge Reservoir, Oregon, 1996.

Nest Site	Emergence Date	Hatchling ID	CL (mm)	CW (mm)	CD (mm)	Wt (g)
01-07-96	22 March 96	01-7a-96	29.1	27.9	14.9	5.3
01-07-96	22 March 96	01-7b-96	27.6	26.7	14.7	5.1
01-07-96	22 March 96	01-7c-96	27.9	27.0	14.9	5.4
01-07-96	22 March 96	01-7d-96	28	26.4	15.2	5.5
01-07-96	22 March 96	01-7e-96	29.6	28.1	14.6	5.5
01-03-96	23 March 96	01-3a-96	28.6	27.8	15.0	5.2
01-03-96	23 March 96	01-3b-96	28.9	27.8	15.2	5.6
01-10-96	23 March 96	01-10a-96	30.2	29.3	15.6	6.1
01-10-96	23 March 96	01-10b-96	29.9	29.0	15.4	6.0
01-08-96	24 March 96	01-8a-96	26.6	25.9	14.8	3.9
01-08-96	24 March 96	01-8b-96	26.9	26.0	14.6	3.9
01-08-96	24 March 96	01-8c-96	27.3	26.5	15.0	4.4

Table 35. Hatchling Data, Tripass Nesting Area,
Fern Ridge Reservoir, Oregon, 1996.

Nest Site	Emergence Date	Hatchling ID	CL (mm)	CW (mm)	CD (mm)	Wt (g)
02-01-96	13 March 96	02-1a-96	32.3	28.2	15.1	6.8
02-01-96	13 March 96	02-1b-96	30.1	28.4	15.3	5.9
02-01-96	13 March 96	02-1c-96	30.8	28.6	15.2	5.9
02-01-96	13 March 96	02-1d-96	32.1	29.1	15.4	6.1
02-01-96	13 March 96	02-1e-96	31.8	30.0	15.6	6.2
02-03-96	13 March 96	02-3a-96	29.4	28.7	15.5	5.5
02-03-96	13 March 96	02-3b-96	29.6	28.6	15.2	5.4

Table 36. Hatchling Data, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 1996.

Nest Site	Emergence Date	Hatchling ID	CL (mm)	CW (mm)	CD (mm)	Wt (g)
04-01-96	13 March 97	04-1a-96	30.5	29.9	15.4	6.4
04-01-96	13 March 97	04-1b-96	32.2	30.4	15.8	6.3
04-01-96	13 March 97	04-1c-96	31.8	30.5	14.8	6.3
04-04-96	13 March 97	04-4a-96	30.4	30.0	14.9	5.7
04-04-96	13 March 97	04-4b-96	26.4	24.8	13.6	3.7
04-04-96	13 March 97	04-4c-96	27.2	27.1	13.6	4.1
04-04-96	13 March 97	04-4d-96	27.0	26.3	14.8	4.5
04-05-96	13 March 97	04-5a-96	30.3	28.9	15.8	5.8
04-05-96	13 March 97	04-5c-96	28.3	28.3	15.6	5.3

Mean length of time hatchlings were tracked was 193 hours (range 3 - 1560). Mean distance traveled by hatchlings was 3.3 meters (range 0.1 - 17.4). Mean distance traveled per day by hatchlings was 0.76 meters (range 0.003 - 4.9). Greatest distance traveled by a hatchling in one day was 5.8 meters.

Hatchlings were very lethargic. It was not uncommon for them to remain seemingly motionless for several days. Hatchlings were never observed moving to another location, but stayed hidden under mud and vegetation.

Hatchlings emerged from the nest site in random directions regardless of nest site slope, aspect, or proximity to the water. Of the 28 hatchlings, 11 traveled south upon initial emergence from the nest exclosure, 8 traveled north, 5 west, and 4 east. Half of the hatchlings moved toward the water, and half moved away from the water. Of hatchlings emerging from nest sites having > 5 degree slope (n = 9), 4 traveled up slope, and 5 traveled down slope.

Descriptions and illustrations of individual hatchling movements are provided in Tables 37 - 45 and Figures 19 - 27.

Table 37. Post-Emergence Hatchling Movement Data, Nest Site Number 04-01-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 02 April, 1997.

	Hatchling 04-1a-96	Hatchling 04-1b-96	Hatchling 04-1c-96
Date of Emergence:	13 March 97	13 March 97	13 March 97
Tracking Method:	Orange Fluorescent Dye, Magnetic Locator	Orange Fluorescent Dye, Transmitter # 831	Orange Fluorescent Dye, Magnetic Locator
Dates Tracked:	13 - 21 March 97	13 - 28 March 97	13 March - 02 April 97
Total Distance Tracked:	0.3 meters	2.1 meters	2.7 meters
Ave Distance Traveled Per Day:	0.03 meters	0.13 meters	0.13 meters
Greatest Distance Traveled in 1 Day:	0.3 meters	1.0 meters	1.5 meters
Slope of Nest Site:	21 degrees	21 degrees	21 degrees
Aspect of Nest Site:	SE	SE	SE
Initial Direction Traveled From Nest Site:	South-Southeast, toward water	East, away from water	North, away from water

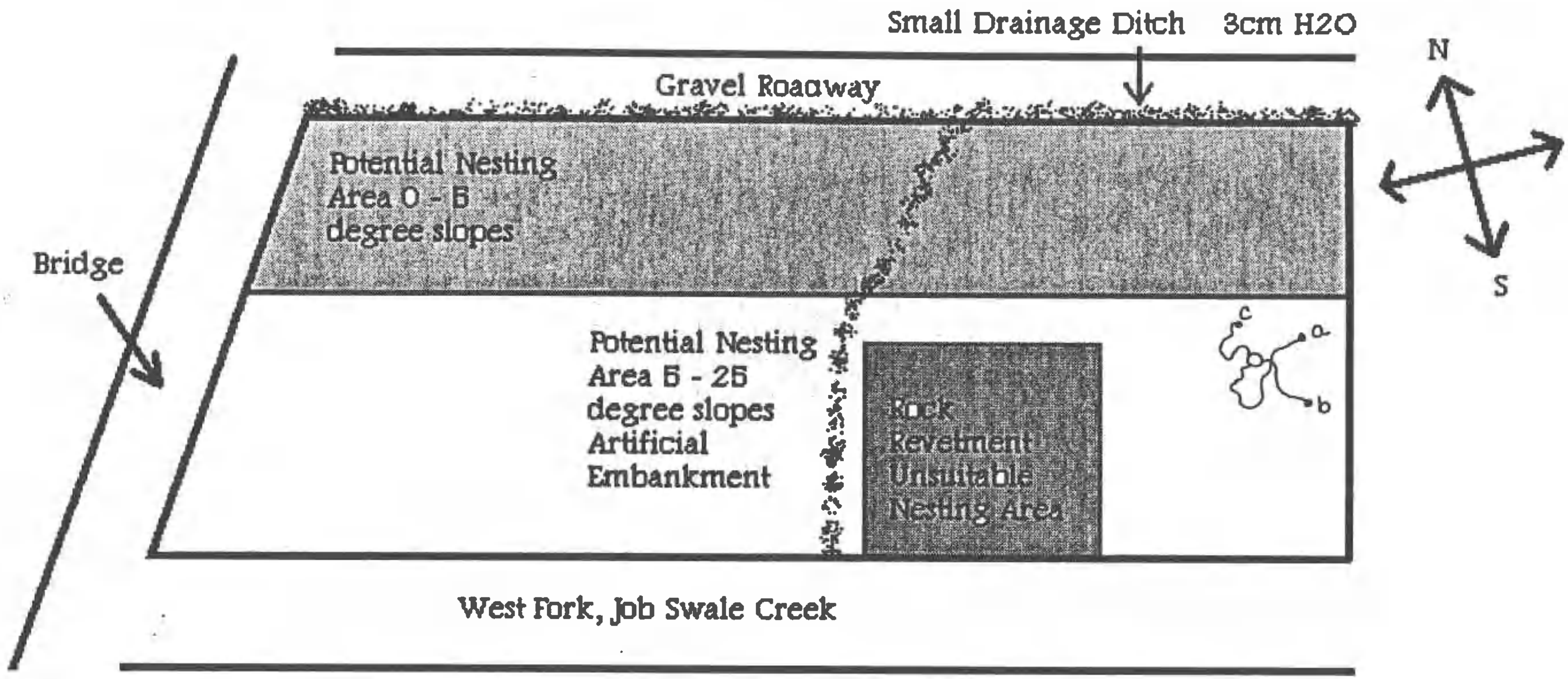


Figure 19. Post-Emergence Hatchling Movements, Nest Site Number 04-01-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 02 April, 1997.

Table 38. Post-Emergence Hatchling Movement Data, Nest Site Number 04-04-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March 1997.

	Hatchling 04-4a-96	Hatchling 04-4b-96	Hatchling 04-4c-96	Hatchling 04-4d-96
Date of Emergence:	13 March 97	13 March 97	13 March 97	13 March 97
Tracking Method:	Pink Fluorescent Dye	Pink Fluorescent Dye	Pink Fluorescent Dye	Pink Fluorescent Dye
Dates Tracked:	13 March 97	13 March 97	13 March 97	13 March 97
Total Distance Tracked:	1.0 meter	1.5 meters	2.2 meters	0.2 meters
Ave Distance Traveled Per Day:	1.0 meter	1.5 meters	2.2 meters	0.2 meters
Greatest Distance Traveled in 1 Day:	1.0 meter	1.5 meters	2.2 meters	0.2 meters
Slope of Nest Site:	21 degrees	21 degrees	21 degrees	21 degrees
Aspect of Nest Site:	SE	SE	SE	SE
Initial Direction Traveled From Nest Site:	Northeast, away from water	Southeast, toward water	South, toward water	Southwest, toward water

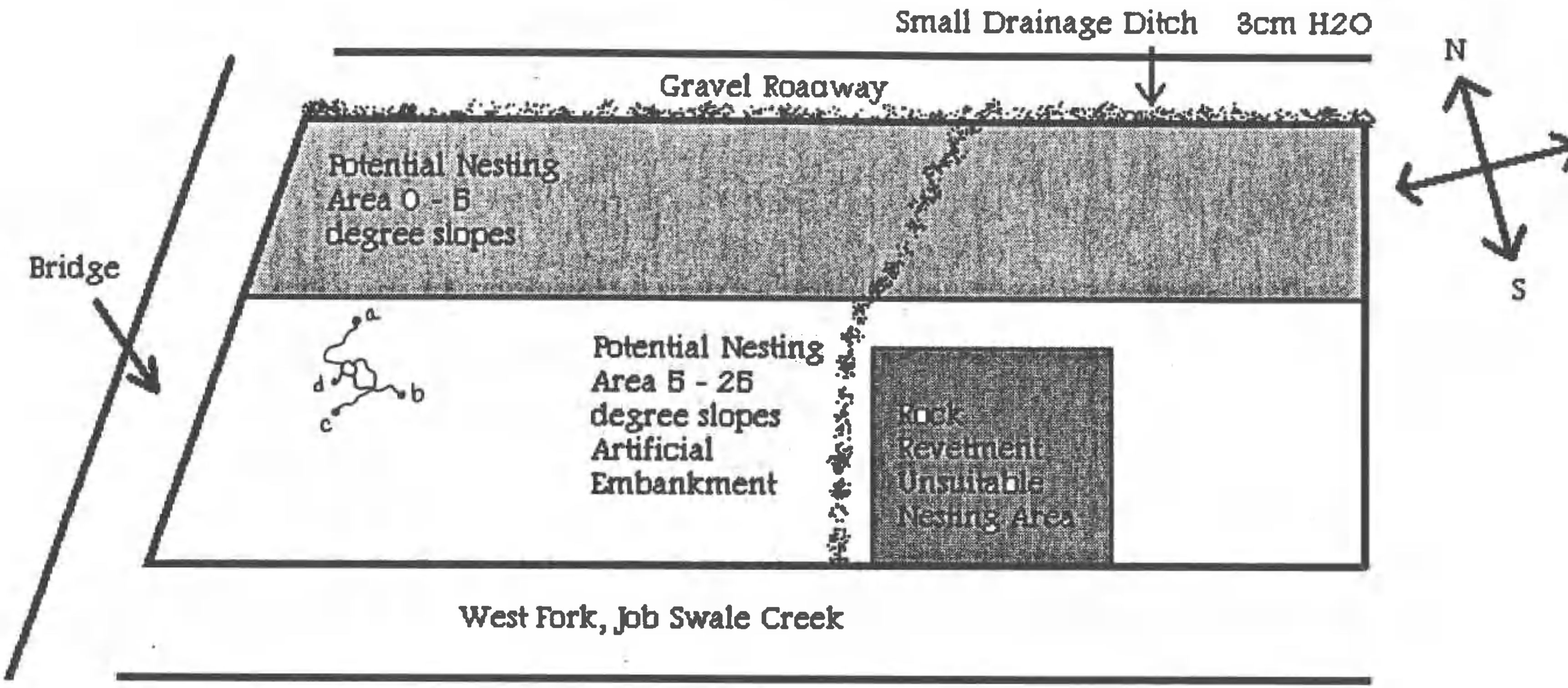


Figure 20. Post-Emergence Hatchling Movements, Nest Site Number 04-04-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March, 1997.

Table 39. Post-Emergence Hatchling Movement Data, Nest Site Number 04-05-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 17 May, 1997.

	Hatchling 04-5a-96	Hatchling 04-5b-96
Date of Emergence:	13 March 97	13 March 97
Tracking Method:	Orange Fluorescent Dye	Orange Fluorescent Dye
	Transmitter # 002	Magnetic Locator
Dates Tracked:	13 - 17 May 97	13 March - 15 April 97
Total Distance Tracked:	17.4 meters	0.1 meters
Ave Distance Traveled Per Day:	0.27 meters	0.003 meters
Greatest Distance Traveled in 1 Day:	5.8 meters	0.1 meters
Slope of Nest Site:	0 degrees	0 degrees
Aspect of Nest Site:	--	--
Initial Direction Traveled From Nest Site:	South, away from water	East, away from water

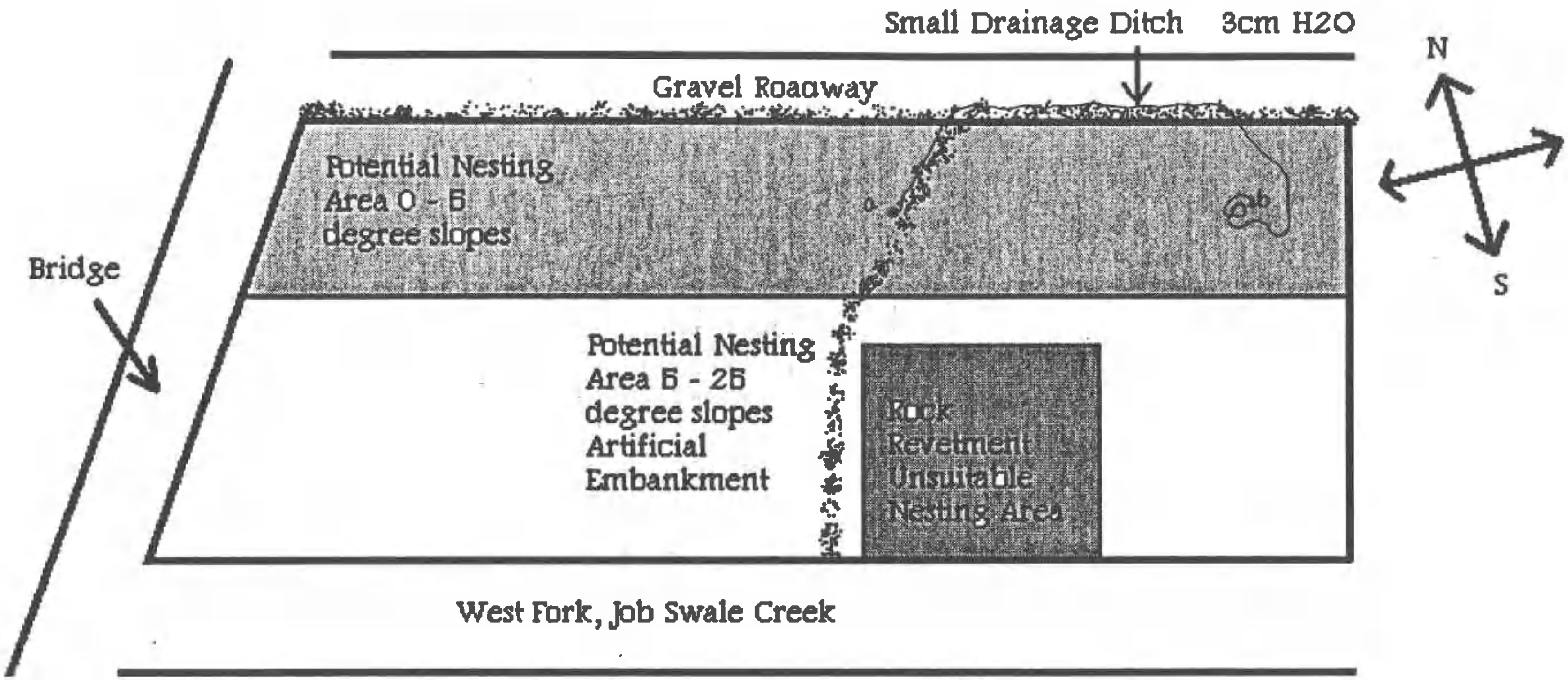


Figure 21. Post-Emergence Hatchling Movements, Nest Site Number 04-05-96, South Marsh Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 17 May, 1997.

Table 40. Post-Emergence Hatchling Movement Data, Nest Site Number 02-01-96, Tripass Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 09 April, 1997.

	Hatchling 02-1a-96	Hatchling 02-1b-96	Hatchling 02-1c-96	Hatchling 02-1d-96	Hatchling 02-1e-96
Date of Emergence:	13 March 97	13 March 97	13 March 97	13 March 97	13 March 97
Tracking Method:	Orange Dye, Magnetic Locator	Orange Dye, Magnetic Locator	Orange Dye, Magnetic Locator	Orange Dye, Transmitter # 820	Orange Dye, Magnetic Locator
Dates Tracked:	13 - 28 March 97	13 - 19 March 97	13 - 28 March 97	13 Mar - 9 April 97	13 - 24 March 97
Total Distance Tracked:	1.3 meters	0.8 meters	0.5 meters	0.1 meters	2.9 meters
Ave Distance Traveled Per Day:	0.07 meters	0.13 meters	0.03 meters	0.004 meters	0.26 meters
Greatest Distance Traveled in 1 Day:	1.1 meters	0.3 meters	0.5 meters	0.1 meters	1.4 meters
Slope of Nest:	5 degrees	5 degrees	5 degrees	5 degrees	5 degrees
Aspect of Nest:	S	S	S	S	S
Initial Direction Traveled:	North, away from water	South, toward water	West, away from water	Southeast, toward water	Northeast, toward water

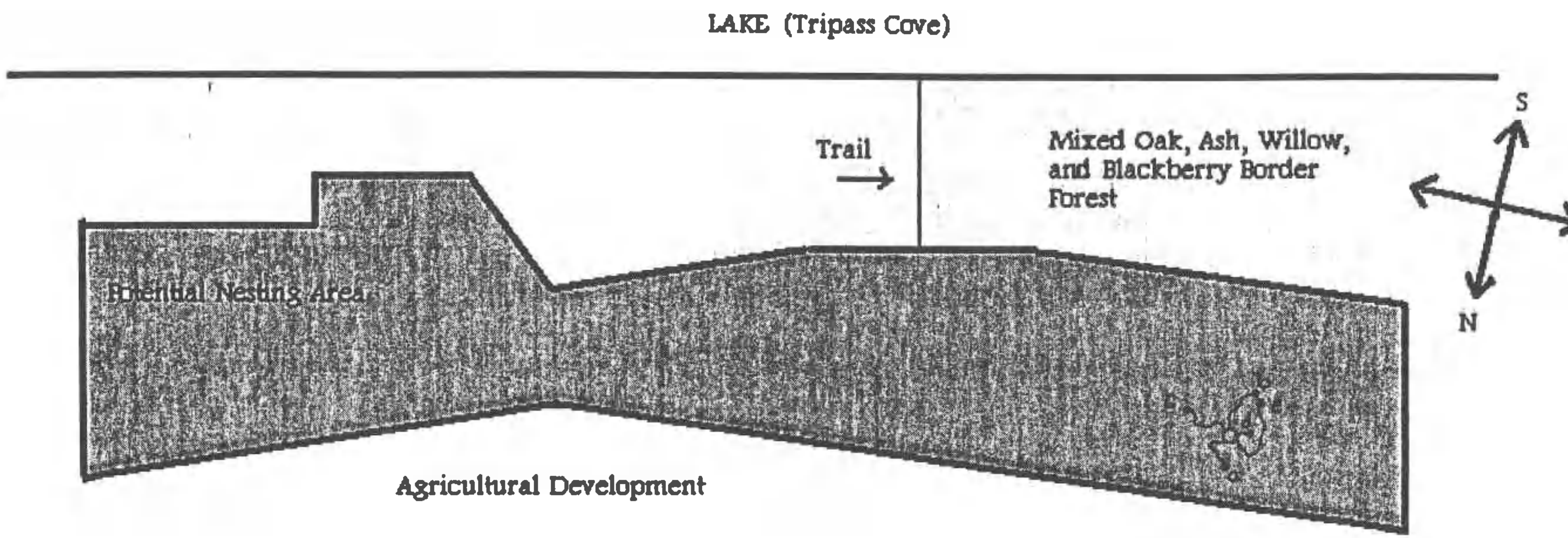


Figure 22. Post-Emergence Hatchling Movements, Nest Site Number 02-01-96, Tripass Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 28 March, 1997.

Table 41. Post-Emergence Hatchling Movement Data, Nest Site Number 02-03-96, Tripass Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 27 March, 1997.

	Hatchling 02-3a-96	Hatchling 02-3b-96
Date of Emergence:	13 March 97	13 March 97
Tracking Method:	Pink Fluorescent Dye	Pink Fluorescent Dye
	Magnetic Locator	Transmitter # 851
Dates Tracked:	13 - 24 March 97	13 - 27 March 97
Total Distance Tracked:	0.4 meters	0.6 meters
Ave Distance Traveled Per Day:	0.04 meters	0.04 meters
Greatest Distance Traveled in 1 Day:	0.4 meters	0.3 meters
Slope of Nest Site:	0 degrees	0 degrees
Aspect of Nest Site:	--	--
Initial Direction Traveled From Nest Site:	East, away from water	North, away from water

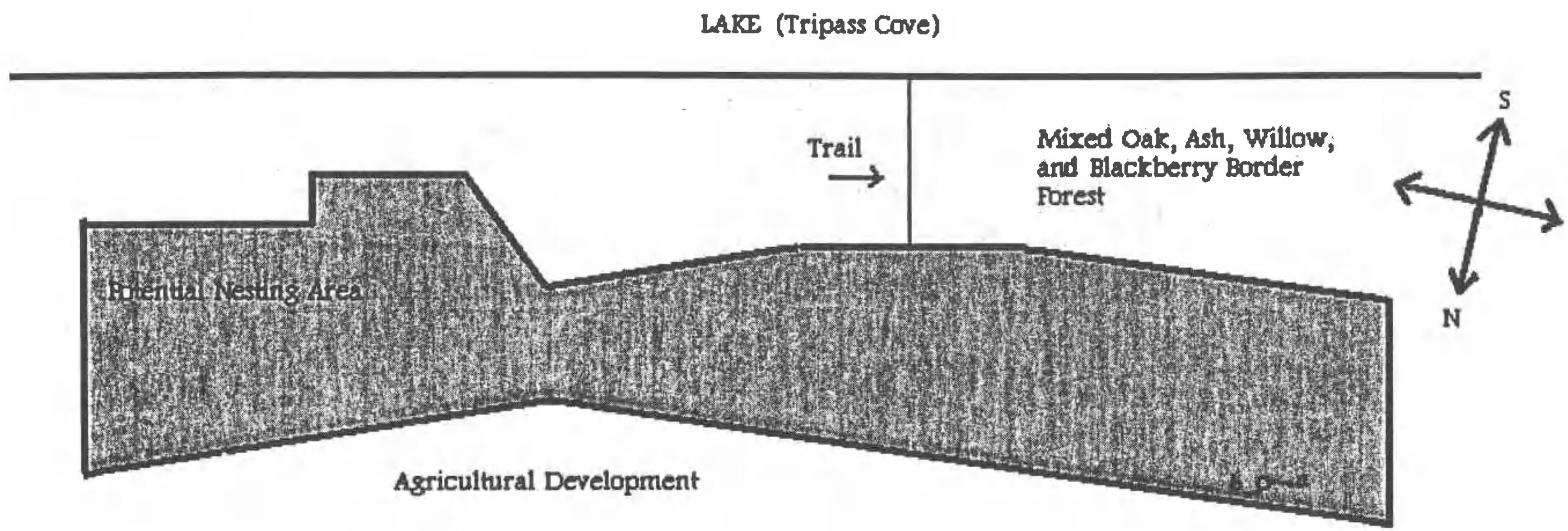


Figure 23. Post-Emergence Hatchling Movements, Nest Site Number 02-03-96, Tripass Nesting Area, Fern Ridge Reservoir, Oregon, 13 March - 27 March, 1997.

Table 42. Post-Emergence Hatchling Movement Data, Nest Site Number 01-03-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 23 March - 04 April, 1997.

	Hatchling 01-3a-96	Hatchling 01-3b-96
Date of Emergence:	23 March 97	23 March 97
Tracking Method:	Orange Fluorescent Dye, Magnetic Locator	Orange Fluorescent Dye, Magnetic Locator
Dates Tracked:	23 March - 04 April 97	23 March - 01 April 97
Total Distance Tracked:	4.0 meters	1.1 meters
Ave Distance Traveled Per Day:	0.31 meters	0.11 meters
Greatest Distance Traveled in 1 Day:	2.0 meters	0.6 meters
Slope of Nest Site:	0	0
Aspect of Nest Site:	--	--
Initial Direction Traveled From Nest Site:	North, away from water	West, away from water

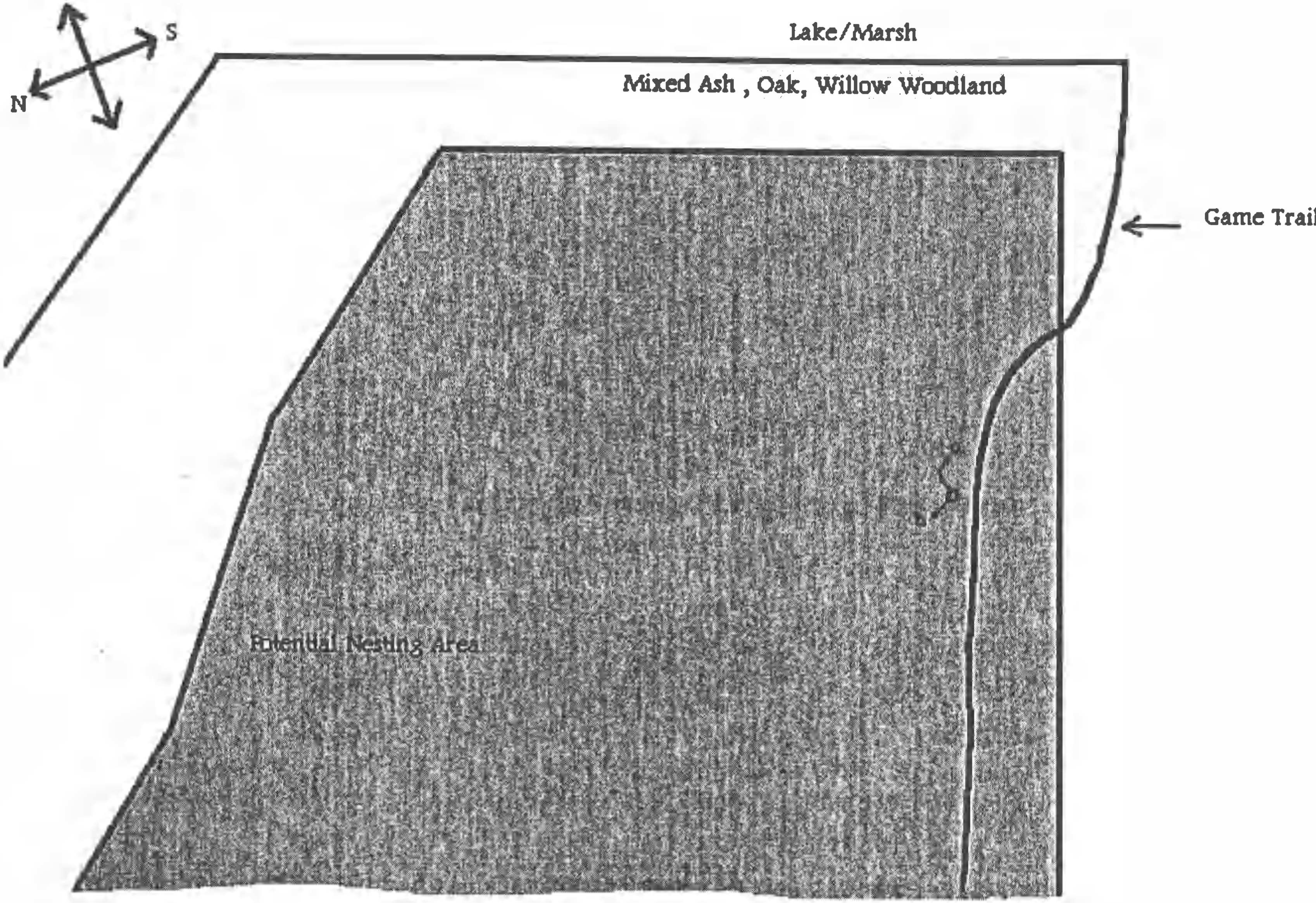


Figure 24. Post-Emergence Hatchling Movements, Nest Site Number 01-03-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 23 March - 04 April, 1997.

Table 43. Post-Emergence Hatchling Movement Data, Nest Site Number 01-07-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 22 March - 30 March, 1997.

	Hatchling 01-7a-96	Hatchling 01-7b-96	Hatchling 01-7c-96	Hatchling 01-7d-96	Hatchling 01-7e-96
Date of Emergence:	22 March 97	22 March 97	22 March 97	22 March 97	22 March 97
Tracking Method:	Pink Dye, Magnetic Locator	Pink Dye, Transmitter # 840	Pink Dye, Magnetic Locator	Pink Dye, Magnetic Locator	Pink Dye, Magnetic Locator
Dates Tracked:	22 - 30 March 97	22 - 23 March 97	22 - 26 March 97	22 - 27 Mar 97	22 - 30 March 97
Total Distance Tracked:	1.0 meters	1.0 meters	0.7 meters	3.2 meters	0.4 meters
Ave Distance Traveled Per Day:	0.12 meters	1.0 meters	0.18 meters	0.64 meters	0.05 meters
Greatest Distance Traveled in 1 Day:	1.0 meters	1.0 meters	0.5 meters	1.4 meters	0.4 meters
Slope of Nest:	5 degrees	5 degrees	5 degrees	5 degrees	5 degrees
Aspect of Nest:	S	S	S	S	S
Initial Direction Traveled:	Northeast, away from water	East, away from water	Southeast, away from water	Southwest, toward water	West, toward water

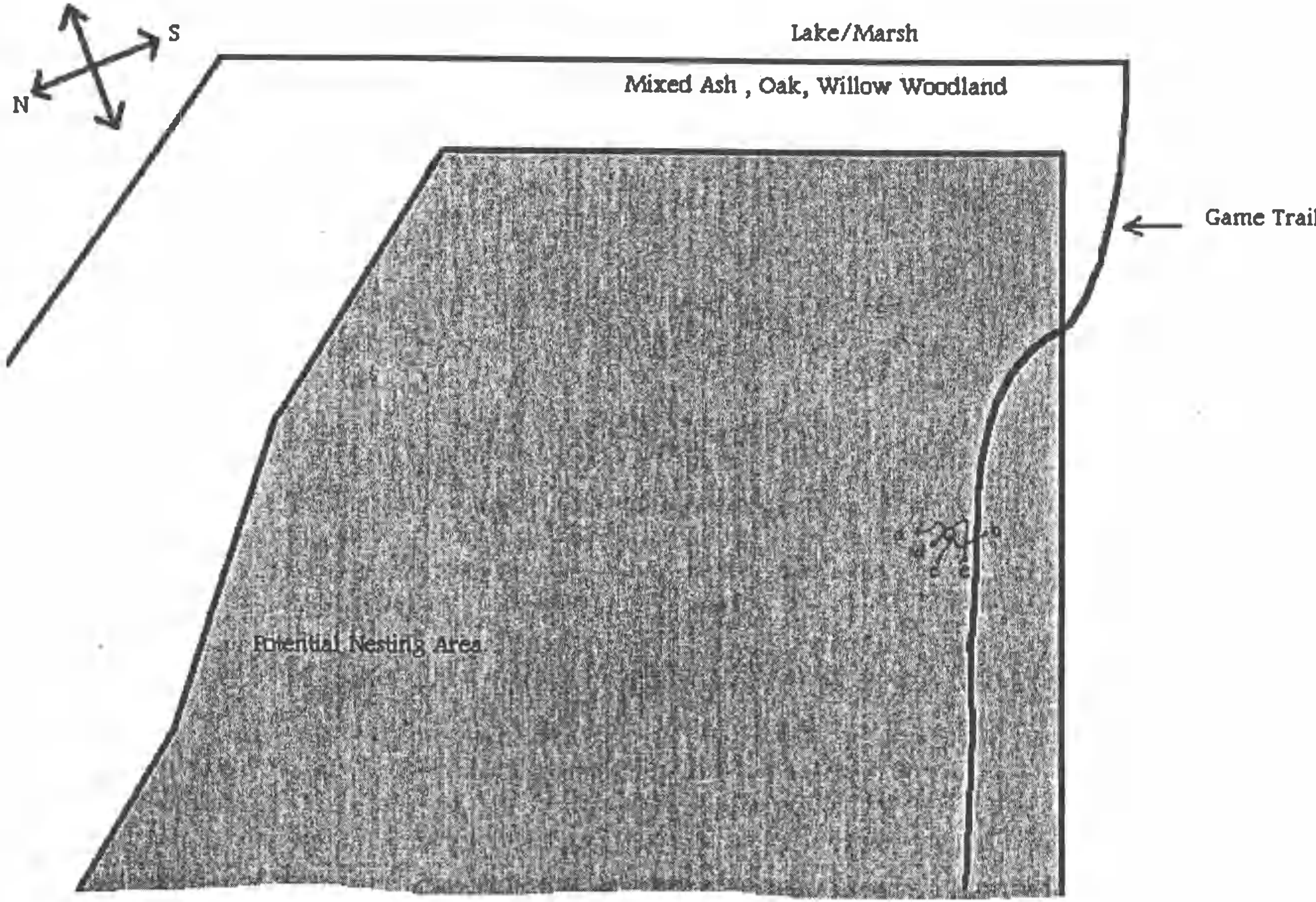


Figure 25. Post-Emergence Hatchling Movements, Nest Site Number 01-07-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 22 March - 30 March, 1997.

Table 44. Post-Emergence Hatchling Movement Data, Nest Site Number 01-08-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 24 March - 06 April, 1997.

	Hatchling 01-8a-96	Hatchling 01-8b-96	Hatchling 01-8c-96
Date of Emergence:	24 March 97	24 March 97	24 March 97
Tracking Method:	Orange Fluorescent Dye Magnetic Locator	Orange Fluorescent Dye Magnetic Locator	Orange Fluorescent Dye Magnetic Locator
Dates Tracked:	24 - 25 March 97	24 March - 06 April 97	24 March - 04 April 97
Total Distance Tracked:	2.9 meters	0.2 meters	5.0 meters
Ave Distance Traveled Per Day:	2.9 meters	0.02 meters	0.45 meters
Greatest Distance Traveled in 1 Day:	2.9 meters	0.2 meters	2.0 meters
Slope of Nest Site:	5 degrees	5 degrees	5 degrees
Aspect of Nest Site:	SE	SE	SE
Initial Direction Traveled From Nest Site:	Northwest, away from water	West, toward water	South, toward water

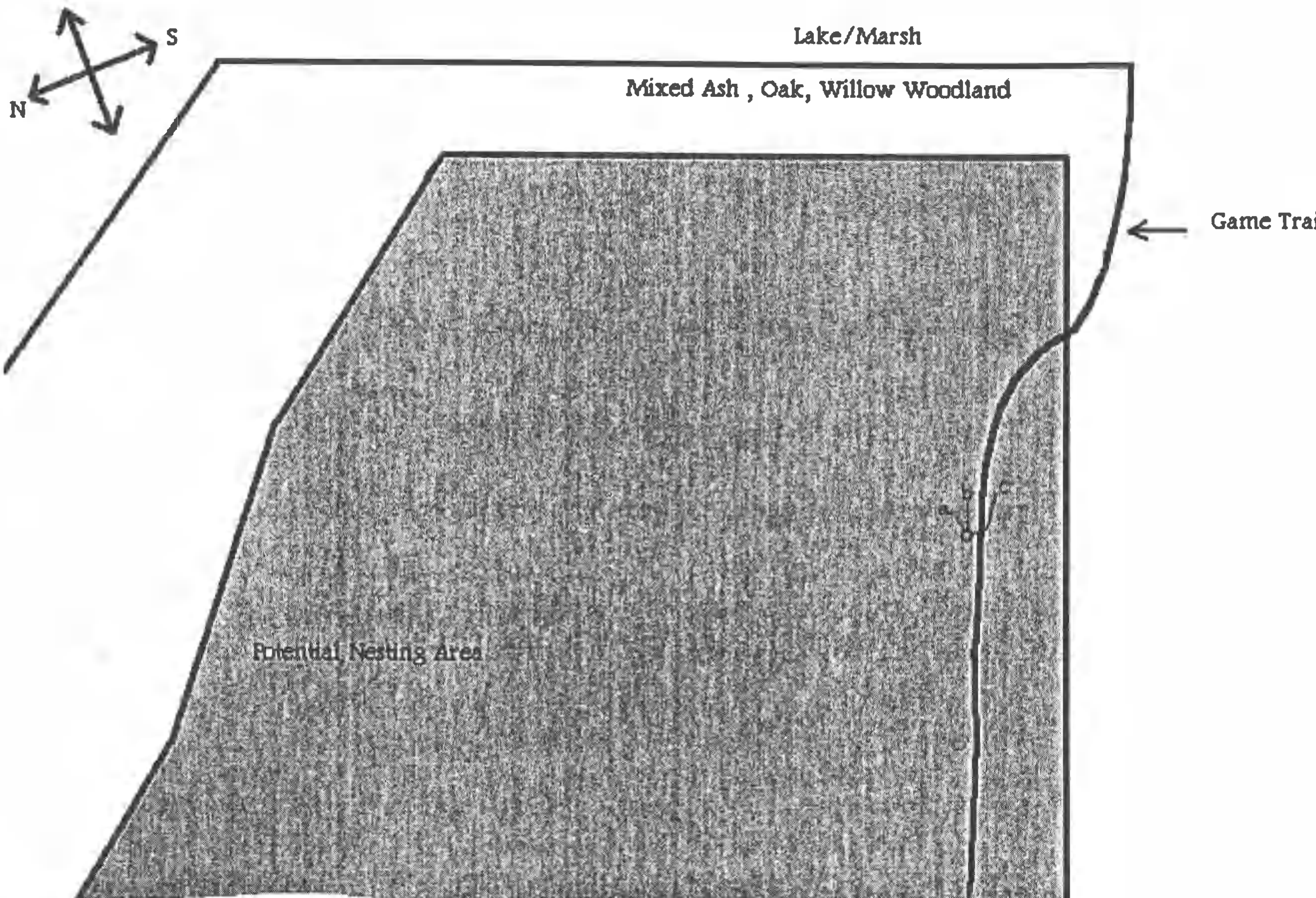


Figure 26. Post-Emergence Hatchling Movements, Nest Site Number 01-08-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 24 March - 06 April, 1997.

Table 45. Post-Emergence Hatchling Movement Data, Nest Site Number 01-10-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 23 March - 10 April, 1997.

	Hatchling 01-10a-96	Hatchling 01-10b-96
Date of Emergence:	23 March 97	23 March 97
Tracking Method:	Pink Fluorescent Dye, Magnetic Locator	Pink Fluorescent Dye, Magnetic Locator
Dates Tracked:	23 March - 07 April 97	23 March - 10 April 97
Total Distance Tracked:	0.5 meters	2.0 meters
Ave Distance Traveled Per Day:	0.03 meters	0.1 meters
Greatest Distance Traveled in 1 Day:	0.5 meters	0.3 meters
Slope of Nest Site:	5 degrees	5 degrees
Aspect of Nest Site:	S	S
Initial Direction Traveled From Nest Site:	East, away from water	West, toward water

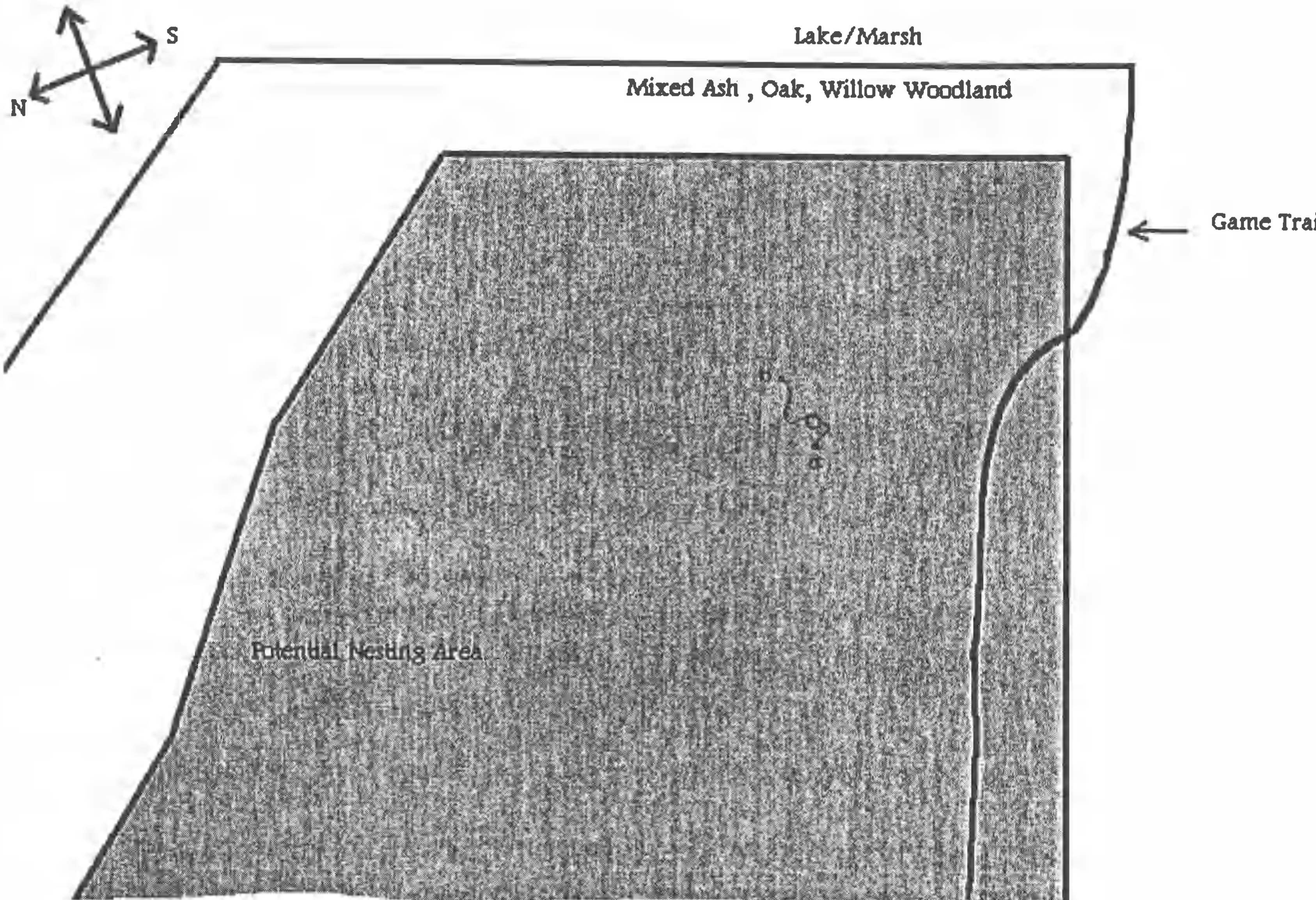


Figure 27. Post-Emergence Hatchling Movements, Nest Site Number 01-10-96, South Applegate Nesting Area, Fern Ridge Reservoir, Oregon, 23 March - 10 April, 1997.

<u>Adult Telemetry Results</u>:

Capture Results:

Trapping effort at Fern Ridge Reservoir during 1995 and 1996 totaled 43,704 trap hours (Table 46 and 47).

Between 01 May and 08 June, 1995, 11 turtles were captured by traps set in the Old Long Tom Channel and adjacent ponds, Tripass Cove, and Kirk Pond. Three of these were captured on two separate occasions. Three additional turtles were captured by hand during nesting forays. Of the 14 turtles captured, 4 were females and were affixed with transmitters.

Between 25 March and 14 June, 1996, 41 turtles were captured by traps set in the Old Long Tom Channel and adjacent ponds, Tripass Cove, and Kirk Pond. One turtle was captured on two separate occasions. Of the 41 turtles captured, 9 were females; eight of which were affixed with transmitters.

Table 46. Trap Effort, Fern Ridge Reservoir, Oregon, 01 May - 04 June, 1995.

Trap Location	No of Days	No of Traps	Trap Hours	Captures	Ave Hrs / Capture
Old Long Tom ①	14/19	14/8	7,824	11	711
Kirk	19	3	1,296	2	648
Tripass	19	3	1,296	4	324

① Two trapping sessions were conducted on the Old Long Tom Channel; 14 days with 14 traps, and 19 days with 8 traps.

Table 47. Trap Effort, Fern Ridge Reservoir, Oregon, 25 March - 14 June, 1996.

Trap Location	No of Days	No of Traps	Trap Hours	Captures	Ave Hrs / Capture
Old Long Tom	26/26/5/17	20/14/10/14	28,128	40	703
Kirk	26/17	3/3	3096	1	3096
Tripass	26/17	2/2	2064	1	2064

Mean CL of all turtles captured during 1995 and 1996 (n = 55) was 175 mm (range 126 - 212); mean CW was 149 mm (range 109 - 166). Mean weight was > 620 grams, and ranged from 490 to > 1000 grams. Of the 51 turtles with distinct annuli, 6 were given estimated ages and 45 were given minimum ages. Mean number of annuli was >15 years, and ranged from 7 to >21 years. Of the 55 turtles captured, 42 were male and 13 were female, indicating a 3:1 male to female ratio.

Transmitter Data:

Twelve female WPT were affixed with transmitters during 1995 and 1996; 1 in Kirk, and 11 in the Old Long Tom Channel and adjacent ponds. Mean CL of all transmittered females (n = 12) was 178 mm (range 138 - 180); mean CW was 135 mm (range 110 - 148). Mean weight was > 770 grams, and ranged from 540 to > 1000 grams.

Mean CL of gravid females (n = 5) was 168 mm (range 164 - 180), and mean CW was 141 mm (range 134 - 147). Mean weight was >814 grams, and ranged from 690 to >1000 grams (Table 48). Of the 12 transmittered females, 9 were successfully tracked through the end of the 1997 nesting season.

Table 48. Measurements of Transmittered Females,
Fern Ridge Reservoir, Oregon, 1995 - 1997.

Turtle No	Transmitter No	CL (mm)	CD (mm)	Wt (g)	Annuli	Gravid?
8924	51857	152	132	560	>16	Unk
8934	51606	165	134	700	>19	Yes
8969	51876	158	127	570	12	Unk
8971	51614	137	110	620	>10	Unk
8973	51866	168	140	805	>11	Yes
8997	51613	166	139	755	>13	Yes
9009	51618	153	119	600	9	No
9014	51616	180	147	1000	>15	Yes
9015	51607	164	143	690	Unk	Yes
9024	51612	170	148	830	>16	Unk
9025	51610	176	143	790	>13	Unk
9031	51856	165	143	790	>20	Unk

Adult Movements and Overwintering:

Movements of all transmittered turtles were bounded by McCutchin ditch to the south and by Castenholtz dock to the north (Figure 1). Turtles moved west into the Frog Pond, but did not travel east into the main body of the lake. Mean distance traveled per day by all transmittered females in the Old Long Tom Channel and adjacent ponds (n = 11) was 26.5 meters (range 0 - 490).

During the winter of 1995, all four transmittered females overwintered in aquatic sites in the Old Long Tom Channel. Two overwintered in the main channel of the Old Long Tom, and two in adjacent ponds. Overwintering dates for 1995-1996 are provided in Table 49.

In 1996, three transmittered turtles in the Old Long Tom Channel overwintered in aquatic sites; one in the main channel, and two in adjacent ponds. Four turtles overwintered in semi-terrestrial tufts of *Phalaris* on the edges of adjacent ponds. Water levels at these overwintering sites fluctuated between 0 - 20 cm of water, depending on precipitation. Three turtles overwintered in terrestrial locations in thick stands of *Spirea* and *Phalaris* near the eastern edges of North and South Applegate. One female did not overwinter, but continued to make small movements in the main channel of the Old Long Tom throughout the winter months. Overwintering dates for 1996-1997 are provided in Table 50.

Mean distance traveled per day by the transmittered female in Kirk Pond was 3.5 meters (range 0 - 29). She overwintered in the northeast corner of Kirk Pond from 12 November, 1996 - 22 February, 1997.

Table 49. Overwintering Dates of Transmittered Female WPTs, Fern Ridge Reservoir, Oregon, 1995.

Turtle Number	Overwintering Locations	Overwintering Dates
9009	Aquatic / Main Channel	14 Nov 95 - 09 March 96
9014	Aquatic / Ponds	30 Nov 95 - 29 Jan 96
9015	Aquatic /Ponds	23 Nov 95 - 30 Mar 96
8934	Aquatic / Main Channel	10 Dec 95 - 26 Mar 97

Table 50. Overwintering Dates of Transmittered Female WPTs, Fern Ridge Reservoir, Oregon, 1996.

Turtle Number	Overwintering Location	Overwintering Dates
9009	Aquatic / Main Channel	22 Nov 95 - 16 Feb 96
9014	Aquatic / Ponds	31 Oct 95 - 22 Feb 96
9015	Aquatic / Ponds	02 Dec 95 - 13 March 96
8934	Semi-Terrestrial	30 Nov 95 - 14 March 96
9031	Terrestrial	29 Nov 95 - 24 Feb 96
8924	Terrestrial	01 Dec 95 - 01 March 96
9025	Semi-Terrestrial	17 Nov 95 - 29 Feb 96
8973	Semi-Terrestrial	22 Nov 95 - 15 March 96
9024	Terrestrial	18 Nov 95 - 04 March 96
8969	Semi-Terrestrial	06 Nov 95 - 17 Feb 96
8997	Terrestrial	30 Nov 95 - 12 March 96
8971	Terrestrial	06 Dec 95 - 07 March 96

Nest Site Fidelity:

During 1995, 1996, and 1997, 6 of the 12 transmittered females were successfully tracked to their nesting locations. Of these six turtles, 3 were tracked to their nesting locations in two different years, and 1 turtle was tracked to her nesting location in 3 different years. In addition, seven turtles, 4 in 1993, 1 in 1994, and 2 in 1997 were located at their nesting locations without the use of transmitters. In all, 19 nesting locations are known for 12 different turtles between 1993 and 1997.

One female, number 8934, was located on her nesting site 5 years in a row (Table 51). She consistently nested in South Applegate between 1993 and 1997. Her nest site locations during 1993 and 1995 were only 5 meters apart. All five nest sites had southern aspects, and slopes between 2 and 18 degrees. Nesting occurred between 11 June and 27 June each year.

Table 51. Nest Site Locations, Turtle Number 8934,
Fern Ridge Reservoir, Oregon 1993 - 1997.

Date of Oviposition	Nesting Area	Slope	Aspect	SLD (m)	Fate
27 June 93	SA	18	S-SE	215	Unk
11 June 94	SA	03	SW	160	U
11 June 95	SA	18	SE	215	ODFW
20 June 96	SA	05	SE	50	U
15 June 97	SA	02	S	124	U

In South Applegate, turtles 9009 and 9014 nested near the same location during 1995 and 1996. Turtle 9009 nested on 10 July, 1995 and on 17 June, 1996. Both nest sites had 5 degree slopes and southern aspects, and one was 141 meters straight-line distance from the water, while the other was 184 meters straight-line distance from the water. The nest sites were 51 meters apart. Turtle 9014 nested on 09 June, 1995 and on 26 June, 1996.

Both nests had southeastern aspects and 5 degree slopes. Both were less than 100 meters straight-line distance from the water, and were 16 meters apart.

In Kirk, turtle number 8997 nested on 04 June, 1996, and on 16 July, 1997. The first nest site had no discernible slope or aspect, and was located 6.3 meters from the edge of the pond. The second nest site had a 10 degree slope, a southeastern aspect, and was located 11 meters from the edge of the pond. The nest sites were 13 meters apart.

WPT females at Fern Ridge Reservoir appear to lay one nest per year, and display nest site philopatry.

CONCLUSION

Discussion:

Western Pond Turtles are aquatic habitat generalists, and have been observed in rivers, streams, lakes, ponds, permanent and ephemeral wetland habitats, and altered habitats such as reservoirs. There is, therefore, great variation throughout their range in available terrestrial nesting habitat. Due to the altered and controlled habitat conditions at Fern Ridge Reservoir, WPTs supported by this habitat are subject to a unique array of habitat attributes. With the exception of relatively dense vegetative ground cover, however, the soil, vegetation, and landform structure measurements of nesting areas and individual nest sites at Fern Ridge Reservoir were physiognomically similar to typical WPT nest site characteristics in other areas (Holland 1994). WPT nest sites located at Fern Ridge between 1993 and 1997 were typified by low slopes, southern aspects, and wide ranges of straight-line distance to water. Nest area soils were very compact and dry during the nesting season and period of incubation, but were often saturated or inundated between November and April, when hatchlings overwinter in the nest. Vegetation was relatively dense; dominated by various low forbs and grasses. None of the nest sites had overstory cover. Percent vegetative ground cover at Fern Ridge nest sites was greater than is typified by nest sites located to date throughout their range (Holland 1994). Percent vegetative ground cover at Fern Ridge was also greater at successful nest sites than unsuccessful nest sites during 1996 and 1997. Percent vegetative ground cover at successful nest sites ranged from 35 to 100 percent, however, and this wide range of vegetative cover at successful nest site may at least cast doubt on the validity and significance of this finding.

Of climatological factors measured during this study, precipitation and number of growing degree days appeared to have the most significant influence on nest success. The period of incubation appears to be most critical for hatchling survival; nest chamber moisture and temperature appear to be the factors that most strongly influence that survival. Successful nest sites at Fern Ridge were exposed to less precipitation during the period of incubation than were unsuccessful nest sites. Precipitation levels during the total period from oviposition through hatchling emergence, however, did not differ among successful and unsuccessful nest sites. Similarly, there were greater numbers of growing degree days during the period of incubation of successful nest sites, but growing degree days for the total period between oviposition through emergence were not different among successful and unsuccessful nest sites. Precipitation levels were lower, and the number of growing degree days were greater during 1994 and 1996, the two years during which several nest sites were successful, than during 1993 and 1995, the two years during which none of the nest sites were successful. On average, precipitation was recorded on 10 more days during the estimated period of incubation in 1993 and 1995 than in 1994 and 1996, and precipitation during June, July and August was, on average, 2 centimeters greater each month during 1993 and 1995 than during 1994 and 1996. The stress of cool, wet summers may be one of the most significant determinants of WPT hatchling development during the estimated period of incubation at Fern Ridge Reservoir.

Nesting area soils may compound the effects of above average rainfall during certain years at Fern Ridge Reservoir. Soils in all five nesting areas had high clay and silt fractions, low permeability, and slow runoff, often resulting in the puddling of water within 0.25 meters of the ground surface in these areas during the summer and fall months. In June each year, the soils in the nesting areas at Fern Ridge were still moist from Spring precipitation, and even small amounts of precipitation would presumably have a significant impact on moisture conditions within the nest chamber. Nesting area soils become progressively drier and harder toward July and August, and precipitation during these months may have less of an effect on nest chamber moisture conditions. The removal of the nest plugs during nest searches may also alter the nests susceptibility to precipitation during the estimated period of incubation. The seal created between the nest plug and the adjacent ground surface by the nesting female through emptying her bladder contents onto the soil before oviposition may act as a barrier preventing precipitation from entering the nest chamber. Similarly, the high shrink-swell potential of these soils may further pose a threat to WPT eggs by creating cracks in the nest through which precipitation could more readily enter the nest chamber.

Although unsuccessful nest sites were inundated for longer periods of time during the winter months than were successful nest sites, moisture conditions in the nest chamber during this period of time don't appear critical in determining hatchling survival. Upon excavation of the unsuccessful nest sites which were inundated during the winter, only undeveloped eggs, and/or partially developed hatchlings were found. The absence of fully developed dead hatchlings suggests that the failure of these nest sites was due to conditions during the period of incubation the prior summer, rather than due to inundation between November through March, when hatchlings overwinter in the nest chamber.

Successful nest sites were exposed to greater numbers of growing degree days, and thus, higher ambient temperatures, during the period of incubation. Nest chamber temperatures of the 10 nest sites monitored during 1996, however, did not reflect this increase in temperature at successful nest sites. There was no difference in nest chamber temperatures among successful nest sites (n = 5) and unsuccessful nest sites (n = 4), although nest chamber temperatures did vary with ambient temperatures (Table 31). Failure to detect differences in nest chamber temperatures among successful and unsuccessful nest sites may have been a consequence of small sample size (n=9).

There was no evidence of females laying more than 1 clutch per year within the five nesting areas at Fern Ridge Reservoir between 1993 and 1997. Nesting females which were individually identified and observed during nesting forays did display nest site philopatry. Although the females which deposited the remaining nest sites were not individually identified or observed during their nesting foray, maps of nest site locations in each nesting area during the five years indicate philopatric behavior. Nest sites within each nesting area were not randomly distributed; 1993 nest sites were within meters of nest sites located during 1994, 1995, 1996, and 1997. Definite quadrats of active nesting exist within larger areas of seemingly potential nesting habitat. Soil, vegetation, and landform structure measurements did not differ among actual nest sites and non-nest sites from both active and inactive quadrats of potential nesting habitats. The number of intact nest sites located in each nesting area during 1993 (n = 29), 1994 (n = 29), 1995 (n = 29), 1996 (n = 32), and 1997 (n = 30) were also essentially the same, further suggesting philopatric behavior. This tendency of females to return to the same area each year to oviposit places tremendous importance on both short and long term management decisions. If female WPTs are unable or resistant to changing their nesting areas, then the identification, restoration, and protective management practices in these areas will be critical in determining the survival of this species in a human dominated landscape. Currently there are only 11 known WPT nesting areas in the Willamette Valley, including Fern Ridge Reservoir, together totaling approximately 5 hectares. Of these, 3 have had only 1 or 2 WPT nest sites located to date. Even if female WPTs are capable of moving to new nesting areas, the lack of new potential nesting habitat may prevent them from doing so.

Nest success at Fern Ridge Reservoir over the five years was very low, even with successful prevention of predation. A 12 percent predation rate of all nest sites, in comparison to the average predation rate in Oregon of over 90 percent, (Holland 1994), however, indicates a significant reduction in predation rates due to the use of predator exclosures at intact nest sites. Of the 122 intact nest sites monitored at Fern Ridge Reservoir between 1993 and 1997, 23 were successful. Based on a Fern Ridge average of 7 eggs per nest site (n = 57) as determined from both successful and unsuccessful nest sites, there were an estimated 854 WPT eggs deposited, of which 10 percent hatched. Overall hatching rates range wide average approximately 70 percent. Survivorship is known to be lower in smaller size classes of WPTs; analysis range-wide suggests that only 10 to 15 percent of a cohort will survive through the first three years (Holland 1994). This could mean a total of only 9 to 13 hatchlings surviving to three years of age at Fern Ridge Reservoir between 1993 and 1997.

Clutch sizes of successful nests at Fern Ridge were relatively small (mean = 4, range 2 - 7) in comparison to range wide averages (mean = 7, range 2 - 13, Holland 1994), and surviving hatchlings were relatively large (mean = 29.3 mm CL, mean = 5.7 grams), compared to hatchlings range wide (mean = 27 mm CL, mean = 4.2 grams, Holland

1994). This finding is consistent with data from other areas indicating that all larger hatchlings (>28 mm) have been from the northern part of WPT range (Holland 1994).

During 1996, two nest sites excavated by ODFW on 12 October did not contain any hatchlings, eggs, or egg shell fragments. The presence of eggs had been verified on the day of nesting at both nest sites. These findings may be the first record of fall emergence in Oregon. Many other explanations, however, do exist. Although the nest plugs at these sites did not appear to have been tampered with, vandalism had been a severe problem in three of the nesting areas during this project, and involved both the destruction of nest sites, as well as the removal of nest chamber contents (eggs and/or hatchlings). Although evidence is lacking, any of several underground predators may have depredated these nest sites. WPT eggs may also be lost through invasion by plant roots or fungal hyphae (Holland 1994).

Hatchling tracking methods employed during 1997 were unsuccessful. Each hatchling was monitored until it made any significant movement, at which time it was lost. Fluorescent pigment trails were visible to a maximum of 0.25 meters in daylight, and 0.5 meters after dark under ultraviolet light. Hatchlings were tiny, well camouflaged, and buried under mud and vegetation, making it difficult to search these areas without stepping on them. Magnetic location was helpful in monitoring the position of a hatchling that did not move for several days, however once the hatchling had moved the magnetic locator picked up signals from too many sources to decipher which signal was from the hatchling and which was not. Hatchlings traveled from location to location so slowly that transmitter batteries died before tracking was an option.

Management Recommendations:

Nesting area searches, and the placement of predator exclosures over intact nest sites should continue to be a management priority at Fern Ridge Reservoir. Predation rates at Fern Ridge decreased from 100 percent in 1992, when the five nesting areas were identified, to 31 percent in 1993, 31 percent in 1994, 0.0 percent in 1995, 2 percent in 1996, and 0.0 percent in 1997. Predator exclosures have proven over the past five years to be a non-invasive, simple, inexpensive, and successful method of increasing potential hatchling survival.

Potential nesting habitat for WPTs was categorically defined as open field. All nest sites at Fern Ridge were located in areas dominated by various low forbs and grasses, and none of the nest sites had overstory cover. The nesting areas, however, are currently under encroachment by woody species, and potential nesting habitat within these areas is decreasing. Efforts to monitor and prevent the invasion of woody trees and shrubs into the nesting areas at Fern Ridge Reservoir should be intensified. The current encroachment of woody species into the native wetland prairies will decrease the suitability of these areas as nesting habitat. Historically, the open nature of these fields was maintained by periodic fire, and the implementation of fire suppression and cultivation prevented the maintenance of these fields in an early successional stage. The use of periodic controlled fires as a management tool in these areas may prove successful. Although labor intensive, the physical removal of trees and shrubs in these areas may be necessary.

If nest excavation by ODFW is continued in these areas, the selection of nest sites should be based, if possible, on predictions of above average rainfall during the period of incubation, especially during June, and predictions of which nest sites may be most susceptible to these cool moist summers, rather than nest sites most likely to be inundated during the winter months.

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