THE WESTERN POND TURTLE: HABITAT AND HISTORY

FINAL REPORT

Prepared by:

Dan C. Holland, PhD

Wildlife Diversity Program
Oregon Department of Fish and Wildlife
Portland, OR

Prepared for:

U. S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P. 0. Box 3621
Portland, OR 97208-3 62 1

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INTRODUCTION

Like many prominent physiographic features of the landscape of the Pacific northwest, the Willamette-Puget Sound (hereafter WPS) hydrographic basin has a relatively recent origin, and a moderately complex evolutionary history. This area was largely a marine terrace/continental shelf environment during the Eocene and Oligocene. Formation of the area was initiated by the development of a volcanic archipelago part of a larger system extending along much of the west coast of the North American continent. This chain of volcanoes served as the foundation for development of a forearc basin, which in turn induced accretion of marine sediments through at least the Pliocene. In the Oligocene, a marine environment existed as far south as present-day Salem. During the middle-late Miocene, intense vulcanism in the area of the Columbia plateau produced massive incursions of lava, which covered many of these sediments. The general pattern from the Miocene onward was recession of the marine environment, and a shift from marine-dominated processes, such that by the late Pliocene other forces were the primary factors involved in the subsequent evolution of the landscape. The uplifting and tilting of the Coast Range, coupled with the intensive orogenic activity (both volcanic and uplift) in the Cascades province resulted in the formation of the large lowland "basin" we now know as the WPS trough. By the late Pliocene-early Pleistocene, the combination and interaction of vulcanism with a high erosion & accretion potential set the stage for the evolution of the landform as we currently recognize it.

For the purposes of this report, the major processes of interest occurred from the Pliocene-Pleistocene boundary onward Initial displacement of the Willamette River to the east side of the basin by uplift and vulcanism in the Coast Range was essentially complete by the onset of the Pleistocene. Subsequent rapid erosion of the uplifting Cascades, particularly during periods of sea-level recession and glaciation, produced extensive and complex deposits of sediments from the rivers draining the west slope of the range. The coalescence of these alluvial fans covered much of the southern two-thirds of the Willamette Valley, and displaced the course of the river to the general area of its present channel(s) between Eugene and Cotvallis. Coupled with minor intrusive landforms derived from the Coast Range formations and localized volcanic/pyroclastic events (particularly in the northern part of the system) , much of the subdivision of the valley occurred during this time. Further north, the river ran to the east of its current channel. In the area of Oregon City, the river ran to the southeast and was joined by an extension of the Tualatin River southeast of its current confluence. Continuing declines in sea level led to a shift in the drainage of the Tualatin through Lake Oswego, while the Willamette continued downcutting through the Columbia River basalts near Oregon City. This action eventually produced the falls. Spread of the Boring lava flows shifted the channel of the Willamette northward , and subsequent flood events reconnected the Tualatin to the Willamette at or near their current confluence.

The influence of Pleistocene glaciation on the dynamics and distribution of entire biotas was profound, perhaps more so than any other geological event in the last few million years. The ecosystems of the WPS trough are no exception. The four major glaciations will not be reviewed in detail here, but their effects will be briefly discussed.

The extent of the advance of the ice sheets varied between epochs, with the most extensive glaciation occurring during the last period, the Wisconsonian. In the area to the north of the Columbia River the Cordilleran continental ice sheet extended into the northern end of the WPS trough, such that the southern end of Puget Sound was buried under several hundred meters of ice. Locally, glaciers of varying size occurred in most if not all of the major drainages on the west slope of the Cascades. A large sheet of ice extended from the Mt. Hood glacier complex down the Sandy River channel almost to its current confluence with the Columbia River (Orr et al, 1992). Concurrent with the advance of the glaciers, the general climate became more cool and moist. In part, this allowed a major southerly extension of the boundaries of the Arcto-Tertiary geoflora (Axelrod, 1958). This also decreased significantly the lower elevation limits of many mesic/cool adapted forms, such as currently typify the flora of higher elevations. As such, at the height of the glacial period the total extent and altitudinal range of xeric-adapted biotas (typical Madro-Tertiary communities like oak forests and grasslands) were considerably less in the WPS trough than in very recent history. Procession and recession of the two basic biotas in this area - one a moist-forest conifer dominated system and the other a more xeric-adapted hardwood/mixed forest and grassland system - probably occurred on a cyclic basis in the basin over the last 700,000 years.

The advance and retreat of the Arcto-Tertiary and Madro-Tertiary geofloras occurred over a vast area of the western North American continent. The influence of this situation was significant on both the local and total distribution of many elements of these landscape biota, producing spatially disjunct relict populations or communities of species in many areas. This pattern is apparent in many areas along the west coast, and as such many situations in the WPS trough are arguably not unique. However, other events were to play a major role in the evolution of the biota of the Willamette landscape, producing in effect a ecological *tabla rasa* of a nature and on a scale that was truly unique. This influence of this phenomenon extends across 15,000 years to the present.

As previously noted, the maximum extent of the continental ice sheet was such that a lobe infringed upon the northern edge of the WPS trough. While its local influence should not be underestimated, the influence on the Willamette drainage proper was probably only slight. However, this lobe was part of a larger ice mass that spread across much of present-day Canada and well into the northern United States. In the area that now constitutes northwest Montana, the meltwaters of the glacier combined with other drainages to form Lake Missoula, which at its apex was over 600 m (2,000 feet) deep and contained in excess of 800 cubic kilometers (500 cubic miles) of water. The waters of the lake were held in place by an ice dam, which at some point approximately 15,000 years BP, suffered a catastrophic failure. The movement of water through this system has been estimated at up to 15.1 cubic km (9.46 cubic miles)/hour, such that the majority of the lake's volume (640 cubic kilometers or 400 cubic miles) drained in approximately 10 days (Orr et al, 1992). The amount of water released in this single flood is greater than the annual flow of all the world's rivers (Orr et al., 1992).

This mass of water moved through the area of eastern Washington, creating the channeled scablands, and temporarily pooled at the Walles Gap in Oregon to create Lake Lewis. The water pooled a second time east of The Dalles, and formed Lake Condon. However, both of these were only temporary impediments to the irresistible force of the flood. Moving through the Columbia Gorge, the height and speed of the flood varied with the width of the river channel. At The Dalles, the flood crest was approximately 1000 feet above the current level of the river. As the flood moved through the Columbia Gorge, it averaged a speed of at least 56 kph (35 mph) (Allen et al., 1986). By the time the cataclysm reached the vicinity of Portland, the flood crest had dropped to 121 m (400 feet). The water spread south throughout the Willamette Basin, covering the valley to the 80 m contour level and forming Lake Allison. The southern terminus of the lake reached the vicinity of Harrisburg (Franklin & Dyess, 1973). The sediment load carried by the lake was tremendous, and in some areas the finer silts were deposited in layers that reached almost 30 m (100') in depth. In addition to the silt, sand, gravel, rock and organic debris carried by the floodwaters, icebergs bearing glacial erratics (rocks) of up to 160 tons were deposited at the upper boundaries of the lake along the perimeter of the valley.

The Missoula flood was the largest catastrophic flood event in the history of North America, and affected 25,000 square kilometers (16,000 square miles). The energy release in the Missoula flood is estimated at the equivalent of 4500 MT (megatons), or 789 times that released during the recent explosion of Mt. St. Helens (Allen et al., 1986). What is perhaps even more astounding is that the initial flood was followed by periodic floods on a (perhaps) slightly smaller scale - the generally accepted figure is that there were approximately 40 major flood events of a similar nature between 15,000 and 12,000 years ago (Allen et al, 1986). The total energy released in these events has been calculated at approximately 180,000 megatons.

While the extent of the floods can be described with a high degree of precision and the total energy release calculated, the actual impact of the floods on the biota can at best be described qualitatively, since no comparable event exists within written human history. Prior to the flood, the biota of the Willamette Valley was probably dominated by the influence of extensive coniferous forests, similar to those that recently occurred and to a limited extent still occur on the slopes of the Cascades and Coast Range above the valley floor. Openings in the forest were likely to be relatively small and scattered, and dominated by a mixture of both conifers and hardwoods. The grassland/prairie environment was probably very restricted and may have had a different mixture of species than in the recent past, although some "wet prairie" areas were no doubt more extensive than in other periods.

Aquatic environments were abundant and widespread, given the amounts of water moving into and through these areas. Riparian areas would have been dominated by a mixture of softwoods and conifers, and the streams and rivers were probably rocky, cold and fast-flowing. Marshes were no doubt abundant in many lowland areas, with habitats being dominated by soft-stemmed emergents and occasional softwoods. The wildlife of the area at that time included mammoth, mastodon, giant sloth and bison, as well as most of the smaller ungulates currently present. The extensive marshes undoubtedly constituted prime habitat for many species of waterfowl. In the skies above the valley, California condors soared with other raptors. The amphibians typical of the more heavily forested habitats extended their range onto the valley floor, and many species of aquatic reptiles, such as garter snakes, western pond and painted turtles were undoubtedly abundant even if somewhat restricted to the more open habitats along the rivers and marshes. Fishes, in particular some salmonids, were probably abundant in the cold, clear waters of the glacial-melt rivers and streams.

The Missoula floods dramatically altered the environment in which these organisms and communities existed. The size and speed of the flood resulted in massive reconfiguration of the regional and local landscape. Forests were uprooted *en masse* and borne along in the flood. The wave front and waters behind it were a gigantic roiling mass of sediments, icebergs and vegetation. The speed and height of the flood obviously diminished as it moved up the Willamette drainage, but there can be little doubt that in the majority of the valley (particularly in the northern 2/3's, it possessed sufficient energy to effectively obliterate most of the communities and minor landforms with which it came in contact. The impacts on the animal community can best be described as devastating. With the exception of some birds, which might have been able to outfly some of the wave front and concomitant winds, most of the animals were either crushed by the wave front or drowned by the following water mass. Even fish populations were probably severely affected due to the massive sediment load carried by the flood. Although the lake existed for only a short period - perhaps weeks or months - there were significant short- and long-term effects. As the lake receded and drained, vast amounts of detritus in the form of uprooted trees and other vegetation were left along the lakeshore, along with the carcasses of countless dead animals. The deposition of the massive amounts of silt carried by the flood would have left deposits of deep mud that extended for miles across and up and down the valley. Locally, some of these sediment deposits were responsible for the formation of small temporary lakes, left behind as the remainder of the valley drained. The extent and thickness of these silt layers varies, but one layer (the Irish Bend Member) covers over 500 square km in the southern portion of the valley and reaches a maximum thickness of over 15 m near Corvallis. Populations of many species in the lowland biota were either effectively eliminated or severely reduced, both in population size and range. The local effects on mesic-adapted forest forms were probably equally severe (at least on a local basis), but there existed a much larger source population in areas above the flood crest to furnish new material to invade and recolonize the "drowned" lowland habitats. However, the nature of the habitat in the lowland areas had now changed, both in quality and quantity. Whereas prior successional patterns were in large part probably in a state of shifting balance between climax and subclimax stages over relatively small areas, the flood situation effectively produced a reversion to conditions that would favor primary and secondary successional species over much of the landscape. Among the groups most likely to "benefit" from this change would be many of the marsh/riparian species, such as willows, sedges and similar emergents. Pioneering individuals of other woody species undoubtedly were able to become established, but their subsequent spread and dominance was restricted by the subsequent flood events, such that for a period of two to three thousand years, much of the Willamette Basin was in a highly disturbed state, with a matrix of successional habitats of different ages and compositions. For species that are favored by frequent disturbance of this type (such as waterfowl, some small mammals and amphibians), this represented a period of prolonged population increase and a re-establishment of their local distribution. For many other species, however, particularly those dependent upon intermediate or infrequent-scale disturbance, the valley remained relatively inhospitable habitat.

The recession of the last glaciers of the Wisconsonian epoch began approximately 12,000 years ago. Pollen records (Hansen, 1942; 1947) from the sediments of Lake Labish (NE of Salem) indicate that there were several significant changes in the local climate in the Willamette Valley, which in large part reflect similar regional trends. By 9000-7000 years BP, the shift in pollen records indicate a decline in the mesic- and cool-adapted forests of white pine *(Pinus monticola)* and sitka spruce *(Picea sitchensis).* This decline continued through at least 4000 years BP, with an increase in abundance of warmer and more xeric-adapted species such as Douglas fir *(Psuedotsuga menziesii)* and Ponderosa Pine *(Pinusponderosa).* It is postulated that the white oak *(Quercus garryana)* reached a maximum during this period. Subsequently, the climate became slightly more cool and moist, which in turn played an important role in maintaining the matrix-like dispersion of habitat types within the Willamette Valley. During this time, another factor which was to significantly influence the subsequent composition and distribution of the local biotic landscape had arrived on the scene - the first humans.

<u>The biotic landscape of the Willamette Valley in the Holocene</u>

In reality, it is not possible to discuss the evolution of the Willamette biotic landscape over the last several thousand years without including a discussion of anthropogenic effects. However, in what follows I temporarily defer this discussion and portray the landscape as it existed prior to approximately 1800 AD. This will then be followed by descriptions of the valley prior to extensive settlement and development by European cultures. I will then discuss (in part) the reasons for the physiognomy of the area as reflective of anthropogenic influences by the aboriginal inhabitants. This will be in turn be followed by a discussion of the nature and extent of alteration(s) of the area due to the influence of settlement by European cultures.

The actual climax state of the vegetation in the Willamette Basin has been the subject of some debate. Weaver and Clements (1938) indicated that the postulated climax state was the hemlock-red cedar forest present in the adjacent coast range. Hansen (1942) noted that given the existing precipitation regime, the establishment and/or maintenance of the mesic-adapted hemlock *(Tsuga heterophylla)*- red cedar *(Thuja plicata)* association was unlikely. Shantz and Zon (1924) classified the area as a Douglas fir forest, and Kuchler (1964) in the most generally accepted classification considered the valley to be capable of supporting a mixture of Douglas fir and white oak. Based upon precipitation regime, a slight shift towards increased aridity would hypothetically favor a return to dominance by Oregon oak. All of these scenarios depend to a greater or lesser extent upon an assumption of homogeneity of climate and edaphic factors within the area, which in fact are unlikely to be realized. Local variation in precipitation and soil development may significantly alter the short- and long-term probabilities of establishment and maintenance of any of these systems over a significant portion of the area. Regardless of the hypothetical climax state of the system as a whole, the functional structure of the Willamette biotic landscape can best be described as a dynamic matrix.

Historical records of the appearance of the landscape emphasize in part the heterogeneous nature of the valley. However, as with all such observations, the extent and nature of the description is affected by a number of factors, including cultural bias, time, effort and experience. This led (and continues to lead to) selective emphasis on certain features of the landscape at the "expense" of others, therefore producing an under-representation of the probable diversity of the area. To the researcher attempting to reconstruct this historical environment, this factor should serve as a omnipresent caveat.

Bearing in mind that we will never know with a high degree of certainty the total extent and nature of the system, what follows is a conservative attempt to portray the appearance of the system circa 1800 A.D. from the point of view of an ecologist.

The Willamette Basin is a typical interior lowland north-south trending valley approximately 208 km in length and varying from 30-60 km in width. The valley floor occupies a total area of 5,600 square kilometers (COE, 1940). The elevation at the upper (southern) end approaches 120 m and decreases almost uniformly to slightly above sea level at the northern end. Minor hills such as the Chehalem and Tualatin Mountains intrude on both the eastern and western edges of the valley, and numerous small senescent volcanic plugs occasionally rise above the valley floor for 60-80 m. Soils are largely alluvial, very thick, moderately differentiated and arise from intensive erosional environments in the flanking Coast Ranges and Cascades. Mean annual precipitation approaches 100 cm, most of which falls as rain in the late fall-mid spring. The system is drained by the Willamette River, a 9th order stream with two forks. The Middle Fork arises in the Cascade Range to the southeast, and the Coast Fork arises from the northern edge of the Calapooya Mountains at the southern end of the valley. There are several large tributary systems of 4th order or greater, including (from south-north), the McKenzie, the Long Tom, the Marys, the Calapooya, the Santiam, the Luckiamute, the Yamhill, the Pudding, the Mollala, the Tualatin and the Clackamas. At the northern end of the Willamette, it merges with the Columbia. The main stem channel of the Willamette is a complex, braided system with numerous meanders reflective of the relative age of the system and the complex pattern of alluviation present in the valley. From Eugene to Portland, the river channel measures 272 km in length over 176 km straight-line distance (Hoerauf, 1970). Below Salem the degree of meander is considerably less than upstream from this location.

The vegetation of the system is a complex mosaic of forest, shrubland, grassland and aquatic elements produced by the interaction of local climatic conditions, soil types, annual flooding and fire. The overall characterization of the system would be that of a highly complex sub-climax mosaic. The appearance of the majority of the system is that of a complex interdigitation of aquatic, wetland, grassland, and forest habitats extending throughout the valley. For the purposes of this report, I will discuss the various communities present in relation to the general type of system, i.e. forest, grassland, etc. and the subtypes within that system.

There are four basic forest types present in the Willamette Basin. These are herein classified as conifer-dominated upland, oak forest, mixed (hardwood/softwood) forest, and riparian forest. Franklin and Dyess (1973) do not include the mixed forest-assemblage as a distinct type. The conifer-dominated upland occurs in surrounding mountains and foothills and occasionally interdigitates with the other forest types in the region of the hills trending into the valley in an east-west direction or on north-facing slopes. This forest type becomes more extensive and occurs in lower-elevation areas in the northern part of the valley, constituting the most extensive landform cover from the vicinity of the Mollala

River northward (at least on the east side of the valley). These mesocosms display extensive old-growth areas represented either by typical elements (cedar, fir, hemlock) or the functional equivalent in Douglas fir- dominated systems. Because of its pioneering habits, Douglas fir is a common co-dominant in many areas of mixed forest on the valley floor proper, particularly in areas that are only intermittently subject to burning. The shrub understory in these areas is dominated by western hazel *(Corylus cornuta),* snowberry *(Symphoricarpos alba),* baldhip rose *(Rosa gymnocarpa)* and oceanspray *(Holodiscus discolor).*

The oak forest of the valley floor is dominated by Oregon oak but occasional Black oak *(Quercus kelloggii)* is present, particularly near the southern end of the system. The extent of this community reaches its height in the southern and central parts of the valley, extending north to the vicinity of the Pudding River on the east side in a more or less continuous expanse interlaced with other habitats. On the west side of the valley, the distribution is occasionally interrupted by the small extensions of the coast range and other local landscape features. This type reaches its northern limits in the vicinity of the Tualatin drainage. Within the valley, Oregon oaks may occur in pure stands, as isolated trees or small clusters of trees, or in association with other broadleaf and conifer species. The growth form of the species also varies depending upon the fire history of the area. In mixed forest areas or foothill sites, the tree grows in a "forest-form" (Thilenius, 1968) - tall with a slim trunk, with ascending branches near the crown which form an effective canopy. The "savanna-form" trees are more decumbent in general shape, with large-diameter trunks, massive branches and a extensive spreading crown. Associated understory shrubs comprise four communities (Thilenius, 1964), the first dominated by hazel and swordfern *(Polystichum munitum).* In this association forest-form oaks are most common and abundant. The second association is dominated by cherry *(Prunus* spp.) and snowberry. The third system is dominated by serviceberry *(Amelanchier alnifolia)* and snowberry. In these communities both average basal area and height of the oaks decrease. In the fourth community, the shrub dominant is poison oak *(Rhus diversiloba)* Savanna-form oaks are least dense and small forest-form trees are most abundant in this community. A common broadleaf associate in these communities is big-leaf maple *(Acer macrophyllum).*

In the forest-form, oaks and other tree species may cover large areas, often thousands of hectaresin extent. Canopy closure in these systems is moderate to high, although not to the extent observed in many conifer-dominated associations, Extensive litter buildup facilitates retention of soil moisture and provides important refuge and foraging areas for a variety of species of small vertebrates and invertebrates. Savanna-form oaks often occur as isolated trees of considerable age (up to 308 years, Thilenius, 1968) and size - some almost 1 m dbh. These trees also occur in small groups. Individual trees or small clusters represent effective "islands" in a grassland savanna "ocean", presenting the only cover for miles in any direction. The tree itself and the associated understory microhabitat represent critical foraging, refuge and nesting sites for many species.

The third forest type (mixed-forest) is a somewhat artificial classification, and does not necessarily correspond to conventionally defined and limited "mixed-forest" types in other areas (such as the black oak-yellow pine - incense cedar associations of central

Oregon). Rather, this represents a mixture of trees and other elements that may or may not represent a "stable" association. This type, and the species that comprise it, may occur on an opportunistic basis in a given area or may persist in ecotonal situations. These areas exist throughout the valley, but are perhaps less common toward the northern end due to the presumed competitive dominance of the conifers in a more "predictable" environment. Common elements of this subtype are oak (both Oregon and black), big-leaf maple, madrone *(Arbutus menziesii),* Oregon ash *(Fraxinus latifolia)* and ponderosa pine. In the extreme southern part of the system, incense cedar *(Libocedrus decurrens)* occur on drier slopes and reach the northern terminus of their range. Other occasional conifers on the valley floor include ponderosa pine and grand fir *(Abies grandis),* the latter in more mesic habitats. This forest association forms a critical link between many communities, and like many such ecotonal systems, may hold not only "edge species" but may serve as important habitat for species normally associated with adjacent communities. As such, the area-specific biological diversity of this subtype is often higher than that of surrounding habitats.

The fourth type, the riparian forest, is perhaps the easiest to classify due to its close association with watercourses. The dominant elements of the riparian forest are typically black cottonwood *(Populus trichocarpa),* willows *(Salix* spp.), dogwood *(Cornus nuttallii),* and alder *(Alnus rubra and A. rhombifolia).* Associated species typically include Oregon ash, Oregon oak, big-leaf maple, and occasionally ponderosa pine and Douglas fir. Understory elements vary with frequency of inundation and other factors. In bottomland forests (dominated by oak/ash/willow or ash/maple/willow), rose and serviceberry are common understory species. In more open situations, particularly along the edges of slackwater habitats, cattail *(Typha* sp.), bulrush *(Scirpus* sp.) and sedges *(Carex* spp.) are often locally abundant forms. In habitats that suffer predictable scouring or prolonged immersion, the understory elements may be essentially absent or of a transient nature.

The characteristics associated with the development of this community typically include a high water table and frequent inundation. The forest occurs along all watercourses in the basin, including rivers, streams, oxbow lakes and to a limited extent marshy areas. Presence of the elements of this community may also be an indication of a high surface water table (where no surface water is otherwise visible), or may reflect the former existence of a stream channel or other watercourse. Along the main stem of the Willamette, the riparian gallery forest may extend for several kilometers on either side of the river channel, due to the wide floodplain and the highly braided channel present in this system. This is particularly true in the lower stretches of the valley. Along the upper third of the system, and along some of the tributaries (such as the Long Tom and Santiam) the riparian gallery forest may be relatively thin - perhaps only a few tens of meters wide, before giving way abruptly to grassland habitats. The height of the gallery forest varies with species and location. Along the main stem of the Willamette, cottonwoods may commonly reach heights of 50 m (162 ') and occur in almost pure stands over large areas. In other sites, particularly along the smaller drainages such as the Long Tom, willows and alders occur in mixed stands of an almost brushy nature, forming thick bands of dense vegetation along the watercourse from the very edge of the bank.

Riparian forests furnish a direct connection between terrestrial and aquatic ecosystems in the valley by serving as a transition zone for many species, and by producing significant inputs of structural material and ultimately nutrients for the aquatic environments. These areas are among the most structurally complex of all habitats in the Willamette, and assist in the formation and maintenance of multiple channels along stream and river courses. The root masses of trees and emergents along the watercourse serve to create unique microhabitats in the aquatic/terrestrial environment interface, and tree and litter-fall into the system not only provides structural heterogeneity, but a major source pool of nutrients. The riparian forest entrain (at least temporarily) snags and other organic debris carried by flood waters, and thus contributes to the recycling of materials in the system that would otherwise be eventually lost. Riparian forests also serve as "buffers" to adjacent habitats during periodic flooding.

Species diversity in this community varies, with relatively few vertebrate species (other than fishes) obligately tied to this habitat. However, the presence of a diverse invertebrate fauna (as a prey base), the wide variety of specialized microhabitats and the structural complexity of the system produce at least temporary use by a wide variety of vertebrate species. The relative influence of this community on the structure and diversity of the ecosystem as a whole is disproportionate in relation to the actual area occupied.

Shrubland habitats are relatively rare in the Willamette, and usually occur as a transient successional phenomenon in ecotonal areas between forest and grassland habitats, or in isolated patches within grassland areas. Common dominants here include rose, poison oak, serviceberry, cascara *(Rhamnuspurshiana),* black hawthorn *(Crataegus douglassi)* or similar species. These areas are usually very limited in extent, and often appear in edge situations which favor adventitious species, such as produced by fire or predictable flooding. Although often transient in both location and duration, these areas may provide important foraging and breeding habitat for many "fugitive" species, both vertebrates and invertebrates.

Grassland habitats are a dominant feature of the Willamette Valley landscape. The species composition of these areas is somewhat conjectural, with a mixture of both native and introduced elements present. Typical species are Hall's bentgrass *(Agrostis hallii),* alpine wheatgrass *(Agropyron caninum),* California brome *(Bromus carinatus),* Columbia brome *(B. vulgaris),* California danthonia *(Danthonia californica),* blue wildrye *(Elymus glaucus),* eight-flowered fescue *(Festuca octoflora),* California fescue *(F. californica),* red fescue *(F. rubra),* western fescue *(F. occidentalis),* Alaska oniongrass *(Melica subulata),* pine bluegrass *(Poa scabrella),* big squirreltail *(Sitanion jubatum)* and Lemmon needlegrass *(Stipa Zemmonii)* (Habeck, 1961). A more complete list is provided in Franklin and Dyess (1973). The open prairie areas often extend for tens of kilometers across and along the valley, with occasional breaks in the sea of grass provided by watercourses, small ranges of hills with forest cover, and isolated clumps of trees. To the south, the main body of the prairie habitat begins near Eugene, although isolated patches appear south to the vicinity of Cottage Grove. The grassland extends in a swath averaging 32 km in width to the vicinity of the Santiam River. North of this area, the prairie is essentially continuous on the west side of the valley to the drainage of the Yamhill River, with another large disjunct patch in the vicinity of the middle of the Tualatin drainage. On the east side, the distribution is less extensive, being broken up by landform features.

However, the prairie system reaches at least the vicinity of the Mollala River. A small patch of this type of habitat occurs along the Columbia River just east of the confluence with the Willamette, and small patches of the habitat are found in the area of Scapoose. The general estimate of the amount of area covered by the prairie areas was at least one-third greater than that covered by the forests (Wilke, 1841).

In the Willamette Valley, as elsewhere, the extent and persistence of most of the grassland habitat is closed tied to periodic disturbance by fire. Succession to oak forest or mixed forests would be the probable fate of the majority of these systems in the absence of fire. The procession/recession of woodland edges as evidenced by the presence of different-aged forests and the savanna-form oaks occurs in a dynamic matrix throughout the valley. There may be some areas (called "grass balds") on localized topographic features or hillsides that represent actual climax grassland communities. These areas. are assumed to be maintained by autocthonous soil development and are relatively uncommon.

There are in fact at least two distinct types of grassland/prairie present in the Willamette, the "dry" prairie and the "wet" prairie. Wet prairies are often closely associated with and intergrade with wetland habitats of both a permanent and ephemeral nature. These areas are typically but not invariably associated with high water tables and/or soils with poor drainage. Common species in these habitats, particularly in the southern part of the valley, are tufted hairgrass *(Deschampsia caespitosa)* and camas *(Camassia* spp.).

Grassland habitats represent critical foraging and breeding habitat for many species. The majority of the larger species of vertebrates found in the valley were closely tied to the prairies. Elk *(Cervus elephas),* bison *(Bison americana)* are closely tied to the prairies for grazing, and deer *(Dama hemionus)* utilized both prairie and forest areas. Brown bear *(Ursus arctos),* wolf *(Canis lupus)* and coyote *(Canis latrans)* all foraged extensively in the grasslands. These habitats served as important foraging and resting grounds for hugeseasonal flocks of waterfowl, and California condor *(Gymnogyps californicus)* scavenged the carcasses of the large herbivores. Other groups present included a diverse passerine, raptor and (seasonal) shorebird community, numerous small mammals, and a moderate diversity of reptile and amphibian species.

Wetland habitats are herein defined as those areas that have at least seasonal inundation or water tables that are consistently high enough to support a specialized biota. Under this broad definition, wetland habitats could arguably be more extensive than some forest types, particularly riparian forests. In fact, riparian forests and some mixed forests serve as effective wetland habitats and often form complex mosaics with them. The same case can be made on a much more limited scale for some grassland habitats. Given the pattern and history of flooding by the Willamette and its tributaries, wetland areas are almost ubiquitous in the valley. Periodic flooding by the rivers produced extensive "ephemeral" wetland habitats in bottomland forest areas or in upland swales that were nevertheless *effectively* permanent due to the frequency of flood events. The only situations which consistently lack extensive wetlands are the forest habitats in foothill or montane areas. Even in these areas, microsites with appropriate soil and other conditions often foster the development of wetland communities such as small ponds or swales. Many of these sites are ephemeral in nature. The same can be said of grassland areas, where localized variations in topography and soil development produce specialized ephemeral aquatic habitats, often known as "vernal pools" or "hog wallows".

The species composition of wetland habitats varies with the size of the habitat, soil conditions and the degree and duration of inundation. In ephemeral pool areas, a specialized flora of annuals and grasses often develops. Over larger areas, tufted hairgrass is a common species, along with sedges, reeds *(Juncus* spp.), and spikesedge *(Eleocharis* spp.). In moist-soil areas, hawthorn and associated understory species appear as dominants. Pond and open-water systems support a diverse community of facultative and obligate aquatic species. Dominant species along the edges of shallow water-habitats include cattails, sedges, rushes *(Scirpus* spp. and related forms). In deeper water, rooted macrophytes such as wapato *(Sagittaria* sp.), pond lily *(Nuphar* sp.), burreed *(Sparganium* sp.), pondweed *(Potamogeton* spp.), and milfoil *(Myriophyllum* sp.). With the exception of the latter species, most of these are confined to slackwater habitats. However, rooted macrophytes also occur in the running-water area of the streams and rivers, including homwort *(Ceratophyllum* spp).

Wetland habitats, either associated with running water or in slackwater areas, provide critical habitat for a tremendous variety of species. All species of fishes in the Willamette, obviously, are tied to permanent water. Cold-water obligate forms (such as the salmonids) are largely restricted to river and stream courses, although well-shaded slackwater areas may provide critical refuge sites during periods of environmental stress. More typical warm-water species, such as some cyprinids and to a lesser extent the catastomids, occur widely through these systems. One species, the Oregon chub *(Oregonichthys crameri)* is obligately associated with relatively shallow, warm backwater areas and pools. Many species of amphibians, by virtue of their ties to water for reproduction, depend upon wetland areas for a variety of purposes. Both northern red-legged frogs *(Rana aurora aurora)* and spotted *frogs (Ranapretiosa)* breed in ponded and backwater areas. The spotted frog appears to be restricted to warmer microhabitats within these areas. Both species of native turtles, the northwestern pond turtle *(Clemmys marmorata marmorata)* and the western painted turtle *(Chrysemyspicta belli)* are closely linked to backwater habitats, although the former species occurs in running waters as well. Birds closely associated with these habitats include all species of waterfowl, great blue heron *(Ardea herodias),* osprey *(Pandion haelietus)* and bald eagle *(Haelietus leucocephalus).* Mammals tied to this habitat include river otter *(Lutra canadensis)* and beaver *(Castor canadensis).*

The distribution of wetland habitats varies with local soil conditions, elevation and the frequency of inundation by the river(s) in a given area. In the Amazon Creek drainage and in the area between the Long Tom and McKenzie rivers is a vast complex of wetland habitats interdigitated with riparian forests, wet and dry prairie. At the confluence of the Columbia and Willamette, vast marshes exist which mix with riparian and mixed forest-habitats. Along the former channels of the river(s), wetland areas are extensive. The influence of beaver in the formation and maintenance of wetland habitats has been extensively documented but is little appreciated in a historical context. Periodic and persistent damming of small - moderate sized streams inundates adjacent riparian forest and other habitats, and often creates ideal conditions for the establishment and maintenance of WPT habitat. The presence of shallow water areas created by the impoundment also may favor the establishment of suitable microhabitat for hatchling- 1 st year animals. Removal of trees along the streamcourse may decrease the amount of canopy cover and thus increase the suitability of a given area for basking, and the presence of tree trunks in the water may also increase the number of basking, foraging and refuge sites. As with most other situations in the Willamette, there was probably a dynamic process of loss and recreation of these habitats via catastrophic flooding, succession and normal population cycles of beaver. However, it is highly likely that the widespread distribution and actions of beaver had a significant positive impact on the pond turtle population in this (and other drainages).

Aquatic habitats can be broadly classed into running-water systems and slackwater systems. Running-water systems typically have substrates that are composed of mixtures of rock, cobble and sand. The larger particles are dominant in the upper portions of most drainages, and grading into a predominance of finer sediments further downstream. Running water systems may vary tremendously in their flow rate, with the main stem of the Willamette reaching several hundred thousand cfs at peak flood stage, to small first and second-order streams that may typically flow less than 1 cfs. The flow in these systems typically peaks during winter rains and spring snow melt, and what are running-water habitats for these few months of the year may be slackwater habitats for the remainder. Most of these systems are relatively shallow, due in large part to the tremendous sediment loads carried by the drainage in general. Slackwater habitats such as oxbows may be isolated from flowing water except during the greatest flood events. Turnover in these systems varies tremendously, depending upon location and other factors. Most slackwater habitats may typically become hypoxic, or in the case of some isolated sloughs or backwaters, anoxic during the late summer months.

The main stem of the Willamette, particularly in the area below Salem, is a heavily braided rivercourse, often with four or five recent channels being noted in the appearance of a given area. To a lesser extent this is true of other systems, particularly those in the middle section of the valley. This complex braiding has led to the formation of numerous oxbows, some several hectares in extent, along historic river channels. Although lakes per se are rare, these oxbows function in many ways as lacustrine environments. The vegetation of these areas is in many ways similar to that previously described for wetland habitats, particularly in slackwater habitats. Many of the oxbows contain extensive growths of pond lilies, wapato, pondweed and duckweed. In the late summer, algal blooms are often extensive in these areas.

In running-water habitats, periodic scouring may maintain the vegetative community in a relatively early successional stage, dominated by various types of algae and small rooted macrophytes. Running water habitats are perhaps less extensive in total area than slackwater habitats. The presence of snags and localized outcrops of rock may foster the development and establishment of slackwater microhabitats within the channel of a river or stream. These areas provide critical foraging, movement and spawning habitat for a variety of fishes, among them the salmonids. Sturgeon are apparently unable to penetrate the system above Willamette Falls, although there is reason to believe that they were present in this system during much of the Pliocene and Pleistocene. Other species closely tied to running-water habitats are foothill yellow-legged frogs *(Rana boylii),* western pond turtles, osprey, bald eagle, many of the diving ducks, as well as river otter and beaver.

In summary, the biotic landscape of the Willamette Valley represents a complex mosaic of habitats and successional stages dominated by the influence of flood and fire. The predictable (long-term) flood pattern and the predictable short-term pattern of fire, coupled with local variations in soil type (and development) and climate, produce a diverse ecosystem that hosts a large variety of species. There are relatively few endemics in the area, in part because of the cataclysmic nature of flood events at the close of the Pleistocene. The greatest specific diversity occurs in ecotonal areas, in particular where forest, grassland and wetland meet. The extent of these areas and their degree of interdigitation in the Willamette was almost without parallel. Historically, the vast riparian gallery forests, the grasslands that stretched across the width and along the length of the valley, the park-like oak forests and the tremendous extent of old-growth and mixed forests on the upland fringes produced ecological and evolutionary "opportunities" that fostered the development and maintenance of a degree of biological diversity unmatched in the Pacific northwest - a true "paradise" in many senses of the word. However, analogous situations existed in many parts of the world that were, in relatively short time spans, to undergo drastic modification and simplification through the activities of a novel ecological and evolutionary factor - the advent of large-scale industrializationby humans. The Willamette Valley provides a case study of the effects of this situation.

The historical record of the appearance of the Willamette Vallev ca: 18 10- 1860

Among the first descriptions of the Willamette provided by European cultures closely followed the first settlements in the mid-valley area in the early 1800's Ross (1849) notes that during the American Fur Company venture in the 1810's in the area, it was observed that the Willamette was "... supreme in an agricultural point of view." However, the initial reason for settlement was not related to agricultural development but to exploitation of the beaver population in the drainage. Widespread trapping of beaver began in this time period and was probably the first extensive form of habitat modification produced by European cultures (see previous discussion). A further description notes that "The banks of the river throughout are low, and skirted in the distance by a chain of moderately high lands on each side, interspersed here and there with clumps of widespreading oaks, groves of pine and a variety of other kinds of wood.. .". Franchere (in Quaife, 1954) noted that in 1813 in passing near the confluence of the Willamette and Columbia' ".. . at the spot where we were the oaks and poplar which line both banks of the river, the green and flowery prairies discerned through the trees...". Later, Franchere notes " Leaving the Columbia to ascend the Willamet, I found the banks on either side of that stream well wooded, but low and swampy until I reached the first falls, . . . Banks on either side were bordered with forest trees but beyond that narrow belt, diversified with prairie, the landscape was magnificent."

On a more exploitation-oriented note, Kelley (1834) notes that " In beauty of scenery, fertility of soil, and other natural advantages . . . no portion of our country surpasses that which is found upon the Willamette. The whole valley of this river abounds in white oak and other valuable timber. Fringes of trees grow along the margin of the stream, and back of these are rich bottom lands or prairie grounds of inexhaustible fertility, and adorned with all the wealth of vegetation. From these prairies, which are sometimes a few rods and sometimes several miles wide, often rise round, isolated hills heavily wooded, and presenting a lovely contrast to the sea of grass and flowers from which they spring. " As with many other parts of the country being explored and opened to alteration, descriptions by trained scientists were rare. However, in 1826, David Douglas, a botanist, traveled along the west side of the Willamette from the Umpqua drainage to Fort Vancouver. He notes that in the vicinity of Lafayette on the lower Yamhill there was "...rich prairie, with more oak than pine" and that camas was abundant in the low, wet prairie near Rickreal Creek (in Towle, 1974). During the Wilkes expedition of 1841, Brackenridge noted that the area from the confluence of the Columbia and Willamette south to the vicinity of Champooi (Champoeg) was heavily wooded. Riparian forest element dominants included willow, alder and dogwood. Small prairies were noted in this general area, but did not become extensive until south of Champoeg. Traveling south for 5 days along the west side of the Willamette, the dominant feature of the landscape was the open prairie, as noted in the first day's travel of 15 miles through "... an open prairie country, swelling gently into round hills with a few scattered oaks along their summits." (in Towle, 1974). Further noting the interdigitation of the grassland/woodland habitat by passages such as ". . . a good many large open spaces of prairie pass'd through today", Brackenridge also noted that trees, primarily ash, were found "... in low, wet swales, a streambank forest marginal to the Long Tom., .", and that ponderosa pines were found in clumps at a slight distance from the stream. Scattered "spruce" were noted mixed with oaks on "... the rising ground." (in Towle, 1974). Wilkes (1845) notes that for an area 9 miles southeast of Champoeg "We passed, in going hither, several fine prairies, both high and low." Wilkes further noted that in a range of hills bordering the Tualatin Valley were "...clothed to the very top with grass.", indicating that the prairie was not limited to flatland areas. Other reports from military sources (Howison, 1846) note that "grass grew verdantly in every spot that was at all sheltered... " and that "Within the limits alluded to lies the whole Wilhammette valley; continuous ranges of prairie lands, free from the encumbrance of trees or other obstacles to the plow... in their virgin state these are overgrown with fern, the height of which, say from three to ten feet, indicates the strength of the soil."

Later reports are more detailed, among the most valuable of which is that of Palmer (1847) Palmer made extensive travels throughout the valley, beginning in the vicinity of Oregon City and extending south to the vicinity of the Long Tom drainage. In the area of Oregon City, he noted that "... this land was covered with dense forest, which is now cleared off." In the vicinity of Linn City and Multinoma there are "... several abrupt precipices of various heights, upon each of which is a small level, of lesser and greater widths, clothed with fine grass and studded over with oak timber. ..". The depth of the river varied, and Palmer noted that "... fifteen miles above the Falls is the first gravel bar, at which place, in low water, there is but three feet of water in the channel. In traveling up the river about fifty miles, I found, in addition to the obstructions named, four other gravel bars, over some of which there were only thirty inches of water. In going the next seventy-five miles, I approached the river several times, and found it to have a deep channel and smooth current." The "Quality" (Tualatin) plains were "....about twenty-five miles in length, alternately rolling prairies and timber.. .". Palmer continues with "The Shahalm (Chehelam) is a small stream, which has its origin in the coast range, runs eastwardly and empties into the Willamette, twenty miles above Oregon City. This is skirted with good prairies of five or six miles in width, near the mountains; but towards the mouth is covered with timber and fem." The area drained by the north fork of the Yamhill River was ". . .a beautiful and fertile valley of some twelve miles in width, handsomely covered with groves of white oak and other timber.., intersected with numerous spring branches, the banks of which are lined with timber, leaving in some places fine bottom prairies covered with a rich sward of grass.". The valley drained by the south fork of the Yamhill ". . is about fifteen miles wide, after the stream emerges from the heavy growth of firs already noticed; for there are firs, more or less, its whole length. From the watercourses, upon an average a little over one fourth of a mile, the valley is fine prairie land, soil light and rich, occasionally interspersed with fine groves... It is well covered with grass, as is every portion of the country that has taken oaken groves, and the lower bottoms yield an abundant supply of the *Camas...* " . In the vicinity of the Rickerall (Rickreal) " The valley through which this little stream flows resembles that described as watered by the Yam-hill; perhaps the soil is a little richer." On the Eola Hills "... are several thousand acres of white oak (Oregon oak), from six to twenty feet in height, some of them of large diameter and all with large and bushy tops; the ground being covered with grass, at a distance they look like old orchards." Along the "Lucky-mate" (Luckiamute) "...two principle branches, of about the same length, depth and width, and passes through an excellent valley of land, with the same diversities and excellent qualities for farming which are attributed to the Yam-hill valley - the timber being more of oak and less of fir." Further south, the Mouse (Mary's) River "... has timber on its borders but less than some." In the area of the Long Tom ". ..like all other streams that enter the Willamette upon the western side, heads in the coast range and after breaking its way through the spurs to the plains below, passes through a valley of good soil. It has deep banks, is more sluggish in its movements than those that join it lower down, is filled with dirty water, has a miry bottom, shaded upon its margin with timber, and in size is something larger than the Yamhill." On the east side of the Willamette and south of Oregon City, Palmer describes "... a small stream called Pole Alley (Mollala River), which is skirted with beautiful prairie bottoms of from two to eight miles in length and one to two miles wide; these, with alternate groves of fir constitute the principle characteristics of Pole Alley Valley." Immediately to the south is the Pudding River, described as "The valley up this river to the Cascade Mountains, where it rises, is alternately fine prairie and timber lands, with occasional fern openings...It is finely clothed in grass, and up the river some distance there are valuable mills sites; the water is clear, and well stocked with fish. From the Pudding River south, there are fern openings, which are succeeded by grassy prairies, which give place to fine groves of fir, but sparsely intermingled with cedar." In the vicinity of Champoeg ". ..where they receive the wheat from the settlers of the extensive plain. extending from the Pudding River up the Willamette to the old Methodist mission ground, which is distant thirty miles from the mouth of Pudding River... Back of this for twenty-five or thirty miles is a very handsome country, mostly prairie, and fine timber, well watered, with occasionally a hill.. . ". Further south, in the area currently known as the Mission bottoms, ". . . the road proceeds up the valley, alternately through groves of oak and pine, fern plains and grassy prairies...". Continuing south, Palmer notes "For the first five miles from the river towards the Cascade Range, the soil is gravelly; it is then a sandy loam to the foot of the mountain, and is generally an open plain. The valley upon the east side of the river at this place, is about twenty-five miles in width. It is proper, however, to remark, that there are occasional groves of timber interspersing the prairie, and in some places they reach within a short distance of the river. In this last described tract, there are several varieties of soil, with prairie, timber, upland, bottom, and hill side; the whole is well watered." Further south, to the vicinity of the Santiam, Palmer notes that "...the Santa Anna has four principle branches, each with several small tributaries, all lined with timber, leaving a strip of beautiful prairie land between each, of from one-half to four miles in width.. . A considerable portion of the soil in this valley is quite gravelly, but a great portion is rich, and the prairies are well clothed with luxuriant grass." From the Santiam south, ".. . the valley is about twenty miles in average width for ninety miles, to the three forks. In this distance there are many small mountains streams, crossing the valley to the river... After leaving the Santa Anna, a prairie commences, of from four to twelve miles in width, which continues up the valley for a day's travel, which I suppose to be about fourty miles."

Palmer also makes some interesting notes on the watercourses of the valley, indicating that "Unlike our great prairies east of the Rocky Mountains, those upon the waters of the Pacific are quite small; instead of dull and sluggish streams, that engender miasma to disgust and disease man, those of this valley generally run quite rapidly, freeing the country of such vegetable matter as may fall into them...". Furthermore, in regard to the Willamette, he notes that "Its banks are generally twenty feet above the middling stages, yet there are some low ravines, (in the country called *dues),* which are filled with water during freshets, and at these points the bottoms are overflowed.. .".

Other descriptions of the Willamette are generally less extensive, but re-emphasize many of the characteristics noted by Palmer. Thornton (1849) noted that "The surface of the earth presents in many places, swells of unequal elevation covered with grass having no undergrowth of shrubs and brush and dotted with the most beautiful oaks, that almost cheat the imagination into the illusion that they were planted and tended by the hand of man. Open prairies of inexhaustible fertility, swelling into hills and sinking intovalleys, stretch away in picturesque beauty." Clark (1927) notes that " Certain very definite sections of the Willamette region.. . can be distinguished. The country below the Falls and eastward to the Cascade Range was then heavily timbered . . . Heavy forests of fir, cedar and pine containing individual trees of immense size and a nearly impenetrable undergrowth of evergreen shrubs, wild berry bushes and such like, lent grandeur to this section and by contrast made the open country above the Falls seem even more pleasant and peaceful as a place of settlement." In relation to prairie habitats, he notes that in the vicinity of the Tualatin Hills prairies and woodlands blended in "beautiful proportions". Further descriptions of the southern part of the valley are very limited, but emphasize the extent of the prairie habitat, particularly as it relates to agriculture.

The influence of humans on the biotic landscape of the Willamette Valley

As noted by Towle (1974), "The disparity between a theoretically-derived forest climax and the actual vegetation is suggestive of long and intense interference with natural processes of development." The agent of interference here is human. The timing of the arrival of the first humans in the Willamette Basin cannot be determined with any certainty at this point due to the depositional environment present - anthropogenic material assignable to the Winkle Unit (5,250-34,400 years BP) (Balster and Parsons, 1968) is likely to be very scarce due to the massive amounts of material that cover actual or potential sites (Aikens, 1984). Clovis points recovered from the Willamette Valley have not been directly dated, but similar material from other areas has been assigned an age of 11,500-1 1,000 BP (Aikens, 1984). Definite evidence of occupation by 7900 BP is present in a site near the South Santiam River (Newman, 1966). From this point forward, there is evidence of continuous and increasing habitation of most parts of the Willamette Valley. For a brief discussion of the sites and findings, the reader is referred to Aikens (1984). The activities of the various aboriginal groups played an important role in the recent evolution of the biotic landscape in Willamette Basin, primarily through the use of fire.

In general, fire retards successional patterns in ecosystems, particularly in areas of mixed forest and grassland. In other areas (such as giant sequoia groves), fire may maintain a sub-climax state, while in chaparral ecosystems, the periodic burning represents the effective climax state of the community over (presumably) long periods of time. The literature on the ecology of fire is too extensive to review here (see in part Stewart, 195 1; Pyne, 1982), however it is important to note that along with the flooding regime provided by the rivers tire has been the primary factor shaping the composition and dynamics of many ecosystems in the WPS trough. fires may occur naturally, through lighting strikes or other factors, and there is evidence of non-anthropogenic conflagrations in forest-core areas in the early 1800's (Morris, 1934). Naturally occurring tires may have also occurred in the grasslands or in grassland/forest ecotones. The end result of these periodic fires was to maintain much of the Willamette Basin in a state of sub-climax, producing a complex mosaic of habitats, with grassland/prairie communities dominating the lowland areas. Intermixed with these grasslands were extensive oak forests and mixed forests, and on higher ground or in more mesic habitats, conifer-dominated systems appeared. The primary causal agent in maintaining this matrix was fire. Given the previously noted depositional environment, it would be hard to directly trace the exact timing of the onset of periodic burning by the aboriginal inhabitants, however by a careful analysis of pollen records over the last 10,000 years we might gain an approximate idea of when the grasslands rose to their current position of dominance, and whether or not there was any significant fluctuation in the extent of these systems. Boag (1988) dates the approximate beginning of extensive anthropogenic influence on this area at approximately 6,000 years BP, ".. .when the valley became dry enough to inhabit".

The recent historical record of fire in the Willamette begins with the invasion and establishment of European cultures in the early 1800's, and is prominent in journals of both the explorers and settlers of the period from the 1820's to the 1850's. Douglas (1914) notes that burning was evident throughout the Yamhill valley, and in many other parts of the valley his party traversed in 1826. As Johannessen et al. (1971) note "The significance of his having traveled fifteen days through the Willamette Valley from near the Oregon City falls to its southern extremity without finding enough food for his horses or game for himself further establishes the extent and completeness of burning. In 1834, Work (in Scott, 1924) noted the native inhabitants setting fires along the Mary's River such that grasslands on both sides of the river were eventually involved. Brackenridge (in Sperlin, 193 1) described the effects of a bum in the area of the Long Tom River. Wilkes (1845) noted that the southern valley had "... an uninviting look, from the fact that it had lately been overrun by fire, which destroyed all the except the oak trees, which appeared not to be injured." Similar notes come from Hines (1881) who mentions a lack of feed for the horses as the result of recent fires on the east side of the valley. The documentation of frequent burning by the aboriginal inhabitants is extensive (Lang, 1885; Kirkwood, 1902; Morris, 1934; Sprague and Hansen, 1946). Other sources (Applegate in Schafer, 1943) indicate that burning may have occurred yearly in some areas, as "It is probable that we did not yet know that the Indians were wont to baptize the whole country with tire at the close of every season; but we were very soon to learn our first lesson."

Douglas attributed the periodic burning to an local form of game management tied to hunting practices for deer. Grasshoppers and wild honey were also gathered after the tire. Another important factor in the use of fire was vegetation management. Wilkes (1845) notes that by the process of burning the natives were able to gather enough sunflower seeds such that they were a staple item in the diet. Applegate (in Schafer, 1943) mentions that tarweed was also harvested as a "wild wheat" after burning in late autumn. Boag (1988) indicates that burning by the Kalapuya may have also been closely tied to retarding oreliminating invasion of wetland areas by brush, since these areas produced another staple item in the diet, wapato.

While the advent of periodic burning cannot be determined with any accuracy, the effective cessation can be traced to the late 1850's-early 1860's. This is due to the dramatic decline in the indigenous population caused in large part by diseases introduced from European cultures. Palmer (1847) notes that in the northern part of the valley in 1842 he found a village of the Clackamis that contained ".. .about twenty families.. . the remains of a once powerful and warlike people." Boag (1988) estimates that the region south of the falls of the Willamette held about 3000 members of the Kalapuya at their peak (in the latter part of the l8th century). By the 1850's, they were reduced to small scattered bands who no longer practiced the extensive burning of only a few years before due to fear of retribution from the more recent immigrants, as noted by Applegate (in Schafer, 1943) "The Indians continued to bum the grass every season, until the country was somewhat settled up and the whites prevented them . . . ".

The effect of the cessation of burning was almost immediate. Whereas fire had previously maintained a dynamic balance between forest and grassland habitats, encroachment by forests and shrub habitats was almost immediately apparent, and long-term shifts in the composition of oak forests were also noted. Wilke (1845) mentions that in the plains in the vicinity of the Yamhill were "... a prolonged level of miles in extent, circumscribed by the woods, which have the appearance of being attended to and kept free from undergrowth. This is difficult to account for, except through the agency of fire destroying the seeds...That this is the case appears more probably from the fact that since the whites have had possession of the country, the undergrowth is coming up rapidly in places. " By the 1870's, invasion of brush and scrubby oak forests was so extensive that Chinese laborers were employed to clear these areas (Nash, 1882). In spite of this, many areas that had previously been prairie succeeded to small oak forests by the end of the 1800's (Nash, 1904), with some patches occupying several hundred hectares. Furthermore, cessation of burning also allowed for the invasion and establishment of Douglas fir seedlings under oaks, which in turn grew rapidly and shaded out smaller oaks in many areas. The end result is that in spite of extensive local harvest for timber, the range of Douglas fir probably expanded in the valley through the early 1900's and to a certain extent continues to expand today, Areas that held oak-savanna forests or grasslands in the mid - 1850's have today produced at least one harvest of mature second-growth Douglas fir and are now in varying stages of succession to mature forest.

Settlement and alteration of the Willamette Valley by European cultures began early - the first settlements in the French Prairie area were evident by the 18 10's. However, significant immigration to the area did not begin until the 1840's with the opening of what would become the Oregon Trail. In 1843, the first large influx of settlers (875 persons) arrived in the Willamette Valley. By 1849 the first census tallied 9,083 persons (Kimerling and Jackson, 1985). As was typically the case with the early stages of settlement, the majority of the persons were involved in agricultural practices. The preferred area of settlement was the higher ground in ecotonal area between the forests and grasslands. Bowen (1968) attributes this to two primary factors; flooding and disease, specifically malaria. As noted, "... the records of the Surveyor General indicate that by 1849 only nine claims had been settled along the wooded margins of the Willamette River andits tributary the Muddy River. By the same date more than five times as many claims were to be found to the east, strung out along the base of the foothills. The early settler's avoidance of lands adjacent to the Willamette River can be partially ascribed to fear of high water... driftwood and watermarks on trees testified that every several years the river flooded its bottoms and lower terraces." The account continues " Another equally repellent features of the lower sections of the valley was the swampy, mosquito-infested bottoms upstream from Champoeg. These were rightly perceived to be potential sources of malaria. " The agricultural potential of the prairies was rapidly recognized, such that by 1855 when the Donation Land Act expired "... only the rugged hills along the margins of the valley were unclaimed." (Towle, 1982).

Agriculturalization of the valley paved the way for other forms of alteration - urban, commercial and industrial - in a typical synergistic fashion. This process has had a tremendous impact on the biotic landscape of the valley, as have similar situations throughout the world. For the purposes of this report, the relative degree of the impacts can be divided into two stages - the first lasting approximately 100 years and extending from the 1840's to the 1940's, and the second extending from the 1940's to the present. In large part the pivotal feature dividing these two stages was the construction of a series of dams along the Willamette River and its tributaries. Towle (1982) has described in some detail the changes in the landscape in the first phase. As with his account, this report will focus on changes in communities during these two phases.

Changes in the biotic landscape: 1840's- 1940's

The prairie habitat was undoubtedly the most widespread community in the Willamette Valley at the onset of alteration by European cultures, and remained as such for a considerable time after settlement. Plowing directly altered many grassland areas, particularly those in ecotonal situations. However, the lack of fossil-fuel powered machinery and attendant complexities limited the amount of area that could be effectively cultivated at any one time. The nature of the process, combined with shifting patterns of land use and ownership, led to a patchwork of cultivated areas and native habitats throughout the valley until at least the early 1900's. Kocher (1929) notes that in Linn County by 1924 " Probably more than 90 per cent (of the level prairie land) has at one time or another been in cultivation, but owing to poor drainage conditions many of the fields have been abandoned for cultivated crops...". Cultivation alone resulted in the destruction and/or alteration of much of the prairie habitat to agricultural communities. However, concordant with this situation an extensive grazing industry developed, such that one reporter noted in 1844 "...there are now large herds of cattle here, and more are being driven from California. Beef and pork are becoming abundant . . . Horses are numerous. I know of no country where there are so many cattle and horses for the population." (Clark, 1927). The effects of grazing on native grasslands have been documented extensively elsewhere (see in part USFWS, 199-) and will not be discussed in detail here. However, three particular aspects need to be noted. First, concomitant with the development of cultivation practices and grazing, initial and repeated disturbance of the soil and vegetative communities set the stage for the invasion and establishment of exotic species of plants, particularly grasses and herbaceous annuals. While the species composition of native grasslands over the majority of the valley may never be known with any certainty, what is apparent is that arguably physiognomically similar habitats in this area today are dominated by exotic species. Similar situations occurred in the central valley of California. The effect(s) of this shift in species dominance on the native fauna are in large part unknown, but are unlikely to have been positive for many species. Second, because much of the early grazing activities was free-range, and standing water was scarce and localized in many prairie areas, grazing likely had a disproportionately negative impact on both permanent and ephemeral wetland communities within the prairie habitat. Trampling and consumption of vegetation, fouling of the water with excretia, and importation of exotic species of plants from other areas. The impacts of these situations were most severe on species that are or were tied to these habitats, such as many obligate wetland plants (in particular vernal pool species), many invertebrates, native amphibians such as long-toed salamanders and red-legged frogs, western pond turtles, garter snakes, waterfowl, shorebirds and some small mammals. Third, the general effect of grazing in area, particularly as conventionally practiced, often leads to simplification of the community through alteration or elimination of microhabitats and structural heterogeneity. On a larger scale, the patchwork nature of the agricultural practices led to fragmentation of continuous habitats, with concomitant effects (see discussion later in report).

A significant shift in both the nature and extent of cultivation occurred by the late 1890's-early 1900's (Towle, 1982). Whereas historically dry-land farming for wheat and oats was the dominant practice, with some cultivation of hops and orchards, the advent of new crops, the availability of fossil-fuel powered machinery and changes in the national market led to a diversification of crops and cultivation practices. Open-range ranching was effectively eliminated by 1890, and livestock was essentially confined to pasture lands after that time. By the late 1930's, the development of a market for grass seed fostered by the government (Highsmith, 1950) shifted the cultivation regime to extensive utilization of prairie habitats such that by the 1970's, over 120,000 ha were in cultivation. The nature and extent of cultivation not only resulted in the almost complete elimination of prairie habitats, the conversion of former pasture lands to intensively cultivated areas eliminated many species in many areas that were able to persist in disturbed habitats. Whereas Towle (1982) argues that from the standpoint of periodic burning and resultant gross physiognomy we have returned to a semblance of the prairie habitat, the lack of biological diversity in these agricultural systems makes most comparisons with prairie ecosystems somewhat disingenuous.

Agricultural impacts have not been the only factors affecting the prairie ecosystem in the Willamette. Urbanization, particularly in the central part of the valley, has also resulted in the loss of significant amounts of grassland habitats, particularly in ecotonal areas where interdigitation with riparian woodland, oak forest and shrub habitats occur. Many of the cities and their associated rural areas in the valley occur in what was formerly native prairie habitat. The general impact to many species in the area of the Mary's River has been discussed by Storm (1941).

In summary, the native prairie habitat in the Willamette Valley, which formerly covered several hundred square kilometers, has been currently reduced to a few square kilometers (or less), fragmented and isolated. The loss of these habitats and/or changes in their composition represents an pauperization of the biological diversity and heterogeneity of the Willamette Valley and the elimination of many opportunities for study of the dynamics of successional processes that were critical in maintaining the nature of the valley as it existed for much of its recent history. Because of the lack of accurate and extensive survey information, the actual decline in many species may not be estimable with any degree of accuracy. Regardless, for many species that were obligately tied to grassland/prairie habitats (for whatever reason), it seems reasonable to assume that major declines in their populations resulted from the loss or diminution of these habitats. For species that facultatively utilized the grasslands, some population and/or range reductions undoubtedly occurred.

The forest systems of the Willamette Valley were affected to varying degrees by the increasing level of human alteration of the area. As previously noted, most early settlements were in ecotonal areas between forests and grasslands. Forests furnished building materials and fuel for the early settlers. The forced cessation of burning actually produced an increase in the extent of many (but not all) forest and shrub communities. Invasion of the grassland areas, as previously noted, was rapid and extensive, such that by the late 1800's the extent of forest-form oak, mixed forests and shrubland communities probably increased significantly in the valley. On a forest-type basis, various communities increased or decreased over time, as described below.

Coniferous forests with old-growth characteristics in the foothills of the valley were cut to varying degrees during the 1800's and early 1900's. The pattern of logging rapidly spread beyond the limited areas of suitable timber in the lowlands into more montane areas. However, Douglas fir, because of its adventitious nature, rapidly invaded or became re-established in many areas. The rapid growth of this species produced a harvestable crop of second growth trees of large size in many areas, such that much of the lower elevations of the valley is a patchwork of different-aged stands dominated by this and associated species. The suppression of fire allowed an expansion of this association into areas that were previously oak-dominated or a mixture of oak forest/grassland. The recent emphasis on decreasing cycle time between harvests has resulted in a more homogeneous matrix in this community, both in terms of structural and biotic diversity, resulting in a disproportionately large area maintained in a very early "successional" stage, and managed for maximum growth rates of the timber "crop". This in turn leads to a further simplification of the system through suppression of competition by other species. The loss of old-growth areas in the valley has resulted in the undoubted loss of many species obligately tied to this association. Species favored by second-growth conditions have become more abundant, and possibly even extended their total range. However, these communities lack the degree of diversity, both structurally and biologically, typically present in many old-growth systems.

Oak forests have undergone both localized expansion and generalized declines. The savanna-form oak exists today largely as a relict in the midst of a sea of cultivation. While these isolated trees or groups of trees undoubtedly provide some benefit for a few species (primarily birds), their functional role in the larger community has been effectively eliminated throughout most of their historic range. The forest-form oak has undergone a mixture of both localized expansion in areas formerly dominated by grassland communities, aswell as a general contraction of total range due to conversion of forest lands to agricultural, urban/rural and industrial uses. Additionally, areas that were formerly dominated by oaks are now in varying stages of succession to mixed-forest habitats or to conifer-dominated systems. The species assemblages associated with the oak forests or associated ecotones have suffered varying degrees of impact. Large taxa, such as brown bear, have been completely eliminated from the Willamette Valley (as well as the majority of their range in North America). Some bird species, such as band-tailed pigeons, have also undoubtedly declined due to loss of foraging areas and roosting sites. Reptile and amphibian species associated with oak understory habitats have also undoubtedly undergone periodic localized declines as habitats became smaller and more disjunct. Insect species associated with forest edge habitats have also undoubtedly declined throughout much of their range in the valley. While significant numbers of oaks remain in much of the valley, the forest per se is now restricted to a much smaller total area than it historically occupied, and the large groves of oaks are now very scarce and confined to upland areas. Similarly, the nature of the ecotonal situation with many other habitats has changed dramatically. Oaks in many cases are confined to isolated strips along riparian areas, with the transition zone to other native habitats (where present) being very limited abrupt. As previously noted, the loss of all but a few grassland habitats has effectively eliminated the forest/prairie mosaic. Fragmentation and isolation of oak habitats have also contributed to the decline of the collective species assemblages in this system.

Mixed-forest habitats, primarily if not exclusively those dominated by Douglas fir, undoubtedly increased as the result of recent human alteration of the valley occurred. In areas where both oaks and fir occur, fir seedlings rapidly outgrow and eventually shade out the oaks, thus resulting in a gradual progress towards a conifer-dominated system. In some areas, isolated oaks may still occur in the midst of otherwise extensive stands of fir, primarily because of the potential long-life span of an oak. Existing patterns of timber harvest and land use will undoubtedly favor the persistence and possible expansion of this community. Mixed forest habitats with other species assemblages, such as ponderosa pine, incense cedar and/or hardwoods, have been subject to localized clearing for timber harvest, agricultural or other purposes. Given the limited distribution of these systems, it is likely that they have decreased significantly from their former abundance, even if the total loss (in terms of area) seems small in comparison to the loss of prairie habitat. This is particularly true in the southern part of the valley. As previously noted, mixed forest habitats not only act as ecotones between other habitats types, they often foster the development of biological diversity that is disproportionate to the amount of areas they actually occupy. For some "edge" species, particularly those that are favored by early-mid successional patterns associated with Douglas fir-dominated systems, the alteration of habitats in the Willamette has undoubtedly led to increases in the total population size and actual range. For species favored by other associations, specifically those in the more xeric habitats in the south of the valley, there has undoubtedly been a decline in their total population size and local range.

Unlike the other forest types, there is no "mixed message" concerning the impact of recent human activity on the riparian forest; The overwhelming result of human alteration of the area has been a massive decline in and alteration of the riparian forest communities of the Willamette Valley. The floodplain of the Willamette was historically 1.6 - 3.2 km wide over much of its length, and in certain areas (such as the confluence of the Santiam and Willamette) ranged up to 10.5 km wide (Towle, 1974). Most of this floodplain was covered with riparian forest elements. The riparian forest also extended up many of the smaller tributaries, although it was not as extensive as in the lowland areas. As noted by Towle (1982) "Clearance of the floodplain forest has been one of the most striking modifications of vegetation patterns. The loss of riparian forest areas began with the first settlement in the Willamette by European cultures. Clearing of land for homes and use of wood for building materials or fuel was common, but such impacts were localized and probably relatively insignificant as long as the human population remained small. However, this obviously did not occur. Commercial exploitation of the riparian forest began in earnest in the late 1800's, as noted by Nash (1904) "The side river courses through the Valley (and there are many of them) are marked by belts of dark fir timber - the course of the Willamette itself by masses of soft wood trees, willows, cotton wood, white poplar, bass-wood, white fir, of great height and thickness. But a few year ago, this timber was called worthless, nowadays the steamboats tow great rafts to the paper mills of Oregon City every year, and many thousands of feet of softwood are utilized in several of the industries of the city."

The trees along the river channels were not only an important source of pulp, they also produced an impediment to navigation, particularly as snags. The Willamette was opened to commercial river traffic (shallow draft steamboats) by the 1860's. The

Willamette was (and still is) declared a navigable waterway to the head of the ferry street bridge in Eugene. To facilitate navigation on the river, several different projects were initiated. As noted by Sedell and Froggatt (1984) " By 1872, the channels and sloughs of the Upper Willamette were being closed off and the water confined to one channel. These channels were closed off using nearby snags from the channel and cottonwoods growing along the river. Wing dams were constructed with firs and willows and other small trees cut from the banks." The size and number of the trees used is impressive - between 1870 and 1950, over 65,000 trees were pulled and cut up (Sedell and Froggatt, 1984). Many of the cottonwoods were 50 m (162') in height and 2 m in diameter. The number of trees removed in this fashion averages one for every 1.6 m of stream, compared with a current figure of one snag remaining every 300-400 m (Sedell and Froggatt, 1984). In spite of the massive program of snagging, river traffic continued to dwindle. By the late 1800's river traffic above Salem was sparse, as noted by Corning (1947) "Inability of the government to keep the channel open as far as Corvallis for more than seven months of the year, was an added factor in the decline of river commerce." Other factors included a shift in crop production away from wheat and oats, competition from the railroads and the continued shifting of the river channel. Corning (1947) notes this as follows ". ..each winter's high waters altered portions of the irregular channel; a captain returning downstream on the heels of flood, no matter how moderate, could expect to encounter some part of the way that he had not seen or navigated before, and must alter his charts accordingly. The waters invaded the shallow lowlands with unpredictable restlessness, and the stream grew broader and shallower." By 1903, traffic above the Junction City landing was scarce, " After that day the bankside fuelyards no longer stood neatly stacked with cordwood. Silence deepened over the stream and gradually a semblance of the original wilderness returned to its shores. Trees interlaced deeply their branches; new growth stemmed from old wood; small tributary streams of former canoe and flatboat commerce were screened away with precluding finality. Sandbars grew and snags piled up where no snagboats came to remove them ,.. Only the infrequent tugboat climbed the river to tow down some raft of logs. The river had seen its "great day" and that day was over." However, despite this contention clearing of the riparian forest continued. Between 1900 and 1950 the U.S. Army Corps of Engineers removed over 35,260 snags and live trees (Sedell and Froggatt, 1984).

The massive alteration of the riparian forest as previously noted had just begun to taper off when yet another major impact developed, the clearing of floodplains for agricultural purposes. As noted by Towle (1982), floodplain soils are well suited for irrigation and allow a greater diversity of crops to be raised in an area than is possible using upland soils (such as occur in the former prairie areas) alone. However, the key to profitable utilization of these soils is not only the availability of irrigation water during the summer months, but also flood control. In this respect, the development of dams along the Willamette has played a pivotal role in the alteration, not only of riparian forest habitats, but much of the remaining native habitat in the Willamette Valley as a whole. These project effectively began in the 1940's with extensive planning by the predecessors of the Corps of Engineers (U.S. Army Engineers, 1938) and after World War II the Corps itself. Fern Ridge dam on the Long Tom River was completed in 1942. Several additional dams on the Willamette and tributaries furnished not only predictable releases of water for irrigation but also relatively cheap power to facilitate use of pumps and associated equipment. In the five southern counties of the Willamette Valley, the amount of land under irrigation quadrupled between 1945 and 1969 (Towle, 1982). Although the presence of the dams has not prevented flooding (as with the December 1964 flood), it has apparently, as noted by Towle (1982) changed at least ". . .the perception of the flood hazard." Furthermore, the development of the dams - whether for flood control, irrigation, power generation or whatever purpose - has fostered the continuing alteration of floodplain habitats on a scale and to a degree that would not have been possible in their absence. A detailed discussion of the effects of dams on the biotic environment will follow in another section.

The massive alteration and removal of riparian forests in the Willamette was apparent even to many non-scientists by the 1950's and 60's. In large part the concern over the potential loss of the remainder was the impetus for the Willamette River Park system, created by legislation in 1967. This created in effect a series of "greenway areas" along the Willamette River designed primarily as recreational use-areas and secondarily to preserve the nature of the area. However, even within these putatively protected areas, habitat loss continues at a significant rate. Wickramaratne (1983) noted that between 1972 and 198 1 the loss of vegetation in the Linn and Benton county areas amounted to 294 hectares, or 5.6% of the total area of the greenway.

In summary, habitat loss and alteration of riparian forests within the Willamette drainage can best be described as massive. The gallery forest - an area of tall cottonwoods interspersed with other species, which formerly covered the floodplain for a distance of 1.6 to 3.2 kilometers along much of the river, now exists as a tiny strip - often a few tens of meters wide - along most of the drainage. These strips often abut intensively cultivated areas, such that for many kilometers there is no effective ecotone, but rather an artificially sharp demarcation between habitat types. Other smaller forest areas along the tributaries have also suffered declines although probably not to the extent noted along the mainstem of the Willamette. The alteration and/or loss of these forest habitats has had and continues to have a significant impact on the endemics and species assemblages that occur in them. These impacts are not restricted to the species alonebut also affect the biogeochemical cycle of the floodplain due to a synergistic loss of nutrient input, buffering capacity, general structural complexity, microhabitats, effective shoreline length and an increase in effective habitat fragmentation. The effects of these changes extend far beyond the river itself, but are most obvious in their relation to the next habitat type, wetlands.

As previously noted, much of the Willamette Valley, particularly along the floodplain, could be classified as wetland habitat. Here I will focus on those areas not dominated by riparian forests but that are instead characterized by a specialized biota, with soft-stemmed emergents or aquatic macrophytes the dominant flora elements. The distribution of these areas extends throughout the Willamette, although they most common and extensive along the floodplain of the mainstem of the river. Major "core" areas of wetlands exist in the delta at the confluence of the Columbia and Willamette, and in the area between the main stem of the Willamette and the Long Tom drainage, now in large part occupied by the city of Eugene. Major losses of wetland habitat have occurred throughout the WPS trough and are part of a larger pattern of wetland losses throughout the United States (Dahl and Johnson, 1991). The reasons for and extent of these losses vary from area to area, ranging from conversion of marsh lands downstream from Portland during World War II to shipyards, to drainage of wetland habitats by tiling in some parts of the valley to allow cultivation, to wholesale till in the Eugene area to foster urban and industrial expansion. A less obvious but equally important form of loss is the elimination of habitats created and maintained by periodic flooding. Construction of dams and close regulation of water flow along the main stem of the Willamette and most major tributaries have effectively eliminated the periodic flood events that produce these habitats. The areas in large part have either been eliminated through conversion to agricultural habitats or are in varying stages of succession to other communities, most typically riparian forest. Other losses have been incurred through changes in historic waterflow patterns, either through diversion of surface flow or changes in groundwater levels, removal of or decreases in beaver populations, invasion and establishment of exotic vegetation that forms effective monocultures (such as reed canarygrass, *Phalaris arundinacea),* and "mitigation" practices that replace complex habitats with structurally and biologically simplified areas, disparagingly but accurately referred to as "duck donuts". As previously noted, these habitats are biologically diverse and structurally complex, and the dynamics of these situations remain poorly understood despite significant amounts of research over the last twenty years. The loss and/or or diminution of natural wetlands has resulted in a general decline in many species that facultatively use wetland habitats, and a major decline in species that are obligately associated with them. Many of the vertebrate species in the Willamette drainage currently listed as Federal candidates (or officially listed as threatened or endangered) are closely associated with wetland habitats. These include the Oregon chub, the northern red-legged frog, the spotted frog, the western pond turtle and the tricolored blackbird. Several species of candidate or listed plants also occur in these areas.

Loss or degradation of these habitats is perhaps a matter of greater concern than the loss of many other habitat types within the valley for several reasons. First, the relative percentage of wetlands lost is probably higher than for any other habitat type (except possibly riparian forest). Although extensive areas that are classified as wetland remain (based in large part on soil conditions), many of these do not function as complex habitats typically associated with wetland ecosystems. As such, the remaining habitats have disproportionate value, not only as reservoirs of biological diversity, but also as heuristic and practical models for the study of wetland function. Second, while in a structural sense recreation of some other habitats may be possible given low-intensity management efforts (such as periodic burning to restore or recreate grassland systems), existing information and practices are inadequate to allow "reconstruction" of most if not all of the native wetland communities in this area, even with intensive management and manipulation. Third, information from intensive studies in other areas (particularly the eastern United States) indicates that the relative importance of wetland communities in functional inter-relationships with other habitat types may have been significantly underestimated. As such, protection of remaining areas, particularly in those sites in ecotonal situations, is of paramount importance. Fourth, other information indicates that fragmentation of wetland habitats may have disproportionately negative impacts on some taxa, in particular birds and turtles (see discussion later in report). Given the highly disjunct and fragmented nature of existing wetland habitats, projected patterns of alteration will likely only exacerbate these and other negative effects.

Aquatic habitats along the Willamette have also suffered significant negative impacts associated with human settlement of the area. The extent and degree of these impacts varies from area to area. For the purposes of this report, the most significant are those directly tied to the structural alteration of running-water(riverine) habitats (Cowardin et al., 1979). Aquatic habitats may be significantly altered by inundation (via construction of a dam), channelization, changes in water flow patterns, or diversion (leading to dewatering). In part, all of these situations have affected and continue to affect the biophysical processes of aquatichabitats in the Willamette drainage. Generally speaking, the construction of dam(s) in a river system have significant effects not only within the area inundated by the reservoir, but upstream and downstream of these areas as well. Briefly, these include creation of novel (pseudo-lacustrine) habitats in areas where they may not have previously existed, alteration of microclimatic patterns (particularly around large reservoirs), changes in nutrient cycling patterns, and creation of habitats that foster the introduction and spread of exotic species. All of these situations probably occur to greater or lesser degrees within the Willamette drainage. Channelization, either in the form of direct excavation of a drainage or "stabilization" of banks via placement of riprap or other diversion structures results in a change in historic water flow patterns, generally leading to a gross simplification of structure within the system and possibly changes in nutrient cycling patterns. Attendant "maintenance" activities such as roads and vegetation control impact adjacent habitats through removal of native vegetation and facilitating incursion and establishment of exotics. The Amazon Creek area in the vicinity of Eugene demonstrates many of these characteristics. Changes in water flow patterns are often interrelated with temperature and other effects. Unseasonal discharge of water cooler or (rarely) warmer than historically was present in the system may have significant effects not only on species of fish, but other taxa as well. Changing the amount of discharge may lead to major changes within the primary producer community as well. Diversion, leading in some instances to dewatering or a change in the historic flow pattern, may lead to the acceleration of successional processes, such that formerly ephemeral (but predictable) wetland areas undergo succession to other habitat types, most typically riparian forests. The extent and nature of flood control efforts in the Willamette (see Emmer and Muckleston, 1971) and similar efforts has had and continues to have a significant negative impact on many aquatic ecosystems in the Willamette drainage. A detailed discussion of this situation is presented later in this report, and the reader is referred to Petts (1984) and Boon et al. (1992) for a general discussion of human impacts to riverine systems,

In conclusion, the Willamette Valley represents a heavily altered ecosystem. Widespread and inter-related changes in all major habitat types have occurred. There has been a significant overall decrease in the total size and range of native habitats, which have been replaced with agricultural, urban or commercial/industrial habitats. The native prairie, riparian forest and wetland communities have suffered disproportionately higher losses than other systems. The general trend in the valley is toward increasing amounts of edge habitats, usually those heavily altered by human activity. Remaining native habitats are often small, fragmented and disjunct. The short-term ecological consequences of this situation have been the extirpation of some species, severe declines in populations of many others (Storm, 1941) and a general trend towards the progressive decline in the biotic diversity of native ecosystems. Changes in water flow patterns and elimination of most of the riparian forest system, as well as attendant changes in many other habitats, has changed the nature and extent of certain biogeochemical processes operating within the regional ecosystem as a whole. The long-term effects of these changes are somewhat unpredictable, but likely to include continued disruption of natural processes, continued habitat loss and fragmentation, loss or further declines in many species, and an increasing and possibly autocatalytic trend toward simplification and homogenization of a complex ecosystem.

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CHAPTER 2

A Synopsis of the Natural History of the Western Bond Turtle *(Clemmys marmorata)*

A Synopsis of the Natural History of the Western Pond Turtle *(Clemmys marmomta)*

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Taxonomy

The western pond turtle was first described as *Emys marmorata* based upon specimens collected in the Puget Sound area (Steilacoom) in 1841. The first use of the combination *Clemmys marmorata* was by Strauch in 1862. Seeliger (1945) described two subspecies, the northwestern pond turtle *(Clemmys marmorata marmorata)* from the area north of the American River in California, and the southwestern pond turtle *(Clemmys marmorata pallida)* from the coastal area south of San Francisco. The San Joaquin Valley is considered a zone of intergradation between the two subspecies. Holland (1992) indicated that there are three morphologically distinct forms within what is currently recognized as *Clemmys marmorata,* which in fact comprises three species. Two of these roughly correspond to the currently described subspecies and the third is an undescribed form from the Columbia Gorge.

Description

The western pond turtle is a "typical" member of the family Emydidae, reaching a maximum length of 210 mm and a maximum weight in excess of 1200 g. Maximum size varies geographically, with animals from southern California rarely exceeding 160 mm. The largest animals (over 200 mm) have been found in the Lost and Klamath rivers of Oregon. The largest animals known from the Umpqua and Willamette drainages are slightly over 190 mm and exceed 1100 grams.

Color and markings vary ontogenetically, geographically and sexually. Hatchlings and juveniles tend to darken with age, and markings in adults generally-become less distinct. Animals from the southern part of the range (currently described as *Clemmys marmorata pallida)* are typically lighter in overall color, with light yellow or brown predominating as a ground color. Contrast between shell color and dorsal skin color in this taxon is greater than in the northern subspecies. Ground color of the carapace varies from yellowish (in *C. m. pallida)* to brown to black. A small percentage of the females in a population may have a terra-cotta/reddish carapace. In some large males, melanin pigments fade in a patchy manner, producing a carapace with a piebald appearance. The carapace may be unmarked, or possess a series of small fine black or dark brown lines radiating from the growth centers of costal and vertebral shields. Occasional specimens possess a complex series of dark vermiculations on the carapace. The color of the plastron is usually cream to pale yellowish or very light brown in color. Dark mottling is present on the majority of specimens, and covers from 5-100% of the plastron. Staining of the plastron by tannin is common specimens in ponds and lakes, and in many such animals the plastron appears to be uniformly dark reddish-brown.

Western pond turtles are strongly sexually dimorphic (Fig. 1). Holland (1992) indicated that 26 of 28 characteristics used in a discriminant analysis vary significantly between males and females. Secondary sexual characteristics are present in almost all animals > 110 mm carapace length, and gonadal development and differentiation is obvious at this size throughout the range of the species. In general, females have more heavily domed and higher (deeper) shells than males of equivalent sizes. The head in females is smaller than in males of the same size, and the angle of the snout differs. In males, the snout is usually 10-15 ^{0} from the vertical while in females the snout is parallel to the perpendicular axis of the head, or at a 5 ^{0} angle or less, In females, the head and sides of the neck are usually more heavily mottled, while in males the color is more uniform. The throat in females is often light yellow in color, and flecked with small brown lines or spots. In males, the throat is usually lighter in color with few or no markings. In large, old males the throat may be bright white or yellow, and can be distinguished at distances of over 100 m with binoculars. These latter characteristics are most evident in larger animals. Some animals may exhibit localized variation in throat and limb color due to diet. For example, animals that prey heavily on introduced crayfish *(Procambarus* and other taxa) often develop a salmon-colored suffusion of the throat and limbs. The characteristics that distinguish the sexes generally become more obvious with increasing size and age, and are more readily apparent in the northern subspecies (C. *m. marmorata)* than in the southern subspecies *(C. m. pallida).* Additionally, a small percentage (occasionally as high as 1-2%) of the animals in any given population may display characteristics that are intermediate between the sexes. In most cases, these are females with relatively low-domed shells, angled snouts and thicker tails.

Range

The western pond turtle historically ranged from the vicinity of Puget Sound to the Sierra San Pedro Martirs in Baja California Norte, chiefly west of the Sierra-Cascade crest (Fig. 2). Isolated populations are or were known from the area of Puget Sound, the Columbia Gorge, the Mojave River in California and the Carson and Truckee rivers in Nevada. The latter two populations are probably the result of introductions (Cary, 1887; Holland, 1991a) Isolated records exist from a number of sites well outside the current range, and probably represent introductions.

Distribution - Oregon

In Oregon, the species is known from many areas within the western 1/4 of the state (Holland, 1993). The species is found in the Basin and Range, Klamath Mountains, Coast Range, Willamette Valley and Western Cascades physiographic provinces (Orr et al., 1992). The majority of sightings and other records occur in the major drainages of the Klamath, Rogue, Umpqua, Willamette and Columbia River systems. Isolated records are known from several smaller drainages in the Coast Ranges, among them the Coos, Coquille, Siuslaw and New River systems. The statewide range of the species is shown in Figure 3. Isolated records for the vicinity of Bend (T. DeLorenzo, C. Moehl, pers. comm.) and the John Day drainage (Black and Storm, 1970) undoubtedly represent introductions. The status of the animals (several reported sightings and 1 specimen (Storm, 1948)) from the Tilamook area is unclear, but may represent introductions or an isolated population.

Behavior

Western pond turtles have a well-developed sense of sight and hearing, and are generally very wary, although they may become desensitized to certain types of disturbance (i.e. automobile traffic on a bridge). Turtles are especially sensitive to movement, often engaging in escape behavior at distances over 100 m. Under undisturbed conditions, turtles spend considerable amounts of time engaged in thermoregulatory behavior. Holland (1985a) has described two basic types of this activity: emergent thermoregulation, in which turtles bask on logs, rocks, emergent vegetation, debris and occasionally mud or sand banks and aquatic thermoregulation, in which animals exploit thermal gradients within the aquatic habitat by laying in the top 3-6 cm of the water, often in or on top of vegetation (such *as Ruppia* or *Elodea)* The latter occurs in many areas, particularly in late summer. Temperatures in these situations may be as high as l0-15 ° Celsius above the water immediately underneath. For a more complete description see Holland (1985a, 1991a).

Foraging behavior also occupies a considerable amount of time. Turtles locate food by sight or smell, and are often seen "cruising" along the bottom or banks of a watercourse, occasionally pausing to ingest some item. Turtles engaged in this activity may remain submerged for 60 minutes or more, but more frequently rise briefly to the surface every few minutes to breathe or examine their surroundings before returning to the bottom. Feeding is normally solitary, but large numbers of animals may aggregate at the carcasses of vertebrates.

Aggressive interactions are common and may occur during both thermoregulatory and other activities. The most common aggressive behavior consists of an open-mouth gesture, which may be followed by a lunge and/or biting motion (Bury and Wolfheim, 1973). Shoving, rocking or "bumping" on emergent basking sites is also common and appears to be size-related, with smaller animals the more frequent recipients of this activity than larger turtles. Nevertheless, turtles may occasionally be seen "stacked" two and three deep in areas where basking sites are limited, For a more complete description of behavioral interactions see Holland (1985a, 1991a).

Diet

Western pond turtles are dietary generalists. Bury (1986) and Holland (1985a, 1991a) list known food items from several major groups of animals, either as prey or carrion. The dominant item in the diet of the turtle may vary from area to area depending upon local conditions. In general, the majority of the diet is composed of small aquatic invertebrates, including crustaceans (cladocerans, native and introduced crayfish), insects (the larvae of midges, dragonflies, beetles, stoneflies, caddisflies) and occasionally annelids. Turtles may also engage in neustophagia (Holland, 1985b; Bury, 1986), a modified form of gape-and-suck feeding on small invertebrates (such as *Daphnia)* in the water column. Bury (1986) indicates that turtles from northern California may occasionally eat frogs or small fish, however it is unclear whether or not these were captured while alive or ingested as carrion. Holland (1985a) found only two vertebrate items in over 500 stomach flushings, both of which may have been scavenged. Graf (1939) indicates that predation by adults on crayfish and ducklings has been noted. More recent information from Site OR 039 W (in the Willamette drainage) indicates that turtles may occasionally prey on the egg masses of native ranid frogs (J. Kaupilla, pers. comm.). Hatchlings prey primarily on nekton and the larvae of small aquatic insects such as mosquitoes, and other small invertebrates.

Carrion may form both a locally and/or seasonally important part of the diet. Scavenging has been noted on the carcasses of several species of mammals, birds, reptiles, amphibians and fish. Use of plants appears to be relatively infrequent, with foraging noted on pond lily *(Nuphar polysepalum)* inflorescences (Evenden, 1948), willow and alder catkins, and ditch grass inflorescences (Holland, 1991a). Some use of filamentous green algae has also been noted (Holland, 1991a), and post-partum females have been observed to ingest large amounts (up to 8.5 g) of tule *(Scirpus* sp.) and cattail *(Typha latifolia)* roots (Holland, 1985a) The prey is ingested in the water, as the species is apparently unable to swallow in air (Holland, 1991a).

<u>Home Range</u>

Bury (1972) indicated that in a northern California stream, males have an average home range of 0.976 ha (2.41 acres), while that of females averages 0.248 ha (0.61 acres) and juveniles 0.363 ha (0.9 acres). There was considerable overlap in home ranges among all sexes and sizes. More recent studies confirm this general pattern (see relevant sections of this report) and indicate that home ranges vary considerably in size between riverine and lacustrine habitats.

<u>Activity</u>

Western pond turtles are active on a year-round basis in both aquatic and terrestrial habitats. Previously, it was thought that while turtles in the southern part of the range (central and southern California) were active on a year-round basis, turtles in the northern part of the range were largely inactive during the winter months (Holland, 1991a) More recent data indicates that at least some activity occurs year-round in the northern part of the range as well. Records exist for turtles emergent basking in west-central Oregon during December and January, and several records exist for movements within the aquatic habitat during the winter months. Turtles have been observed swimming under ice several centimeters thick when the water temperature was approximately 1° Celsius. In some habitats, turtles may engage in communal overwintering, with large numbers concentrated in a relatively small area. Observations at a site in the Willamette drainage in late 1993 noted 43 turtles overwintering in the mud at the bottom of a shallow pond within an area of < 1 m2. Results from telemetry studies indicate that smaller aggregations may occur in other areas. Emergence from terrestrial overwintering sites may occur as early as March and as late as June, probably in response to yearly variation in temperature conditions. The majority of emergent basking seems to occur from April through June, and except for periodic terrestrial excursions by nesting females, most of a given population appears to exist in the watercourse in this time period.

Movement to overwintering sites (where it occurs) appears to begin as early as late September and as late as November. Turtles are also known to move between over-wintering sites, and will occasionally emerge from both terrestrial and aquatic overwintering sites to bask on sunny days. This behavior may continue throughout the winter and into early spring.

Habitat Reauirements - Aquatic Habitats

The western pond turtle has been described as an aquatic habitat generalist (Holland, 1991a; WDW, 1993) and to a certain extent this is true. The species occurs in a wide variety of both permanent and ephemeral aquatic habitats throughout its range, but significant geographic variation exists in its occurrence in some types of habitats (Holland, unpubl. data). The species ranges from sea level to over 1375 m (4500 ') in most of its range, although the maximum altitude at which the species occurs generally decreases in the northern part of the range. A few records exist for sites up to 2048 m (6700') in California, although the species is uncommon anywhere above 1529 m (5000'). Pond turtles have been observed in rivers (Pig. 4), streams (Fig. 5), lakes (Fig. 6), ponds (Fig. 7), permanent and ephemeral wetland habitats, and altered habitats including reservoirs (Fig. 8), abandoned gravel pits, stock ponds, and sewage treatment plants. Sightings in altered habitats (such as sewage treatment plants) often represent animals displaced by destruction of natural habitats, and no data exists to date to indicate that turtles are capable of maintaining viable populations in reservoirs or "artificial" watercourses.

In Oregon, the species is found primarily in rivers, larger-order streams and wetland habitats. In the Klamath basin, the majority (>8O%) of records are from the Klamath and Lost River and the Klamath Lakes. Relatively few (<5%) of the sites are in streams. In the Rogue drainage, records are almost equally distributed between the river, larger-order streams and small ponds. In the Umpqua, most records (>80%) are from rivers and streams. In the Willamette, a significant percentage of the records are from wetland/pond areas (often old oxbows) adjacent to the river, while most others are from riverine or wetland sites. Relatively few of the records (ca: 5%) are from streams. Records from the coastal region are approximately equally divided between riverine, stream and lake habitats. All records in Oregon from the Columbia are from pond or wetland habitats, although two records from streams may exist on the Washington side of the Columbia Gorge.

Within the aquatic habitats used by western pond turtles, distribution may vary both seasonally and locally. Along most major rivers (such as the Willamette), turtles were continuously distributed throughout most of the drainage, but were concentrated in areas of optimal habitat such as side-channels or areas of low current. During periods of high flow, individuals may move into oxbow (Pig. 9) or other wetland habitats adjacent to the river and return when flows decrease. Turtles also move overland between aquatic habitats, often at distances exceeding 1 km.

The size of the aquatic habitat utilized by western pond turtles may also vary on a seasonal and local basis. In some areas, turtles may utilize ephemeral pools only a few square meters in extent. Turtles are also found in the Klamath Lakes, which cover several dozen square kilometers. However, in this area turtles are or were concentrated along the fringe of the lake. Turtles also inhabitat ponds which may vary in size by 50% or more in the course of a year. Turtles are known from several areas where water is present (either in a pond or stream environment) for only a portion of the year. In these situations, turtles may aestivate in the mud in the watercourse (such as a pond) or in upland areas adjacent to the watercourse (ponds and streams) during the late summer-early spring.

The structure of aquatic habitats used by pond turtles varies widely. In most habitats, emergent basking sites in the form of rocks (Fig. 10), logs (Fig. 11) or emergent vegetation are present. However, in certain sites (particularly altered watercourses such as stock ponds) such elements may be scarce or absent. Refugia, in the form of undercut areas along the banks (Fig. 12), submerged vegetation (Fig. 13), rocks, logs, or even mud are typically present in almost all areas utilized by turtles. Observations and some habitat use data indicate that turtles may generally avoid areas (particularly in stream habitats) that lack significant refugia. Turtles also seem to avoid areas of open water that lack nearby refugia and/or basking sites.

Aquatic over-wintering sites appear to be variable. In some instances, turtles may overwinter in the mud at the bottom of the watercourse (usually a pond). In other situations, turtles may overwinter in undercut areas along the bank or under logs (Fig. 14, Fig. 15) or areas of emergent vegetation in the watercourse. Turtles may move among several different sites during the winter, often swimming under ice in water temperatures as low as 1° Celsius.

Habitat Requirements - Terrestrial Habitats

Western pond turtles are minimally obligately tied to terrestrial habitats for oviposition, which will be discussed below. In many areas, this species is also tied to terrestrial habitats for other purposes. These include overwintering, aseasonal terrestrial habitat use, and overland dispersal. Ongoing research indicates that in many areas, turtles may leave the watercourse in late fall and move into upland habitats up to 500 m (and possibly more) from the watercourse. Typically, turtles burrow into duff (leaf litter) and/or soil and overwinter in these areas (Fig. 16). Turtles may move several times during the course of the ove-wintering. The time spent in the terrestrial habitat seems highly variable - in southern California turtles may remain in these sites for only a month or two. In Oregon, two turtles spent at least 8 months in or near an overwintering site. Preliminary evidence indicates that the frequency of occurrence of use of terrestrial overwintering sites seems to vary between habitat types - all or the majority of turtles in two rivers in Oregon and northern California over-winter on land. In pond and lake habitats, some turtles over-winter on land and others remain in the pond during the winter. In streams in the Willamette valley, this "mixed-mode" strategy also seems to occur. The site characteristics of the overwintering areas seems highly variable in some respects - sites are known from all aspects and on slopes of 0-35°. A general shared characteristic appears to be that the overwintering microsite has a thick layer of duff - however, the relative composition of this duff (conifer-broadleaf) may be variable. For a more detailed discussion, see the chapter on overwintering elsewhere in this report.

Turtles may also move into upland sites during the other times of the year (Fig. 17), which for lack of a better term is called aseasonal terrestrial habitat use. In these situations, turtles often burrow into the duff layer or occasionally sitting under shrubs. The extent and duration of these activities seems highly variable, and the reasons for these activities are not currently understood (Rathbun et al., 1993). The distances involved do not seem to be as great as those in over-wintering behavior.

Overland Movements

Turtles may also move overland considerable distances (up to 5 km). In some cases these movements may be a response to general environmental stress such as drought. In other cases they may be a part of a turtles normal movements within a home range, which may encompass discrete aquatic habitats (i.e. a series of ponds). All size classes have been observed engaged in these movements. As with the situation above, the extent of and reasons for these movements are poorly understood.

In general, the frequency of extensive overland movement appears to be limited and is somewhat variable. Holland (1992, unpubl. data) indicates that in a 10-year study (1984-1994) with over 2,100 captures and recaptures (total) in 21 drainages along the central coast of California, less than ten instances of movement between drainages were recorded in this time period. The greatest distance moved was 5 km (one instance), and the remainder were less than 3 km. Conditions for overland dispersal in this area are probably among the least stressful in the range of the species due to the generally mild climate and relatively short distances between watercourses. Although the results of this study are tentative, they do seem to indicate that movement between drainages - even under the "best" of conditions - may be a relatively uncommon occurrence. Data from three other sites over a seven-year period (1987- 1994) involving over 1,100 captures and recaptures has yet to reveal any instance of movement among drainages. The intervening habitat in this area is significantly more severe although interdrainage distances are approximately equivalent to those of the previously described site. Genetic evidence (see chapter on molecular genetics) supports the contention that at least some populations of this species are truly "isolated" in relation to dispersal and gene flow.

On numerous occasions, turtles have been observed moving through the terrestrial habitat in apparent response to high flows in stream and river systems. These may represent animals "flushed" from areas under the bank or other refugia. On several occasions, these animals were apparently crossing roads and were killed by traffic.

Reproduction

The reproductive ecology of the western pond turtle is poorly understood, although considerably more information exists on this topic than was the case just a few years ago (Rathbun et al., 1992). Size and age at first reproduction varies geographically. Secondary sexual characteristics and development of gonads are apparent throughout the range by the time the animal reaches 110 mm. A few females from southern California may reproduce at a size as small as 111 mm, and as young as 6-7 years. However, most animals do not appear to develop eggs until they are over 120 mm and at least 8-10 years of age. In the northern part of the range (Rogue River north), the smallest gravid females known are 13 0 mm and probably 10- 12 years of age. Age and size at first reproduction for males is not as well known, but may follow a similar pattern. The lack of females carrying eggs in the 120 mm size range for the northern part of the range may be due in part to the very small sample size available for this size class in this area - only 4 females (out of 136 animals) from the Willamette have been captured from 1987-1993.

In some areas, such as southern and central California, some females may lay eggs every year and a portion of the population may deposit two clutches in a single year. However, dissection of a large series (over 100) of females in 1987-1989 and examination by palpation of over 1200 other females between 1987-1994 indicates that the majority of females probably oviposit in alternate years (Holland, unpubl. data). Several factors may affect this situation, including available food supply, seasonal temperature, age of the animal, and location in the range. Clutch size varies from 1- 13 eggs, and is positively correlated (r = .692) with carapace length . In Oregon, the smallest known clutch size is 3 and the largest is 13. The average for the Willamette drainage is approximately 7.

Oviposition has occurred as early as late April (in southern and central California) (Rathbun et al., 1993) to as late as July, and two records exist for females with shelled eggs in August. Several animals in Oregon with shelled eggs were observed in late July 1994, and a single animal was observed excavating a nest on July 28 1993. However, most oviposition efforts recorded to date have occurred in June and July. Females typically leave the watercourse in the late afternoon and move into upland habitats to excavate a nest. The female empties the contents of the bladder onto the soil, and excavates the approximately lightbulb/pear-shaped nest with alternating movements of the hind limbs. Depth varies from 90-125 mm. Completion of the nest requires from 2-10+ hours. After depositing the eggs (Fig. 18), the female typically scrapes vegetation and soil into the neck of the nest, which forms a "plug". This material is "kneaded" into the neck by the hind feet. Females may make several "false scrapes" (Fig. 19) - excavating nests and then abandon them without depositing eggs. This may or may not be a response to disturbance. Several situations have been noted where the female abandons the nesting attempt after hitting a rock or root during excavation. Females are very sensitive to disturbance during nesting movements, and may return to the watercourse if even slightly disturbed.

Nests are typically excavated in compact, dry soils with a high clay or silt fraction. Slightly over 1% (n=3) of the nests discovered to date have been excavated in soils with any significant amount of sand. Nest distance from the watercourse ranges from as little as 3 m to over 402 m (Fig. 20). Most nesting areas are characterized by sparse vegetation, usually short grasses or forbs (Fig. 21, Fig. 22). Aspect generally tends to be south or west-facing, although a few nests are known from west or northwest facing slopes. Slope varies from O-60^{o}, although the majority of nests are on slopes of 250 or less. Eggs average 3 l-38 mm in length and 20-24 mm in diameter, and weigh 8-10 grams. Incubation time in captivity varies from as little as 60 days (L. Over-tree and G. Collings, pers. comm.) to an average of 73-80 days (Feldman, 1982). In nature, known incubation time ranges from 80-100+ days in California to 94-106 days in Washington. Overall hatching rates average approximately 70%, although complete failure of nests is not uncommon. In southern and central California, some hatchlings may emerge from the nest in early fall, and some may overwinter in the nest. All known instances in northern California and Oregon indicate that hatchlings remain in the nest over the winter, and emerge in spring. Hatchlings are 25-3 1 mm carapace length upon emergence and weigh 3-7 grams. Post-emergence terrestrial movements of hatchlings are essentially unknown, but the aquatic microhabitats in which they occur are often highly localized and distinct.

Growth and Survivorship

Growth rates may vary geographically and under differing environmental conditions. Holland (1985a) notes that in animals from the central coast of California, growth rates for hatchlings averaged 3.29 mm/month during the first season of growth, declined to 1.95 mm/month during the second season and averaged only 0.64 mm/month during the third season and 0.89 mm/month during the fourth season. Rates of growth after the fourth year averaged approximately 0.4 mm/month. Significant inter-individual variation in growth rates within a population may also occur. Interpretation of age structure in turtle populations is typically conducted by counting annuli (growth rings) on plastral shields (Pig. 23), with the assumption that each annulus represents one years growth. However, this effort may be confounded by several factors, including deposition of several rings within one year (Moll and Legler, 1971; Miller, 1955; Woodbury and Hardy, 1948; Holland, unpubl. data). Additionally, in habitats with rocky substrates it is difficult if not impossible on many animals to accurately determine annuli counts due to abrasion of the shield and loss of the annuli. In many cases the annuli on 80-90% of the animals in a population > 120 mm are "unreadable" due to abrasion (Holland, unpubl. data). Additionally, larger turtles typically lack obvious annuli and thus cannot be "aged" by conventional techniques. As such, consistent "age-structured" comparisons across populations based upon annuli counts are difficult if not effectively impossible in many cases (Holland, unpubl. data). As such, *approximation* of age structure in many cases must be based upon interpolation and extrapolation from mark-and-recapture (and growth) data. Examination of growth data from several sites throughout the range indicates that animals in the 100-1 10 *mm* size class are *generally 4-5* years of age, although some may be as young as 3 years and others as old as 8-12 years (Holland, unpubl. data).

Survivorship is known to be lower in the smaller size classes (Holland, unpubl. data) and preliminary analysis suggests that only 10-l 5% of a cohort in the 1,2 and 3 year age classes may survive annually. Beyond this point, survivorship seems to increase and appears relatively high once a carapace length of 120 mm is reached. Annual mortality in adults is assumed to average 3-5%/ year based upon preliminary analysis of long-term mark and recapture data (Holland, unpubl. data). Maximum life span in the wild is unknown, but several records exist for animals probably over 40 years of age (Bury and Holland, unpubl. data) and one animal possibly over 50 years of age was captured near the Willamette River in 1993 (Holland, unpubl. data).

Predation and Mortalitv

A number of species are known predators on western pond turtles. In general, the number of species of predators on small turtles is greater than on adults. Known predators include largemouth bass *(Micropterus salmoides),* bullfrog *(Rana catesbeiana)*

(Fig. 24), (Moyle, 1973; Holland, 1991a, 1993), osprey *(Pandion haliaetus),* bald eagle *(Haliaeetus leucocephalus),* raccoon *(Procyon lotor),* grey fox *(Urocyon cineroargenteus),* coyote *(Canis Zatrans),* feral and domestic dogs *(Canis familiaris),* black bear *(Euarctos americanus),* river otter *(Lutra canadensis)* (Manning, 1992), and mink *(Mustela vison).* Suspected predators include giant water bugs (Belastomatidae), rainbow trout *(Oncorhynchus mykiss),* squawfish *(Ptychocheilus lucius* and *P. oregonensis),* channel catfish *(Ictalurus punctatus),* smallmouth bass *(Micropterus dolimeiui),* northern red-legged frog *(Rana aurora aurora)* and California red-legged frog *(Rana aurora draytonii),* two-striped garter snake *(Thamnophis hammondi),* giant garter snake *(Thamnophis gigas),* great blue heron *(Ardea herodias),* black-crowned night heron *(Nycticorax nycticorax),* golden eagle *(Aquila chrysaetos),* red-shouldered hawk *(Buteo lineatus),* red fox *(Vulpes fulva),* beaver *(Castor canadensis),* nutria *(Myocastor coypu).* Females are frequently observed with extensive scarring on the shell, usually indicating attempted predation by raccoons and/or coyotes. In some areas, females display a rate of scarring up to 6 times greater than that present in males.

Raccoons, skunks, coyotes and possibly red fox are known predators on turtle nests. Observations in several areas from 199 1- 1993 indicate that a significant percentage of the eggs deposited in any one year may be predated. In the Willamette Valley in 1992, 32 predated nests were found in the area of Fern Ridge Reservoir. Extensive searches of these areas in 1993 for hatchlings yielded only three animals. Based upon average clutch size, it is likely that over 99% of the nests in this area were predated. Similar figures exist for the South Umpqua drainages, where surveys in 1992-1993 documented over 120 predated nests.

Of particular concern are the effects of introduced species such as bullfrogs, which may occur in numbers that effectively preclude any significant level of recruitment in some turtle populations. Bullfrogs are also known predators on several other species of native vertebrates, including native frogs, snakes and waterfowl. Similarly, largemouth bass are also known to prey on small pond turtles as well as other native vertebrates. Concern also exists over the possible impact(s) of other exotic species on western pond turtles. Carp *(Cyprinus carpio* and *Carassius auratus)* alter or eliminate the emergent vegetation required as microhabitat by hatchlings. Sunfish *(Lepomis* spp. and *Pomoxis* spp.) may compete for the available prey base, and occur in tremendous numbers in most aquatic habitats within the Willamette Valley, particularly oxbows and slackwater areas.

Another major concern is the possible impact of exotic species of turtles on western pond turtles through the transmission of parasites or pathogens (see discussion on disease). At least 17 species of aquatic or semi-aquatic species of turtles have been recovered from the wild in areas where western pond turtles are known to occur or likely recently occurred (T. DeLorenzo, pers. comm.). Observations from numerous pet stores indicate that species from Africa, Asia and North America are often kept in common containers under highly unsanitary conditions. The potential for the cross-transmission of novel pathogens and/or parasites is thus significantly increased. Many of these turtles escape or are deliberately released into the wild, and have been observed in contact with western pond turtles on several occasions. The most commonly imported species, the red-eared slider *(Trachemys scripta elegans)* has been observed in every major drainage in the range of the western pond turtle in Oregon. Reports of reproductively active female sliders (carrying shelled eggs) are known from the Columbia, Willamette, Umpqua, Rogue and some coastal drainages. Other exotic species reported as reproductively active in the Willamette drainage include the common snapping turtle *(Chelydra serpentina)* and the spiny soft-shell *(Apalone spinefera)*.

Humans are also major predators on western pond turtles. Historically, the species was widely utilized for food (Holland, 1991a) until at least the 1930's (Storer, 1930). This continues on a smaller scale currently in certain areas (S. Sweet, H. DeLisle, J. Applegarth, pers. comm.). Turtles are also collected as pets (Holland, 1991a, 1993), even though such activities are prohibited by law in Oregon. Deliberate shooting has been noted in some areas (Holland, 1991a), (Fig. 25) and incidental catch by fishermen may be a locally and regionally significant source of mortality. Losses from automobile traffic probably match or exceed mortality from most other anthropogenic sources (Fig. 26). In a four month period in 1993, approximately 25 western pond turtles were found crossing roads in the Willamette Valley and were delivered to ODFW offices or to the NERI Turtle Project in Portland. Several of these animals had been hit by automobiles, and at least three cases of mortality were observed. The likely fate of the animals that were hit by traffic would have been eventual death without treatment. The number of animals noted probably represents only a fraction - perhaps as high as 50% - of the animals that were actually or potentially exposed to loss. Assuming that the estimate of 25-50 animals/year is approximately correct, this represents an annual actual or potential loss of 3-5% of the total population in the Willamette Valley. Coupled with losses from other sources, human predation represents a major threat to the long-term existence of the species in this and probably other areas.

Numerous human activities pose a threat to western pond turtles. A diesel spill in Yoncalla Creek (Umpqua drainage) in January 1993 resulted in impacts to at least 50 and probably in excess of 100 western pond turtles. Of a group of 30 animals collected during February and March, at least three have subsequently died despite intensive medical care. Many of the remaining animals exhibit delayed reactions and complications (including liver and possible nervous system damage) from exposure to the contaminants. This situation is not unique - there have been several spills of contaminant material in Oregon into or adjacent to watercourses inhabited by western pond turtles during 1993.

In two bizarre situations (one in California, one in Oregon), turtles have been "scooped" out of ponds by heli-dipping during fire-fighting operations. In the situation in California, several animals were observed to have been dropped on "hot spots" when the contents of the bucket were released (L. Wold, USFS, pers. comm.).

Disease

The role of disease as a regulatory agent in wild reptile populations is poorly understood. Epidemic diseases have been previously noted in turtles (Dodd, 1988) but such reports are limited. Holland (1991b, 1991c) and WDW (1993) noted that an outbreak of a URD (Upper Respiratory Disease)-like syndrome killed an estimated 35-40% of one of only two known populations of western pond turtles in Washington in 1990. Animals recovered from the wild at this time received extensive and intensive veterinary care, and were monitored on a daily basis for several months. Despite exhaustive measures and heroic treatment efforts, over 55% of the animals held in captivity died. The known mortality from the situation was at least 36 animals, representing 35-40% of the population estimated to exist at the site at that time. A single moribund female western pond turtle was recovered from a site in Eugene in early 1993 and exhibited symptoms similar to those displayed by the Washington animals. The animal died the day after collection and a necropsy revealed that the cause of death was a URD-like syndrome. In a July-October 1993, 42 western pond turtle carcasses were recovered from a lake in northern California (Fig. 27, Fig. 28) under conditions almost identical to those noted in Washington in 1990 (Holland, unpubl. data). The state of the carcasses did not allow necropsy, but it is likely that the cause of death was an epidemic disease. The causal agent in these situations has not been identified with certainty, but is likely to be a viral agent or possibly a mycoplasm. The method of introduction to the western pond turtle population is not known, but in two of the three cases (Washington and Eugene) exotic species of turtles were known to have been introduced into the population and may have acted as vectors.

Parasites

Ingles (1930) first described a new species of trematode recovered from western pond turtles in California. Thatcher (1954) notes that 7 species of helminths are known from western pond turtles. Bury (1986) noted numerous nematodes in the stomachs of animals from northern California, and Holland (1991a) noted lungworms in specimens from central Oregon and northern California. Leeches (*Placobodella* sp.) have been noted on animals from California and Oregon.

Drought

Western pond turtle populations evolved with periodic drought, and declines in population size and changes in population structure were likely a part of the historical repertoire of the species. Observations in California during 1987-1992 indicated that many populations in the southern and central portions of the state were severely impacted by the drought, displaying declines of up to 85% and possibly more. Repeated sampling of several of these populations has indicated that many have failed to recover (i.e. capture rates have remained low from 1991-1994). Coupled with other factors, drought may have a locally and regionally significant negative impact on western pond turtle populations. For a more detailed discussion, see Holland (1991a).

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Figure 1 : Key to sexually dimorphic characters in the western pond turtle (Clemmys marmorata).

Character	Female	Male
a. neck	lateral and dorsal surfaces of head and neck usually mottled or ocellate	lateral and dorsal surfaces of head and neck often uniformly colored, especially in older animals
b. nose	nose relatively short	nose relatively long
c. maxilla	maxilla often with fine dark vertical lines or "mustache"	maxilla lightly marked or or unmarked especially in older animals
d. snout	angle of nose usually vertical or nearly vertical	angle of nose usually 10-15 from vertical
e. throat	often flecked with numerous small dark flecks	usually lightly marked or unmarked
f. vent	usually at or slightly posterior to posterior edge of carapace	usually well posterior to posterior edge of carapace
g. tail	usually relatively long and thin	usually relatively short and thick
h. plastron	area of femoral/anal seam junction usually flat	area of femoral/anal seam junction usually slightly concave
i. shell	shell relatively high/deep in relation to length of carapace	shell relatively low/shallow in relation to length of carapace

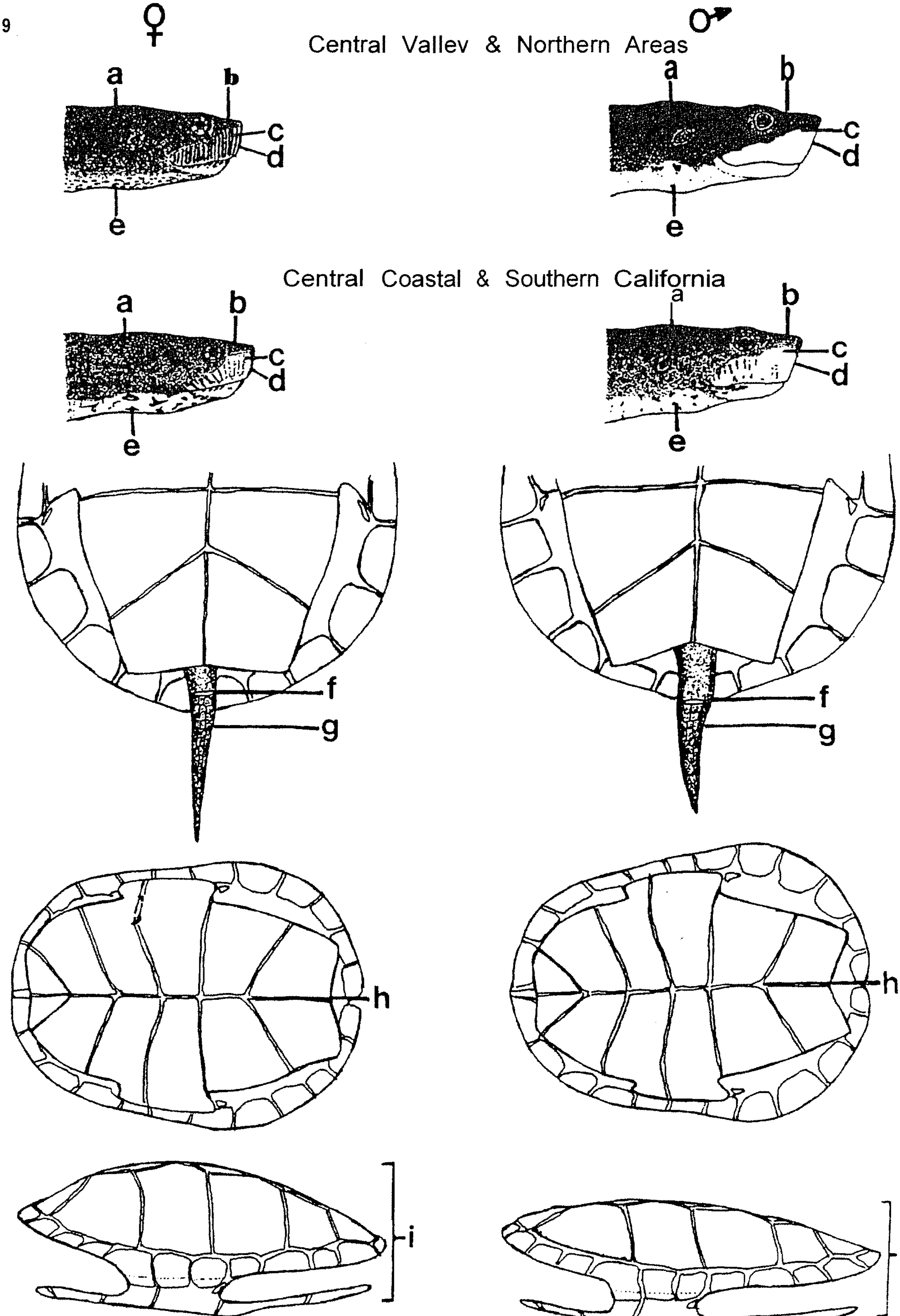
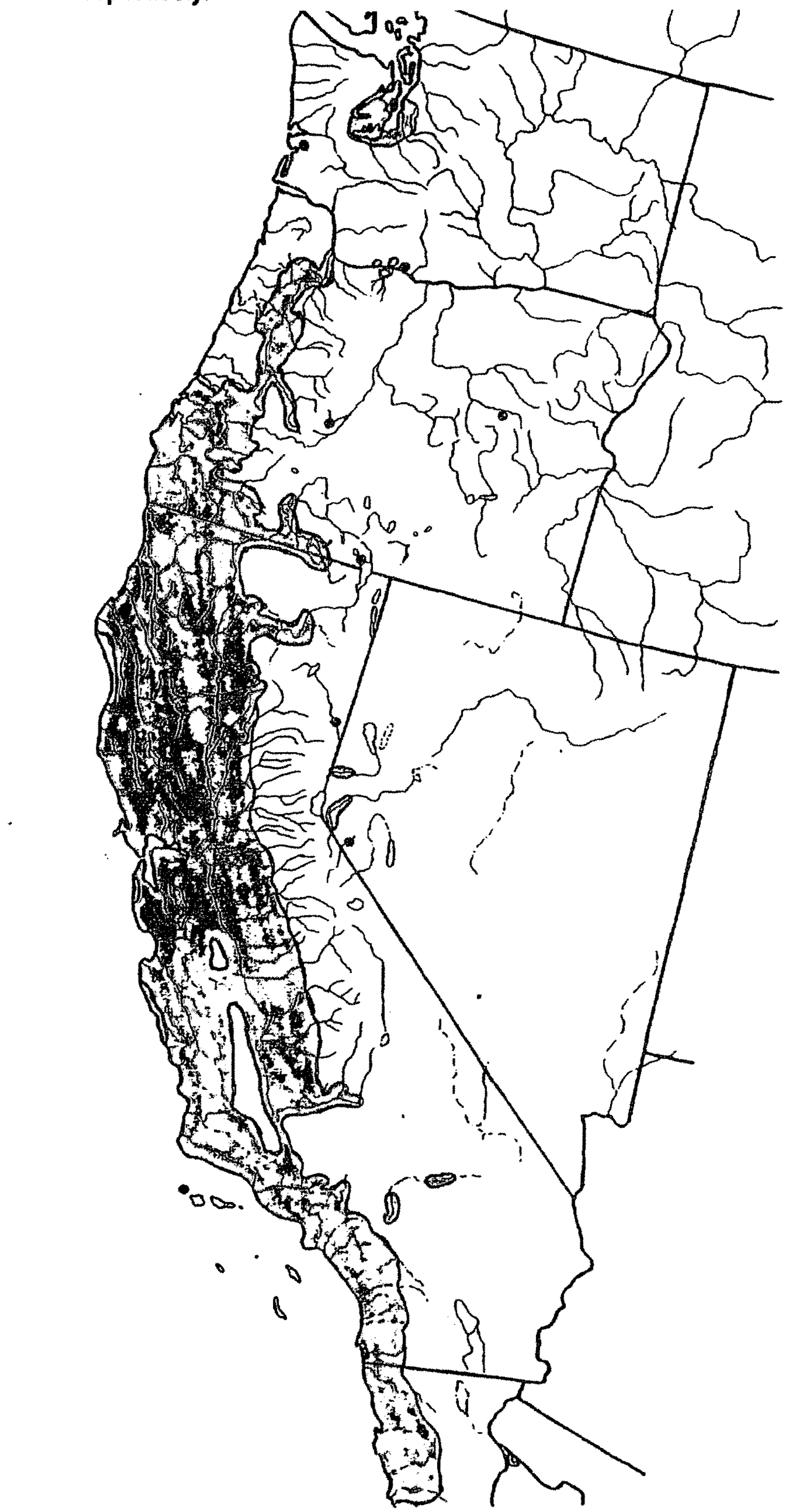


Fig. 3: Key to sexually dimorphic characters in thewestern pond turtle (Clemmys marmorata).

Figure 2: Range of the western pond turtle *(Clemmys marmorata)*. Isolated records are represented by solid circles and usually represent introductions. Records from Idaho and San Miguel Island represent mislabeled and beach-cast specimens, respectively.



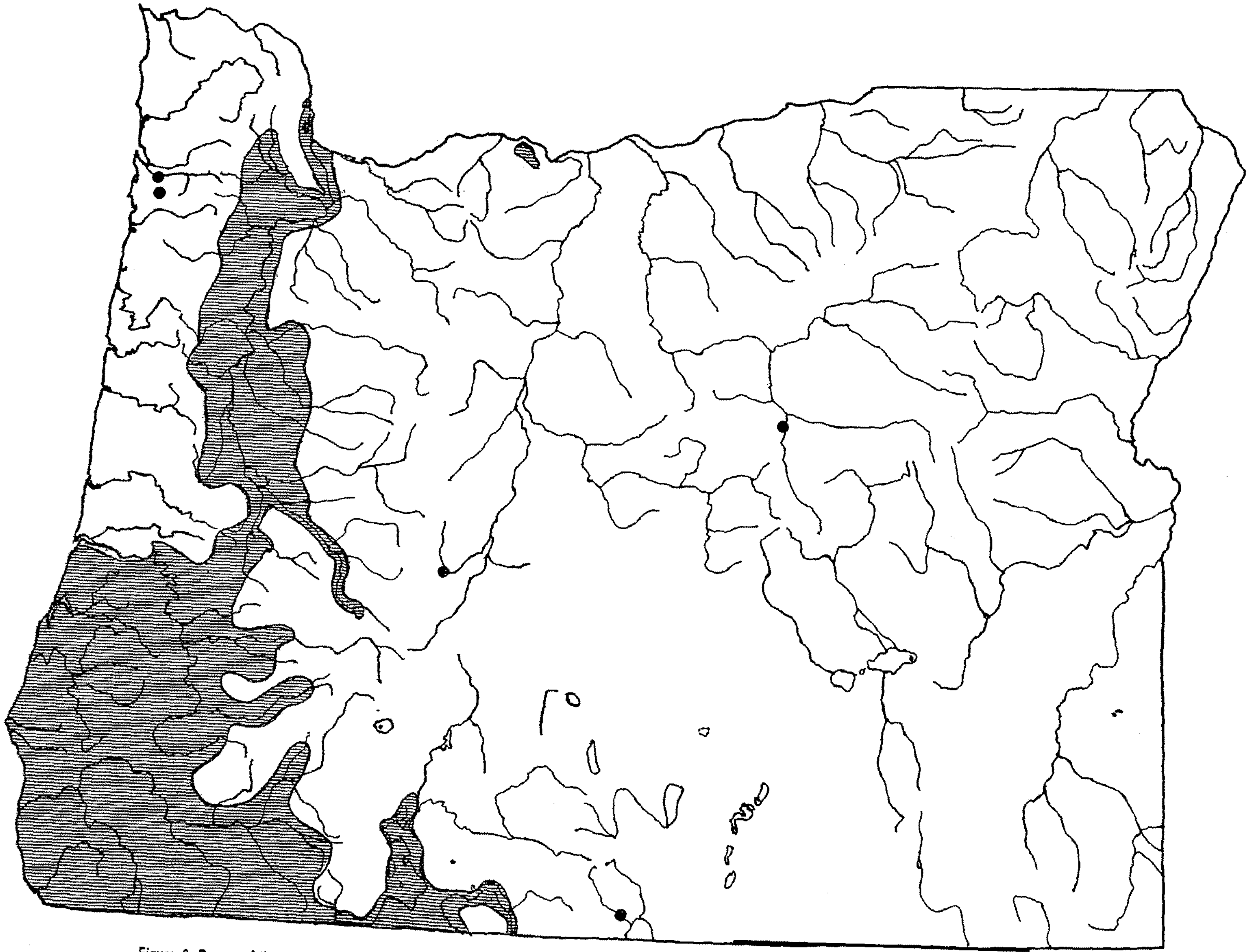


Figure 3: Range of the western pond turtle (*Clemmys marmorata*) in Oregon. Solid circles represent introduced animals but most are not verified by specimens.

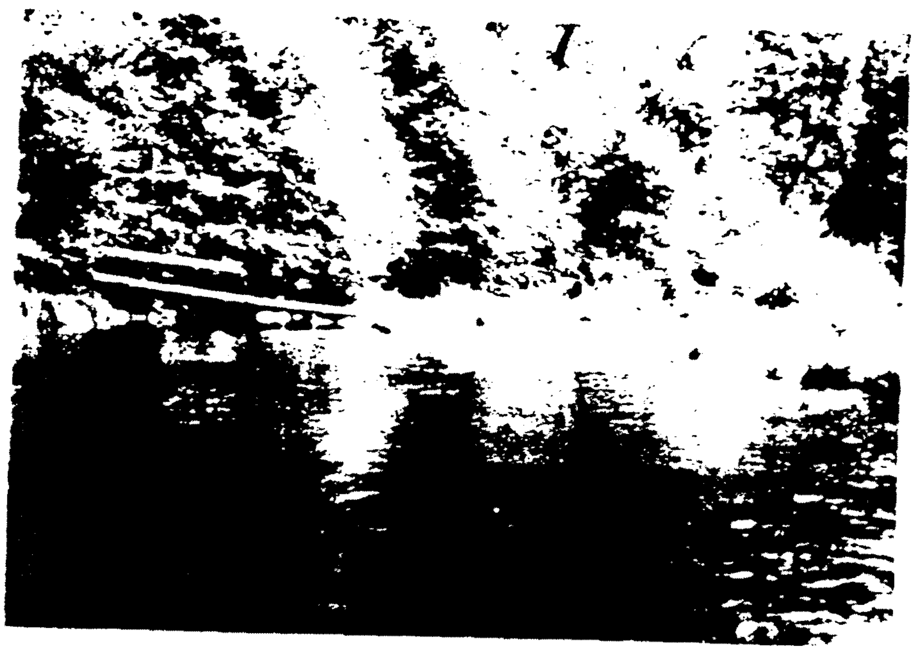


Figure 4: Typical riverine habitat of the western pond turtle in Oregon. Douglas County, Oregon. (Site OR 017 U)

Figure 5: Typical stream habitat of the western pond turtle in northern California. Trinity County. California. (Site CA 014 K)

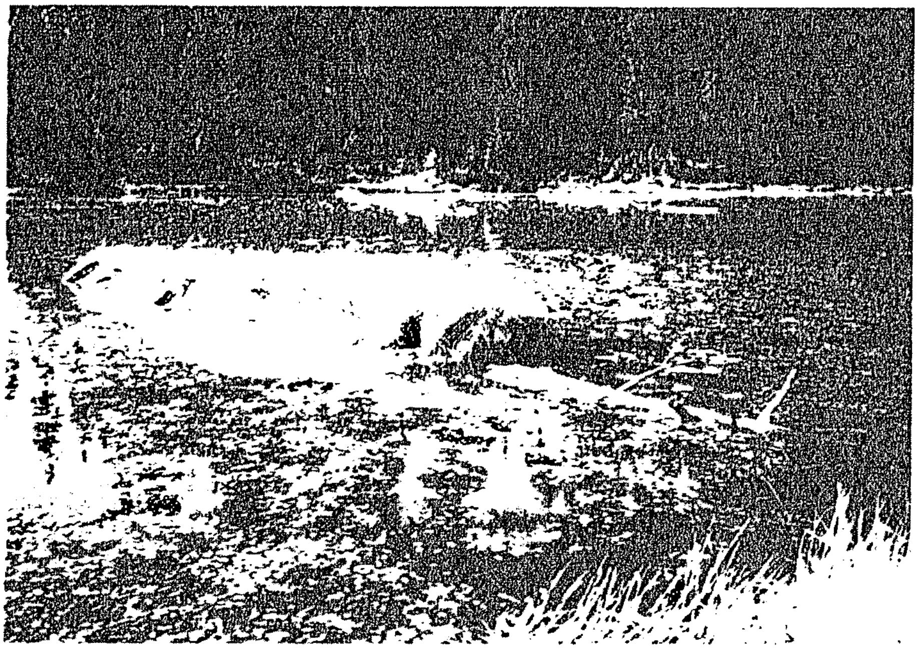


Figure 6: Typical lake habitat of the western pond turtle in Oregon. Douglas County, Oregon. (Site Or 002 U)

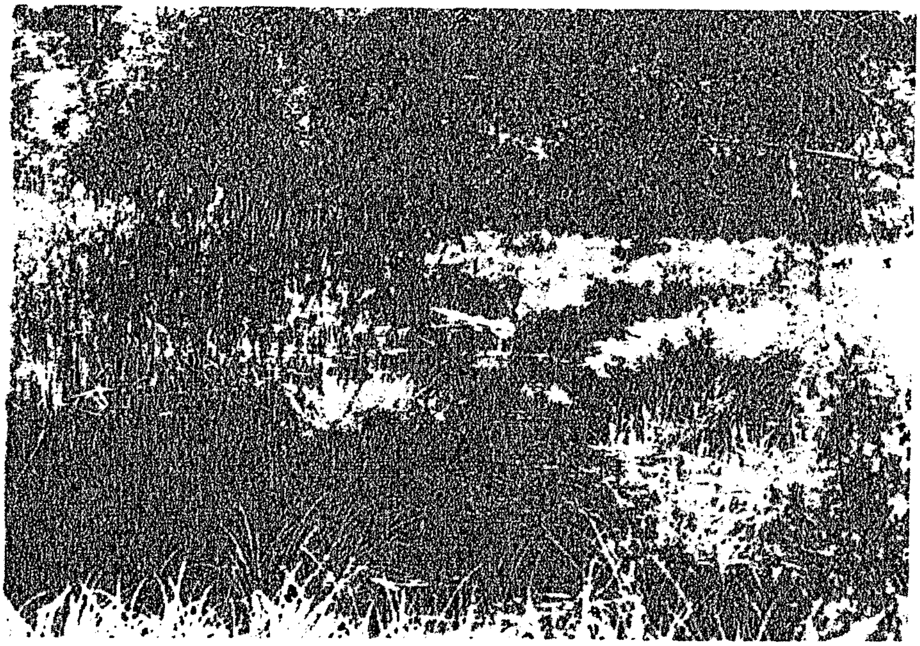


Figure 7: Typical pond habitats of the western pond turtle in Oregon. Lane County, Oregon. (Site OR 039 W)

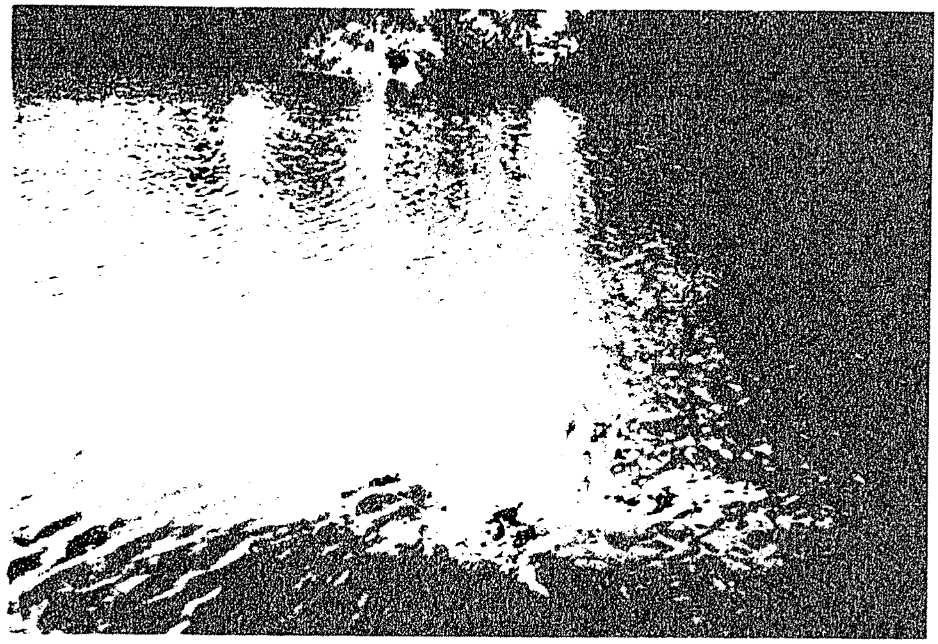


Figure 8: Typical reservoir habitat of the western pond turtle in Oregon. Hills Creek Reservoir, Lane County, Oregon.

Figure 9: Typical oxbow/backwater habitat of the western pond turtle in Oregon. Lane County, Oregon. (Site OR 34 W)

Figure 10: Rock basking site for western pond turtles. Trinity County, California. (Pool 2 D, Site CA 014 K)

Figure 11: Log/stump basking site for western pond turtles. Trinity County, California. (Pool 20 U, Site CA 014 K)

Figure 12: Typical undercut bank refugium for western pond turtles. Trinity County, California. (Pool 12 U, Site CA 014 K)

Figure 13: Underwater view of typical emergent vegetation refugium for western pond turtles. Trinity County, California (Pool 2 U, Site CA 014 K)

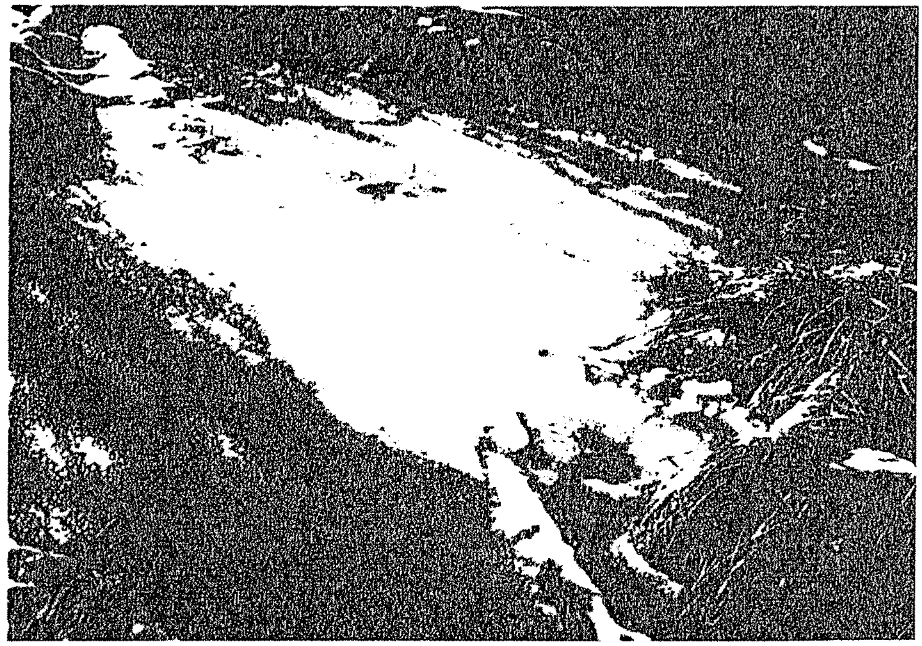


Figure 14: Overwintering site for 43 western pond turtles in pond. Lane County, Oregon. (Site OR 039 W)

Figure 15: Overwintering site for two western pond turtles in lake. Douglas County, Oregon. (Site OR 002 U)

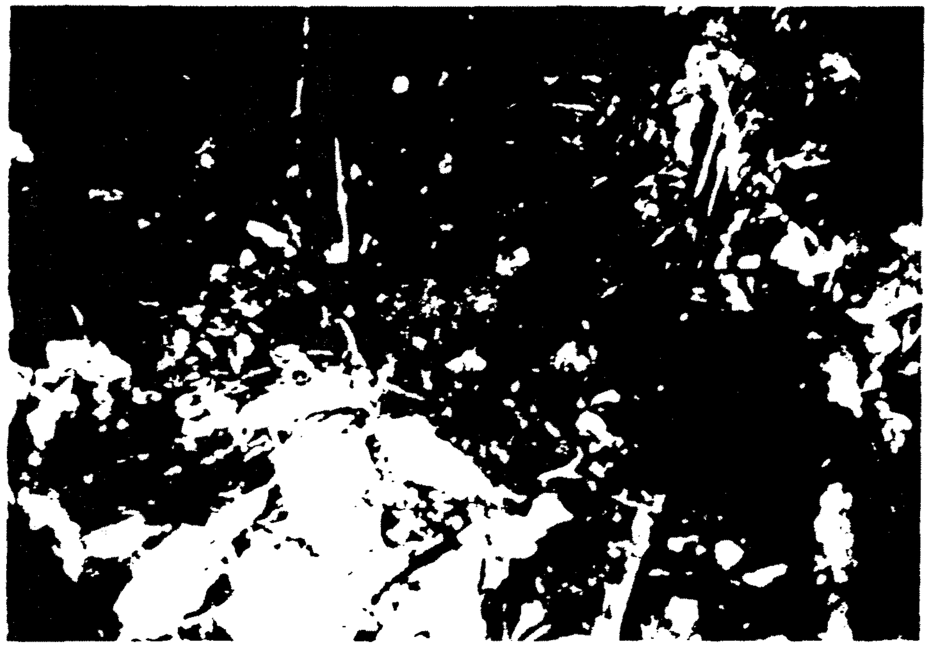


Figure 16: Overwintering turtle in duff. Note green/red transmitter. Douglas County, Oregon (Site OR 017 U)

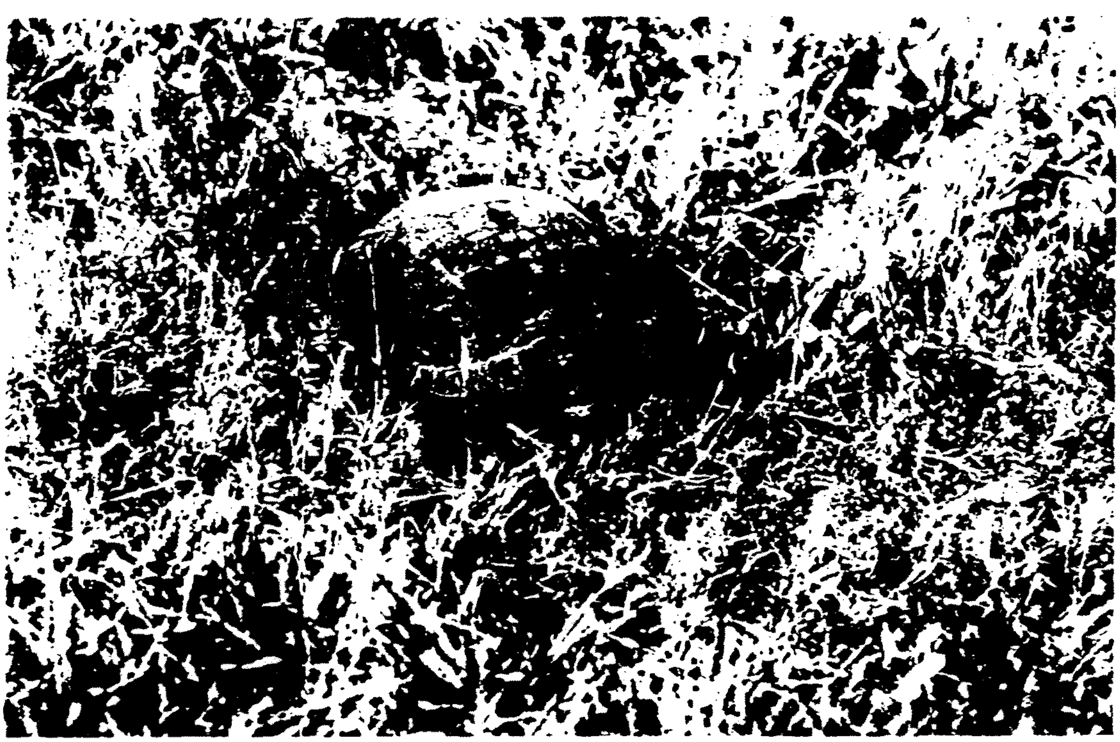


Figure 17: Turtle engaged in terrestrial movement during summer 1992. Lane County, Oregon. (near Site OR 057 W)

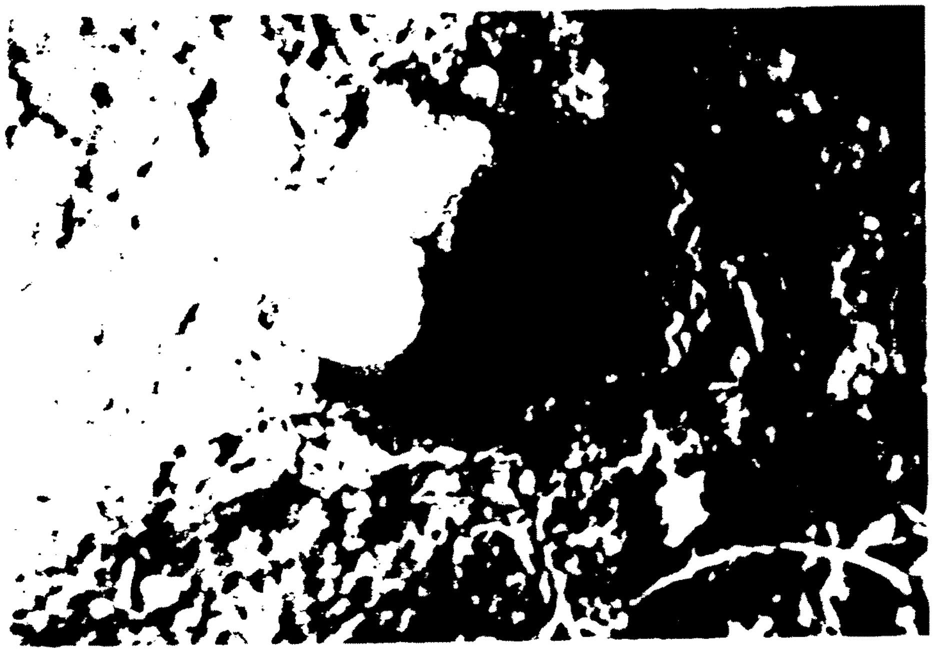


Figure 18: Exposed eggs of western pond turtle in nest (plug removed). Klickitat County, Washington.

Figure 19: "False scrape' (excavated nest with no eggs). Lane County, Oregon. (Site OR 039 W)

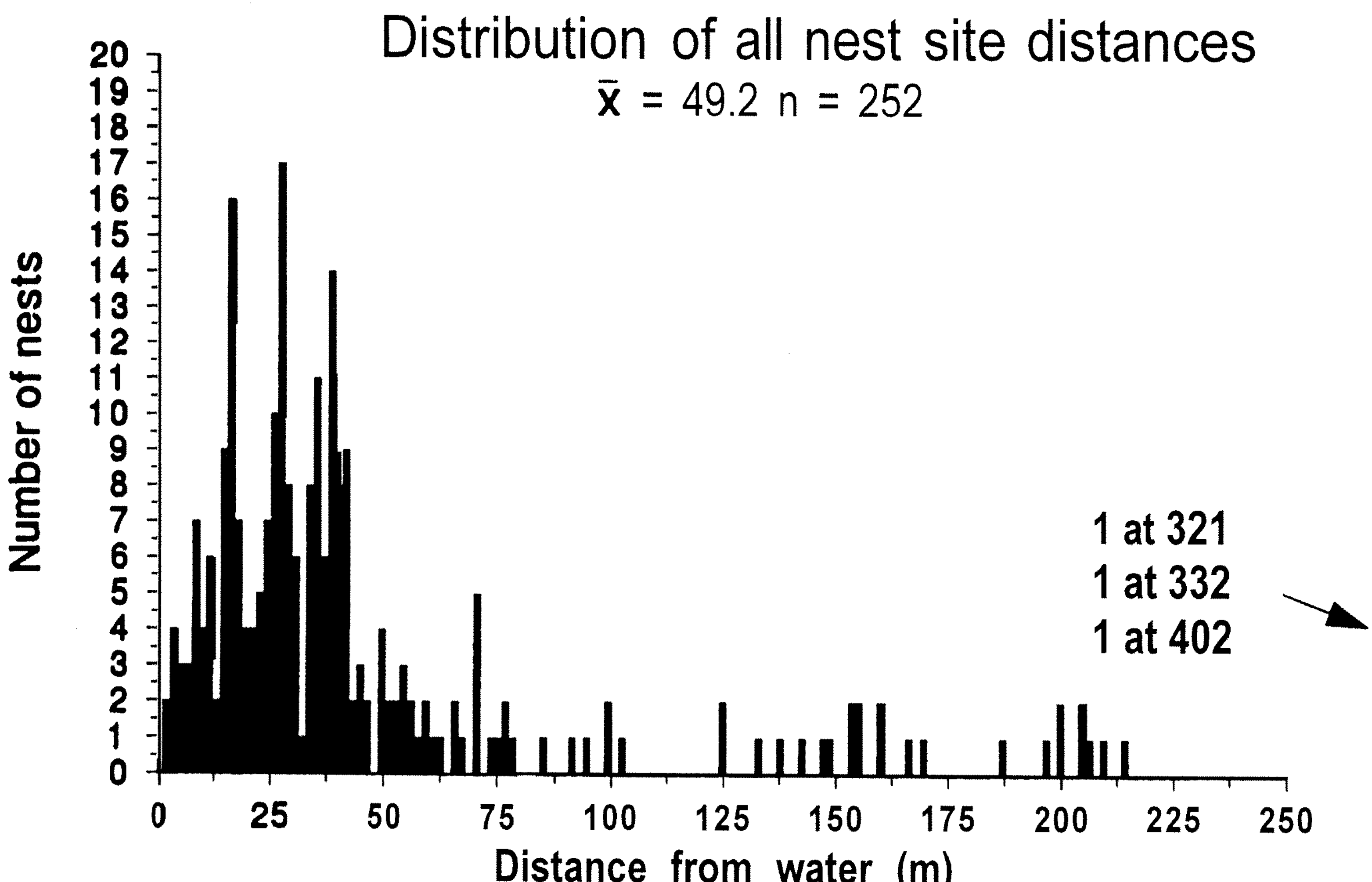


Figure 20: Distribution of all known nest site distances for the western pond turtle.

Figure 21: Typical nesting habitat for the western pond turtle. Site on the south Umpqua River, Douglas County, Oregon. (looking E/NE)

Figure 22: Typical nesting habitat for the western pond turtle. Site on the south Umpqua River, Douglas County. Oregon (looking W/SW)

Figure 23: Well-defined annuli on plastron of adult western pond turtle. Douglas County. Oregon.

Figure 24: Bullfrog *(Rana catesbeiana)* preying on juvenile western pond turtle. San Diego County. California.

Figure 25: Western pond turtle with small-caliber gunshot wound. San Diego County, California.

Figure 26: Road-killed adult (small female) western pond turtle. Douglas County. Oregon. (east of Site OR 017 U)

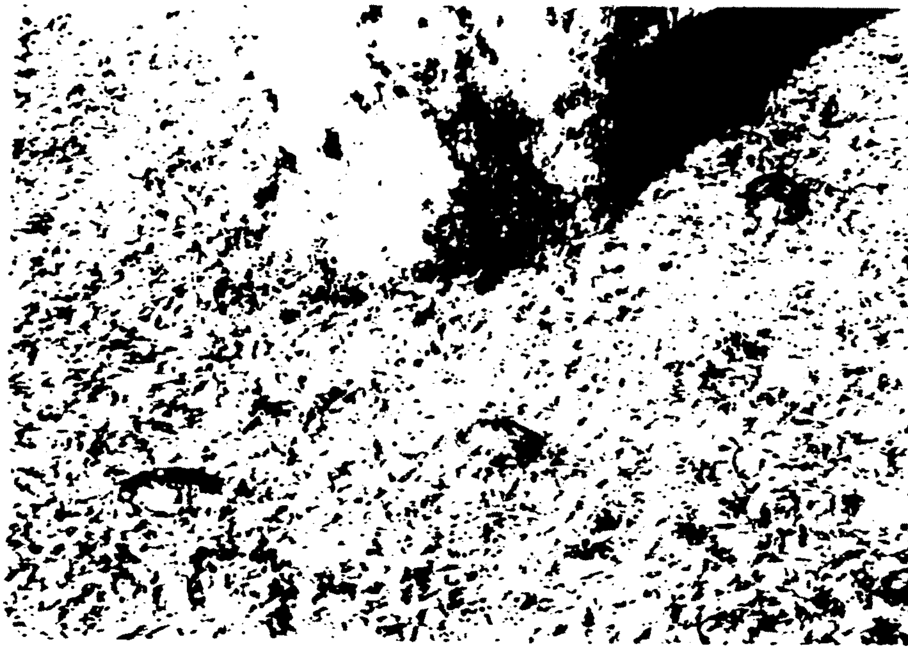


Figure 27: Carcasses (3) of western pond turtles presumably killed by disease in situ. Tehama County, California.

Figure 28: Carcass of western pond turtle presumably killed by disease in situ. Tehama County, California.

CHAPTER 3

Methods

Methods

Overview: Assessment of western pond turtle populations and habitat was conducted by a variety of methods, described in detail below. The basic goals of this effort were:

1) to accurately determine the presence or absence of the species in a given area

2) if the species was present, to determine population structure in relation to number, size and sex ratios of animals

3) to record a specific set of habitat characteristics at all sites surveyed

4) to characterize in detail selected habitats

The protocol and data forms for visual and capture surveys in Oregon were developed by Holland (1993). Terms are defined as follows:

Visual survey: Survey of habitats for turtles using unaided eye or ocular instruments, typically 7-10x power binoculars or 20-60x spotting scopes.

Visual census: Survey of turtle population in which some animals carry a distinctive visual mark allowing estimation of population size via conventional mark-and-recapture estimation techniques, without actual capture of animals.

Capture census: Survey of area by variety of techniques designed to capture turtles if present. These include:

a) live-trapping: use of semi-submerged baited traps designed to lure and temporarily hold turtles.

b) hand-capture: use of snorkeling and free-diving to search likely habitats and attempt to collect turtles therein.

Habitat Survey: Characterization of habitat usually conducted concurrently with visual survey to record general habitat parameters, either quantitative or qualitative.

Habitat Characterization: Characterization of habitat not conducted concurrently with any other survey, designed to measure or estimate specific habitat parameters.

Presence/absence surveys: Presence/absence surveys were conducted in a variety of areas within the Willamette drainage during June-September 1992 and March-October 1993. Data was recorded on the attached form (Appendix A) at the time of survey. Presence/absence was determined in most areas by visual surveys alone, a technique which has proved highly accurate in determining actual presence or absence. Four surveyors including the principal investigator were used during 1992, and three were used in 1993, all of which had conducted surveys in 1992. Surveys were conducted under conditions generally likely to yield observations of turtles, i.e. warm weather with at least intermittent sun. Survey sites were chosen on the basis of 1) known historical localities as reflected in museum, literature or other reliable records 2) reported localities from sources of unknown reliability and 3) areas likely to hold turtles based upon the known distribution and/or habitat preferences of the species. The general procedure was to arrive at the survey site, move slowly and quietly into a position on or near the shore, and visually scan the watercourse with ocular instruments. Distances over which surveys were conducted ranged from a few meters to over 200 m. In certain situations (such as along the Willamette River) survey sites elevated above the water level (bridges or other structures) were used to maximize the area surveyed. The observer(s) checked the water surface for signs of turtles swimming or floating near the surface - often only a small portion of the head was visible. Possible basking or other haul-out sites, masses of aquatic vegetation or other areas likely to hold turtles were visually checked. Although most surveys were conducted from shoreline or near-shore sites, several surveys were conducted from the watercourse using inflatable kayaks (Pig. 1). The amount of time required to effectively and thoroughly check a site varied with the nature and extent of the habitat. Some sites (such as small ponds or short stretches of watercourse) could be checked in 10-15 minutes, while other areas (such as stretches of the Willamette several km in length) often took several hours. Efforts were made to determine the species of every turtle sighted. All surveyors were familiar with the distinguishing characteristics of both species of native turtles in Oregon and common introduced species (Appendix B). All observers were familiar with secondary sexual characteristics of western pond turtles (Appendix C). All surveyors were taught size estimation techniques by the principal investigator. Subsequent evaluation of the accuracy of this technique indicated that the size estimation of a given animal was accurate to +/- 10 mm for over 90% of the animals observed. In certain situations where conditions precluded effective visual surveys or other information indicated that turtles might be present that were not revealed by the visual surveys, capture-censusing was conducted. The majority of these efforts were by live-trapping, but a few were conducted by hand collection.

Determination of population structure: Determination of population structure was conducted by a variety of methods, most often by visual surveys where populations appeared to be small. Because of the number of sightings of small numbers of animals (less than 5), population structure estimation was conducted by visual surveys alone in the majority of situations. Capture-census via live-trapping and hand capture (Fig. 2) were conducted at select sites to assist in population structure estimates, and to serve as a check on the accuracy of visual surveys. Visual censuses were conducted at three sites in 1993.

All turtles captured were marked using a numbering system developed by Holland (1991) involving notching of one or more marginal shields (Appendix D). Date collected on all animals included mark #, carapace length, weight, sex and any evidence of scarring or other abnormalities. All animals were released at the site of capture. A few animals were held up to 48 h to allow attachment of radio transmitters and/or to determine clutch size in gravid females by use of X-rays. Population size estimation was determined by conventional mark-and recapture methods and analysis.

figure 1: Visual surveys for western pond turtles from kayaks. Lane County, Oregon. (Site OR 036 w)

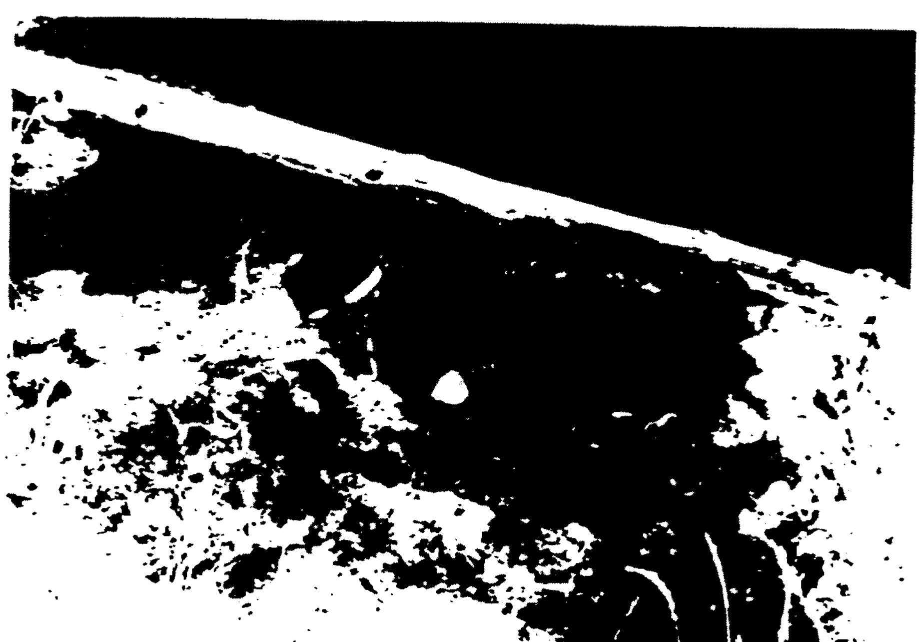


Figure 2: Hand-collection of western pond turtles in pond habitat. Douglas County. Oregon. (Site OR 050 U)

CHAPTER4

Status of the Western Pond Turtle in the Willamette Drainage

Status of the Western Pond Turtle in the Willamette Drainage

Table of Contents

Status of the Western Pond Turtle in the Willamette drainage

Historical Background: Despite an intensive search of historical documents (in part, Judson, 1913) the first published note mentioning western pond turtles in Oregon was that of Storer (1930). Storer claims that Van Denburgh (1922) lists the species as occurring "...about the Klamath Lakes, and in the vicinity of Klamath Falls, Oregon." In fact, Van Denburgh notes only turtles along the east shore of lower Klamath Lake, and the specimens (CAS 47479-47489) collected at that time are all listed as being from California. Lampman (1933) discusses both painted and pond turtles, and notes that the ". . . western pond terrapin is even more shy than the others, and displays an astonishing agility when tightened, running swiftly over stones or driftwood to escape. Each of these species has a market value, though the Painted variety is considered the most desirable. The flesh is tender and exceptionally palatable." Fitch (1936) notes that in the Rogue River basin "The mud turtle (western pond turtle) occurs in most of the permanent streams below the Canadian life zone; it is most common along the larger slow-moving creeks which afford deep pools. It occurs along most of the Rogue River for most of its course though not abundantly." Storer (1937) notes the occurrence of western pond turtles in a number of sites in Oregon, but incorrectly states that " In Oregon, it evidently occurs on the Rogue and Umpqua Rivers, but not farther to the north." Pope (1939) states that "Just how far to the north of the Umpqua River the Pacific Pond turtle occurs is still problematical. " . Graf(1939) describes the species as being "...common in all the sloughs of the Willamette River, and the sluggish streams and ponds of the lowlands" Apparently the species was abundant enough that a friend of Graf's was able to catch and dissect 70 animals, on which he reported that "... out of about 70 stomachs he examined, only three or four contained recognizable remains of young ducks." Graf et al. (1939) note that the species". . . is common on the Willamette River and its tributaries as least as far north as Salem; very common in the sluggish streams and ponds of Benton, Lane and Linn counties. " Gordon (1939) corroborates this statement with " It is common in many of the streams and sloughs of western Oregon, down the Willamette Valley. Around Portland it is rare, and is replaced by the Painted Turtle." Pickwell (1947) notes that "The Pacific terrapin suns itself on the margin of all permanent lowland lakes of the Far West and occurs commonly in the larger permanent streams and their estuaries. This turtle occurs west of the divide throughout the Pacific States, except in desert regions and at higher elevations in the mountains...". Evenden (1948) corrects Storer's 1937 misstatement and discusses the apparent scarcity of the species north of Salem, adding "...I have seen very few of this species north of the general latitude of Salem, Marion County...". Storm (1948) notes that the species was "...extremely common in the lowlands of the Willamette Valley. ." Another record of a specimen taken in 1948 from near Blaine, Tillamook County was noted by Storm (1949). Black and Storm (1970) note an observation of a single male western pond turtle in Canyon Creek (Grant County south of John Day), and state "Turtles have been sighted in ponds bordering the John Day River. It appears western pond turtles are becoming established, but are still limited in numbers." These probably represent introduced specimens, as they are approximately 140 miles from the nearest known location for the species in the Columbia Gorge.

The students of Dr. Robert Storm conducted several studies of western pond turtle populations at 5 different localities between 1948 and 1978. These studies concentrated on trapping to determine turtle population size, structure and movements. The first study was conducted at Kiger Island slough in 1948 (Walker and Allen, 1948) and captured 8 turtles in 6 days of trapping. Jensen and Basler (1960) repeated this effort and trapped 10 turtles in 26 days of effort. Clark (1962) also repeated the two earlier studies and collected a total of 17 turtles in 30 days trapping. A series of studies at "McFadden's Pond" (possibly the same site as Stewart Lake in Storm (1948) were conducted between 1954-1959. A total of 67 individuals were collected in 80 days of trapping. A total of 187 captures and recaptures were made in this period. Wilhemi (1963) collected 49 western pond turtles in 20 days of trapping at Jones-Finney Lake (a.k.a. Finney-Egan Lake) in Marion County. Trapping in 1964 produced 5 more turtles, and Elling (1966) added three more turtles to the total by 8 days of trapping. Mellish and Barstow (1963) trapped 23 turtles, including 4 recaptures, in 15 days of effort at Butler's Pond, approximately 5 miles NE of Corvallis, Buttgenbach and Neeley (1964) collected 24 turtles total in 15 days of trapping at the same site. Struss and Black (1965) collected 10 turtles in 10 days of trapping. Thatcher (1954) collected 64 western pond turtles for examination of parasites. Twelve of these animals were collected in the Calapooia River, Linn County, and the remainder came from five sites in the Rogue drainage in Jackson County. Lahanas (pers. comm.) collected a total of 58 turtles in 49 days of trapping efforts during 1976-77 at Winkle and Whittaker Lakes, south of Corvallis.

Recent Studies: Gaddis and Corkran (1985) did not find western pond turtles during surveys on Sauvies Island and in the Tualatin drainage, although the species is or was known to occur in these areas. St. John (1987) notes 18 localities for western pond turtles in the Willamette Valley, although only 7 specific sites are identified in the Appendix. In discussing the status of the species, he notes "Several western pond turtles were observed at various sites in the study area. However, as mentioned in the species account for this reptile, no juveniles were seen. The introduced bullfrog is known to eat young turtles and could pose a problem for them, such as it has for our native frogs. Though seemingly stable at this time, the western pond turtle should be monitored for future difficulties." Holland (1992) began surveying the Willamette Valley for this species in 1987 and continued these surveys during 1988 and 1989. During this time, a total of 16 turtles were captured at 3 different sites. A maximum of 13 animals were observed in 1989 at Winkle Lake in Benton County. Despite surveys of 10-12 other areas, no turtles were observed. Hayes (1993) conducted surveys for this species at Schwarz Pond below Dorena Reservoir in 1992. The estimated population at this site was a maximum of 12 animals. Results of surveys conducted by the US Army Corps of Engineers at various reservoirs in the Willamette are summarized in Beal (1994).

Survey Effort Coals: The overall goal of the current survey effort for western pond turtles in the Willamette was to allow an assessment of distribution and the status of the species in this drainage. Coincident with this goal was the collection of habitat information and associated species. A copy of the survey form used is shown in Appendix A.

Overall Results: A statewide survey was conducted in 1991 under contract from the Oregon Department of Fish and Wildlife (Holland, 1993). In this project, 145 sites were surveyed (Fig. l), and a total of 227 surveys were conducted. Turtles were observed in 26.2% (n=38) of all sites surveyed.A total of 148 turtles were observed during visual surveys, and the average number of turtles noted per survey was 0.65. Of all sites surveyed, four sites accounted for 41% of all turtles observed. In all but three surveys, 5 turtles or less were observed.

In 1992, under contract from BPA, additional surveys were conducted and several areas were resurveyed. A total of 111 sites were surveyed (Fig. 2), and 113 surveys were conducted. Of the sites surveyed, 63 were "new" sites (not previously surveyed). A total of 18 sites with turtles were observed, 4 of which were "new". A total of 36 turtles were observed, and the average number of turtles per site was 0.324. The average number of turtles observed per survey was 0.3 18. In 1993, a total of 184 surveys at 119 sites were conducted (Fig. 3). One hundred and twelve of the surveys were conducted by the survey technicians, and 72 were conducted by Holland. Of the 112 technician surveys, 63 were "new" sites (sites which had not been previously surveyed). A total of 18 sites with turtles were observed, 11 of which were "new". A total of 92 turtles were observed, and the average number of turtles observed per site was 1 .05. The average number of turtles observed per survey was 0.821. One site accounted for over 60% of the turtles observed. Of the 72 surveys at 58 sites conducted by Holland, 32 of these were "new" sites. A total of 16 sites with turtles were observed, six of which were "new". A total of 55 turtles were observed, and the average number of turtles observed per site was 0.948. The average number of turtles observed per survey was 0.763.

A total of 303 sites have been surveyed in the Willamette Valley under the provisions of the ODFW and BPA contracts. Of these, 57 sites (18.8%) were observed to contain one or more western pond turtles. A total of 524 surveys were conducted, and each site was surveyed an average of 1.72 times . A total of 33 1 turtles were observed in all surveys, for an average of 0.63 1 turtles/survey. A summary of survey information is presented in Table 1.

Other Studies: The US Army Corps of Engineers has conducted survey work for western pond turtles at Fern Ridge Reservoir (K. Beal, 1994), Lookout Point Reservoir and Fall Creek Reservoir (Hardin, 1994). The COE and ODFW conducted cooperative survey efforts downstream from Corps reservoirs (Lookout Point, Fall Creek, Dorena and Cottage Grove) on the Coast and Middle Forks of the Willamette in the summer of 1993 (Moehl, 1994). Results from these studies briefly reported here. Surveys in Fern Ridge reservoir from 12 April to 15 September 1993 were conducted for a total of 423 hours. A total of 240 turtle sightings were made, for an average of 1 turtle for every 1.76 hours of observation. Of all turtle sightings, 7 3 % were clustered in a single area. At Lookout Point, 17 1 surveys were made totaling 82 hours. Turtles were sighted on 115 surveys and not observed on 66 surveys. A total of 119 turtle sightings were made, for an average of 1.45 turtles per hour of observation. At Fall Creek Reservoir, 102 surveys were made totaling over 60 hours. Turtles were observed on 49 surveys and absent on 53 surveys. A total of 93 turtle sightings were made, for an average of 1.53 turtles/hour of survey

(Hardin, 1994). Although in some ways Moehl's study (1994) is not comparable to the previous efforts, a total of 34 surveys were made in the Coast and Middle Forks of the Willamette between late May and 20 July 1993. An undetermined number of surveys in which turtles were not observed (such as in Fall Creek) were also made. A total of 3 10 turtles were observed in approximately 66.08 hours of observation, for an average of 4.69 turtles/hour. One site (OR 036 W) accounted for 62% (n = 192) of all turtle sightings (Moehl, 1994). It should be noted here that it is likely that all of the figures above include multiple sightings and therefore should not be considered as total population estimates.

Locality Data: Prior to 199 1, a total of approximately 35 locality records existed for the Willamette. Currently, a total of locality records exist for a total of 114 sites in the Willamette Valley (Appendix F). Of these, approximately 10 are non-specific ("near Hillsboro", USNM 007595 l-0075950; "Willamette Valley, Clackamas County, MVZ 16856; "Linn County", OSU 331; "Corvallis", "Portland", "Oregon City" (St. John (1987)) and several others represent animals of unknown origin which are likely to have been translocated, such as several specimens from urban Portland (Clackamas Community College). Surveys from 1991-1993 checked approximately 93 of the remaining sites.

Population Structure: Estimation of population structure in western pond turtles was conducted by estimation of size of animals observed during visual surveys and by collection of animals by trapping and/or hand collection efforts. Size is expressed as straight-line carapace length in mm and was estimated in 20 mm increments across the known range of pond turtle carapace lengths (25-210 mm). Animals less than 30 mm were counted as members of the next-largest category, i.e. 30-50 mm. However, no animals in this size class were observed. Estimation of size from visual surveys was checked by concurrent capture efforts. In almost all cases, visual estimates of size were +/- 10 mm of the actual length for most observers and +/- 5 mm for the project director. As such, visual estimates of size by trained observers can be considered to be an approximately accurate estimate of actual size. In some cases during visual surveys, it was not possible to estimate size (for a variety of reasons). However, animals in some of these situations could be classified as adults (>110 mm) and were recorded as such. Given this, the total number of animals categorized by size is invariably less than the actual number of animals observed.

During 199 1, a total of 148 turtles were observed. Size was estimated on 107 animals. Of these, 100 (93.7%) were adults. In 1992, a total of 35 turtles were observed. Size was estimated on 26 of these, and 24 (92.3%) of these were adults. In 1993, 103 turtles were observed (excluding Site OR 036 W) Size was estimated on 94 of these, and 90 (95.7%) were adults.

Other studies produced similar results. COE studies on Fern Ridge Reservoir observed a total of 216 turtles. Of these, size was estimated on 174 animals and 170 (97.7%) were adults. Hardin (1994) observed a total of 93 animals in Fall Creek Reservoir. Of 92 animals on which size was estimated, 91 (98.9%) were adults. In Lookout Point Reservoir, 119 turtles were observed. Size estimations were made on 118 of these, of which 103 (86.4%) were adults. Moehl's (1994) study on the Coast and

Middle Forks of the Willamette observed 148 turtles (excluding site OR 036 W) Size estimations were made on 96 animals, of which 95 (98.9%) were adults.

Population structure estimation was also conducted by capture-census methods. These included live trapping (see Methods) and hand-capture. Live trapping was conducted by the COE at Fern Ridge Reservoir, Lookout Point Reservoir, and Fall Creek reservoir. Live-trapping was conducted by the USFWS at Finley NWR. Live-trapping and/or hand collection was conducted by this project at Staley Creek Pond, Hills Creek Pond, Buckhead Slough, Hospital Creek Pond, Schwarz Pond, Lookout Point Reservoir, Tufti Pond, the Coast Fork of the Willamette River, Golden Gardens Pond, Fern Ridge Reservoir, Kirk Pond, Muddy Creek (Finley NWR), Soap Creek and Towery Farms. Data were also collected on animals delivered to the NERI Turtle Project, to Reta Anderson (Eugene Wildlife Rehabilitator), and from ODOT studies in the West Eugene area.

The Corps of Engineers studies trapped and/or hand-collected a total of 63 turtles at Fern Ridge Reservoir and 26 turtles at Kirk Pond (the excavated lake immediately north of the Fern Ridge Dam). Of the 60 turtles captured in Fern Ridge Reservoir area between 23 April and 14 July in 16,104 hours of trap effort (average 1 capture/recapture per 220.6 h), 59 animals (98.3%) were adults. Two hatchlings were found in 35 hours of search (not included in the total effort above), and a single hatchling was found by a landowner. Overall, of the 63 turtles captured in Fern Ridge Reservoir proper, 59 (93.6%) were adults. In Kirk Pond, 26 turtles were trapped in 7,632 hours of effort, Of these 24 (92.3%) were adults. Capture-census efforts at Lookout Point Reservoir produced 22 turtles, of which 14 (63.6%) were adults. Four of the juveniles came from a single site. Capture-census efforts at Fall Creek Reservoir in 1992 produced three turtles, two of which (66.6%) were adults. Censuses in 1993 produced 8 new turtles, all of which (100%) were adults. In total, of 11 turtles marked at this site, 10 (90.9%) were adults. Hayes (1992) captured 6 turtles at Schwarz Pond, all of which were adults. Additional captures by this project in 1993 at this site totaled 2 animals, both of which were adults.

Capture-census efforts produced a total of 12 turtles at Fiiey NWR. OF these 12 (100%) were adults. Capture-censuses by trapping in the West Eugene area were conducted by consultants for ODOT in 1993 (Fishman Environmental Services, 1994; CH2M Hill, 1994). Collective trapping efforts produced 24 turtles, 24 (100%) of which were adults.

Capture-census was conducted at Site OR 036 W (Coast Fork Willamette on three occasions in 1993. On the first census on 30 June, 22 turtles were captured and marked. Of these, 18 (82%) were adults. The site was recensused on 06 July, and 22 turtles were captured. Of these, 19 were animals that were previously unmarked. Of these, 14 (73.7%) were adults. On 09 August the site was sampled a third time and 14 turtles were captured. Of these, 8 were previously unmarked animals. Of these, 6 (75%) were adults. The site was sampled by trapping on 30 September and a single adult (previously unmarked) was captured in 36 hours of trap effort. In total, 50 animals were captured and marked at this site in 1993, and 39 (78%) were adults. Moehl(1994) estimated the population size at this site at 157.

Capture-census was conducted at Site OR 039 W on five occasions between 1991-1993. In 199 1, three capture efforts (17 July, 27 July, 09 August) were made. Niie turtles were captured in the first effort, twenty-seven in the second, and fourteen in the third. A single capture-census was conducted on 08 June 1992 and eight turtles were captured. Four of these had not been previously marked. This site was recensused on 17 November and 29 turtles were captured. Of these animals, 18 (62%) were adults. On 24 November the site was resampled and an additional 14 animals were captured. Of these 2 (14.2%) were adults. In total, 86 animals have been captured and marked at this site. Of these, 52 (60.3%) are adults.

Excluding sites OR 039 W and OR 036 W, a total of 227 turtles have been captured in the Willamette between 1987 and 1993. Of these, 204 (89.5%) were adults. Including these samples, we have data on a total of 365 turtles, and 305 (85.9%) were adults.

Population Size: Estimates of population size have been conducted for 2 historical sites and 5 current sites in the Willamette. Wilhemi (1964) estimated a population of 180 western pond turtles at Finney-Egan Lake, and Nussbaum et al. (1983) estimated a total population of 75 animals for McFadden's Pond (aka Hewlett-Packard Pond). The COE studies at Fern Ridge Reservoir population estimates based upon the Lincoln-Peterson Index range from 86-280, and from 47-72 using the Schnabel method. For various reasons, these are not considered reliable estimates (K. Beal, pers. comm.). COE population estimates at Fall Creek using the least squares regression is 27 turtles (Hardin, 1994). Using the same method, the estimate for Lookout Point Reservoir is 91 animals (Harding, 1994). The Staley Creek population estimate (Site OR 039 W) based upon a Lincoln-Peterson Index is 216, which is probably a significant overestimate. The Coast Fork Willamette population (Site OR 036 W) Lincoln-Peterson index estimate is 117, although Moehl(1994) estimated a population of 157 prior to the final marking effort. All these estimates must be considered approximations.

Known minimum population size in the Willamette can be roughly calculated by determining the maximum number of animals captured and/or observed at a variety of sites over different time periods, and including data on other animals actually measured. using this method, a "maximum" minimum of 678 turtles have been identified in the Willamette. Using a combination of calculated population estimates and a general estimate based upon experience from previous visual surveys, a crude maximum estimate can be constructed. Holland (1991a) notes that as general rule, approximately 20%-30% of the population in a given area can be visually censused on any given day. On occasion, almost all of a population may be visible - data from survey results at Site OR 002 U indicate that on some days over 60% of the population can be observed in a single survey. On other occasions few or no animals may be present, especially where densities are very low. Using the "20%" estimate and the largest estimated population sizes, the maximum population estimate for the Willamette is approximately 2400 animals. However, it should be noted that this is not a rigorous estimate for a variety of reasons and may well exceed the actual population size by a significant percentage. The derivation of these figures is shown in Table 2.

Population Density: Given the caveats noted above, a calculation of density estimates is also an exercise in approximation. Determination of western pond turtle densities in other areas (Bury, 1972; Holland 1991a) indicates that this species may very rarely achieve densities as high as 3700 animal/ha. Densities in some stream habitats may typically be greater than 1000 animals/ha. However, it should be noted that these figures apply to California, where on the average densities are higher than in Oregon (Holland, unpubl. data). Estimates from small pond habii in the Rogue drainage indicate that under optimal conditions densities may approach 500 animals/ha. Mark-and-recapture efforts at Site OR 002 U indicate a population that approaches 220 animals occurs in an approximately 2.5 ha lake, for a density of 88 animals/ha. Site OR 017 U is a riverine habitat, and appears to support a density of approximately 140 animals/km. The density figure for this linear habitat is approximately 100 animals/ha. Capture-census in 1993 along a 2 km stretch of the Coast Fork (Site OR 036 W) produced an estimated population of 117 animals, or approximately 58 animals/km. The density figure for this area is approximately 23 animals/ha. Some limited historical data on densities is available. Wilhemi (1964) calculated an population estimate of 180 animals for Jones-Finney (Finney-Egan) Lake which is approximately 1.4 ha in extent (by Wilhelmi's stated dimensions). This yields an estimate of 128 animals/ha. However, it should be noted that this population consisted of approximately 98% adults. If the assumption of a 70% "normal" proportion of adults is extrapolated to a "healthy" population, then the population size under undisturbed conditions probably approached 250 animals.

Changes in Population Size & Density: The total extent of the habitat historically utilized by western pond turtles cannot be calculated exactly. Historical and recent alterations of this habitat have undoubtedly significantly reduced this area (see previous discussion). However, as demonstrated by the extent of the existing distribution (Fig. 4) the species historically occurred throughout the Willamette drainage and most of its major tributaries. Linear measurements of this rivers system (such as the US Army Corps of Engineers mapping of the Willamette River and some tributaries significantly underestimate the historical extent of the habitat due to lack of consideration of multiple channels and oxbow areas (Hoerauf, 1970; Sedell and Froggatt, 1984). A crude approximation of the amount of habitat available can be made by summing the linear distances within these systems within the known range of the western pond turtle. For example, within the Willamette from the mouth to the confluence of the Coast and Middle Forks is approximately 187 river miles. Similar measurements on the Santiam indicate that the distance from the confluence with the Willamette to the base of Foster Dam on the South Santiam is approximately 50 miles. Given the caveats noted above, the minimal amount of riverine habitat available is estimated at approximately 761 miles (1219 km). A breakdown of these estimates is shown in Table 3. It should be noted that this figure is restricted to the larger river and stream systems and does not include some major stream areas such as Fall Creek and Gales Creek which are known to hold turtles. It also does not include oxbow areas which are also known to hold animals. Although estimates of local density are difficult due to the very limited number of "healthy" populations from which to calculate an average, at least some data are available in this respect (see discussion above). Assuming a average minimum population of 50 turtle/km and 1200 km of available habitat, the estimated historic population size for the riverine systems along in the Willamette would be approximately 60,000 turtles. Assuming that half this number of animals (likely an underestimate) occurred in stream, oxbow and wetland habii adjacent to the rivers, a total estimated population size of approximately 90,000 animals for the region can be derived. Obviously, there are a number of assumptions about local and regional distribution, habitat quality and density inherent in any such estimate. Given the lack of rigorous quantifiable historical data on the nature and extent of these habitats and the limited number of populations from which to derive current data, any estimates of this sort must be considered approximations.

The relative decline in the population can be calculated as a the number of animals currently estimated to be present as a proportion of the animals estimated to be present historically. Given the maximum number of animals estimated to be present currently (2400) and assuming that only 60,000 animals were present historically, the "best case" minimum decline undergone by this species is approximately 96%. Assuming that the current population size is approximately 1500 animals and that historic population size approached 90,000, the "worst case" relative decline is approximately 98%.

Discussion: As can be observed from the material above, it is apparent that the western pond turtle population in the Willamette drainage has undergone a significant overall decline. This is reflected in several aspects of the overall situation. First, the trapping effort required per catch has increased significantly from the studies conducted in the 1950's and 1960's (Table 4). For example, the average capture rate for site OR 022 W from 1954- 1959 was 1 turtle/19.59 h of trap effort. For Wilhelmi's study in 1964, the average capture rate was 1 turtle143.63 hours of trap effort. For the COE study at site OR 097 W in 1993, the average capture effort was 1 turtle/220 hours of trap effort. Similar results were obtained from the Kirk Pond portion of the study, yielding one turtle for every 254.4 hours of trap effort. Trapping studies by one ODOT consultant in the west Eugene area averaged 1 turtle/ 290.4 h of trap effort (CH2M Hill, 1993). For the other, 111 "trap nights" (est. 16 h/night, C. Galen, pers. comm.) produced a total of 15 captures, or one turtle for every 118.4 hours of trap effort (Fishman Environ. Serv., 1993). For comparison, concurrent trapping efforts at an unnumbered (and undisturbed) site near Site OR 002 U yielded an average of 1 turtle/21 .09 hours of trap effort. Capture rates for some sites in California have averaged as high as 2 turtles/hour of trapping effort.

Second, recent and current surveys of populations which were the subject of intensive study in the 1950's and 1960's indicate that these populations have decreased dramatically in the last 30-40 years. For example, site OR 015 W, the site of Wilhelmi's 1963-64 and Elling's 1966 study, was estimated to hold a population of approximately 180 western pond turtles as well as 75 painted turtles. Surveys at this site in 1988 noted 3 western pond turtles and 7 western painted turtles. Surveys in 1991,1992 and 1993 revealed only 1 western pond turtle and 3 western painted turtles. Studies from 1954-1959 at site OR 022 W near Corvallis captured 67 turtles, and the estimated population was 75 animals (Nussbaum et al, 1983). Three surveys at this site (OR 022 W) in 1991 noted a maximum of three western pond turtles. Two surveys in 1992 noted one possible turtle. Five surveys in 1993 did not reveal any animals. Lahanas trapped a total of 59 animals at site OR 87 W from 1976-1978. Surveys in 1987-1989 noted maximum of 13 animals, and resurveys from 1991-1993 noted a maximum of 5 animals.

Third, many populations exhii evidence of declines in recruitment as reflected in the age/size structure. To compare potential differences in structure, a baseline or "normal" population must be established for reference. Ideally, this population should occur in similar habitat to the populations with which it is compared, and known factors which may affect survivorship (introduced predators, loss of nesting areas, loss of nests) should be absent. Unfortunately, there are relatively few sites which meet these criteria. One such area is Site OR 002 U, which has been sampled yearly (excluding 1990) since 1987. The sample size to date is 18 1. This site is a lake habitat and resembles many lacustrine areas historically present in the Willamette. The sample for this area (Fig. 5) averages 62.8% adults (>110 mm) or 46.58% adults (>130 mm). Another such site is OR 039 W (Fig. 6) where approximately 60.36% of the population are adults (>l 10 mm). If adults are defined as animals over 130 mm, then 47.46% are adults. There is no significant difference between these sites for the <110 mm comparison (0.75<p<O.50) or for the <130 mm comparison (0.90<p<O.75).

By comparison the population at site OR 097 W differs from an expected 62/38 ratio of adults/juveniles at p <.001. Even if we use a value of 130 mm as the upper bound for juveniles, the significance remains at p <.001. Similar results are found with comparisons for sites OR 015 W, an unnumbered site near Corvallis, OR 003 W, OR 087 W, and OR 096 W. Of all comparisons within Willamette Valley populations, only one does not differ significantly (p<0.05) from the postulated "normal" population ratio. This is the site OR 082 W population. The site OR 036 W (Fig. 7) population is marginally significantly different (0.05<p<0.025) if adults are considered to be those > 130 mm. If adults are greater than 110 mm, the p value approximates 0.012. Even if the normal population ratio is "relaxed" to 70/30, the majority of the populations remain significantly different. At this ratio, the Fall Creek and Coast Fork populations do not differ significantly from the normal population ratio. This information is summarized in Table 5.

Capture results reflect a similar pattern. Prior to 1991, capture records for the Willamette totaled 16 animals, of which 15 (93.4%) were adults. By the end of 1991, data was available on 37 animals, 34 of which (91.8%) of which were adults. By the end of 1992, data was available on 77 animals, 70 of which (90.0%) were adults. By the end of 1993, data was available on 136 turtles (Fig. 8) (excluding animals from COE studies), 126 of which (92.6%) were adults. Data averaged over all captures excluding Sites OR 039 W and OR 036 W produces a total of 227 turtles, 204 of which (89.5%) were adults. Including these sites, the overall percentage of adults in a sample of 365 animals is 305 - or 85.9%. The consistency of the proportion of adults in samples - even when the sample size is increased by over 800% from the original sample, argues that the adult-bias is not a sampling artifact. Concurrent capture efforts in many other localities with similar and larger sample sizes indicate that the populations in the Willamette are very heavily adult-biased. Several other populations display the degree of adult-bias (averaging 90%) present in the Willamette region. Similar population structures are present in the Klamath/Lost River system in Oregon, where approximately 95% of the animals captured (Fig. 9) and observed during visual surveys are adults (Holland, 1993). Additional samples in this area collected in 1993 increased the total sample size by 43% (to 102) but did not significantly change the percentage of adults in the sample (Holland, unpubl. data). Samples from two sites in the lower Umpqua (Fig. 10, Fig. 11) average 96.7% and 100%

adults respectively. A similar situation exists in the lower Rogue, with the population at site OR 010 R averaging 85.1% adults (Fig. 12). This phenomenon is not unique to Oregon nor is it of recent advent. Extensive data on over 4000 animals from over 50 populations in California (Holland, 1991) indicates that similar patterns are present in every major drainage basin in the state in which turtles occur. Studies conducted by the students of Dr. Robert Storm in the period between 1948 and 1978 indicate that the pattern of heavily adult biased populations was present by at least the 1950's Studies conducted by Lyle Wilhelmi and Lee Elling at Site OR 015 W from 1963-1964 and in 1966 indicated that the population at this location was composed of over 94% adults (Fig. 13). An earlier study by the students of Dr. Storm at a site near Corvallis (OR 022 W) yielded one juvenile turtle in five years of trapping efforts (Fig. 14). This population was comprised of 98.6% adults. Both repeated visual surveys and trapping at this site in 1994 did not yield any observations of turtles. Studies at another site near Corvallis in 1976-1978 also produced a population in excess of 98% adults (P. Lahanas, unpubl. data).

An important consideration in evaluating the material presented above is the probability that juveniles and adults are being sampled in approximately the same proportions in which they exist in the areas being surveyed. Data on over 2000 animals collected from 1991-1994 indicates that there is no apparent habitat segregation between adult and juvenile turtles in regard to water depth, distance from shore, refuge type and other potentially significant factors (Holland, unpubl. data). Hatchling/lst year animals do apparently require specialized microhabitats in some (but not all) cases; however as these normally constitute only 2-3% of the sample it is unlikely that they would significantly bias the outcome of any population age/size structure analysis. The majority of these 2000+ animals were collected by hand and variables were recorded immediately after capture. The remainder of animals were collected in traps set in a variety of habitats and so placed that they sampled the range of water depth, cover and substrate types present in these areas. Data indicate that animals as small as 37 mm have been collected in the traps (Holland, unpubl. data; S. Wray, pers. comm.), and that the results of trapping usually approximate those of hand-capture in regard to the determination of population structure. As such, contentions that trapping or hand collecting under-represents the proportion of juveniles in a population lack an empirical basis and are in fact contradicted by the best available evidence.

Extensive data from several dozen sites, both within Oregon and in California, indicates that a typical adult/juvenile ratio for a western pond turtle population varies between 55/45 and 70/30. This hold true for samples as small as 20-30 animals and for samples of over 700 animals. A series of representative populations are presented in Table 6.

Fourth, as noted in detail above, the number of sites surveyed that hold pond turtles is relatively low for this hydrographic basin - only 18.8% of 303 sites surveyed. Holland (1993) noted that in the Umpqua, 45.7% of the 46 sites surveyed held turtles. In the Rogue, only 8.5% of the 48 sites surveyed held turtles. In the Klamath, 30.2% of the 43 sites surveyed held turtles. Furthermore, despite increasing survey effort, the number of sites in which turtles are known to occur in the Willamette does not show a concomitant increase. Holland (1993) notes that in surveys of 145 sites in the Willamette Valley, 38 (26.2%) were identified that held western pond turtles. By early 1994, we had surveyed 303 sites, of which 57 (18.8%) held western pond turtles. Although the sample size was increased by 104%, the number of sites documented to hold turtles rose by only 50%.

Fifth, the average number of turtles observed per survey in the Willamette has averaged <1 during all three years of survey efforts. Averaged over all three years and 524 surveys, the average number of turtles observed per survey was 0.631. Of 106 surveys during which turtles were observed, single animals were observed in 41.5% (n=44) of all surveys. Sightings of 5 animals or less accounted for 91.5% (n=97) of all surveys. In only 4 surveys were 20 or more animals noted, and three of these were at a single site (OR 036 W).This information is summarized in Table 7. North of Salem, only a single site has been documented in which more than 5 turtles were observed. Two other sites held 4 and 5 turtles, but the majority of sites in this area held only a single animal. Between Eugene and Salem, only two sites have been identified which held more than ten turtles - both on USFWS property.

Sixth, remaining aggregations or populations of turtles occur in relatively small areas. The largest remaining population in the Coast Fork is concentrated in approximately 2 km of the watercourse. Moehl's (1994) study indicates that the observed density for much of the remainder of the Coast and Middle Forks averages only 4 turtles/km, and no turtles were observed in Fall Creek. The population at Site OR 039 W is concentrated in a pond only 0.78 ha in size. The estimated 91 turtles at site Or 082 W occur in an area of 1765 ha, although only a fraction of this habitat is typically utilized by turtles. The population in site OR 097 W is largely concentrated on the west and southwest sides of the reservoir, albeit in an area covering several hundred hectares. The OR 050 W population (20+ animals) occurs in a single stream less than 2 km in length.

Seventh, most remaining aggregations occur in habitat that can be characterized as moderately to heavily disturbed. Even the two largest populations occur in lightly to moderately disturbed habitats. The habitat on the north side of Site OR 036 W is relatively undisturbed, however extensive disturbance occurs on the south bank in the form of low-density urban areas and intensive cultivation. Site OR 039 W occurs in a clear-cut area but is otherwise undisturbed. The OR 103 W and OR 082 W populations occur in habitat that contains a large percentage of introduced species, both of plants and animals, and which undergoes significant changes in water level that do not mimic historical water flow patterns.

Eighth, most remainin g populations are highly fragmented. The conquences of population fragmentation are well known in both a theoretical and practical sense, and include decreased total population size, decreased resistance to perturbation, decreased gene flow, and an increased probability of extinction. Overall, the average straight-line distance between "aggregations" (4 or more) of turtles north of Salem averages 32 km. Between Eugene and Salem the distance averages 20.8 km. In the area from Eugene south the distance averages 16.6 km. If the "outlier" of site OR 039 W is excluded from this calculation the average distance decreases to 13.75 km. It should be noted that these figures under-represent potential dispersal distances through the watercourse or overland due to the non-linearity of watercoursesin the first case and topographic relief in the second case.

Summary: In conclusion, in the Willamette drainage the western pond turtle exhibits numerous characteristics of a species in a state of general decline. The total number of animals is low, estimated to range between a minimum of 1500 and a maximum of 2400. This represents a decline of from 96-98% from levels conservatively estimated to be present in the late 1800's. A total of 524 surveys at 303 sites throughout the Willamette produced a total of only 58 sites (18.8%) that hold turtles. The average number of turtles observed per survey was 0.631, and only three sites were observed to hold 20 or more animals. Other surveys in the general area located three additional populations that hold 20 or more animals. Visual and capture censuses by both this and other projects confirm that remaining populations of turtles are very heavily adult-biased, averaging 90% adults. Under normal circumstances, western pond turtle populations consist of 55-70% adults. At present two and possibly three populations exhibit what can be considered to be "normal" age/size distributions. The estimated maximum total population size of these three populations is 458 animals. This is likely to be an overestimate and the actual number may be closer to 300-350. Most remaining turtle populations are small, highly disjunct, and located in degraded habitats.

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Year	Total #Sites	#Surveys	#"New" Sites	#Sites w/o turtles	#Sites w/turtles	#Surveys w/o turtles
1991	145	227	145	107	38	177
1992	111	113	63	93	18	89
1993-Techs	87	112	63	69	18	89
1993-Holland	58	72	32	42	16	48
Totals	401	524	303	311	90*	403

Table 1: Results from western pond turtle visual surveys in the Willamette drainage, 1991-1993.

* some sites duplicated in this total.

Source estimated number of	Maximum number of known individuals	Maximum animals present
Surveys 1991-1993	165	825*
Moehl(1994) (excl. Site OR 036 W)	90	450*
Hardin (1994) OR0103 W	11	55*
Hardin (1994) OR 082 W	39	195*
Site OR 097 W	89	280**
Site OR 036 W	63	151**
Site OR 039 W	86	216**
ODOT West Eugene Study	28	30**
Willamette Collective	107	214**
Total	678	2416

Table 2: Estimated minimum and maximum population size of western pond turtles in the Willamette drainage.

* estimated by 20% "rule" (see text)
** estimated maximum population size by mark and recapture studies or repeated observations

River Stretch	Distance (km)	Source
Willamette R., mouth to confluence of	331	COE Aerial Photographs Coast and Middle Forks
Middle Fork Willamette River, confluence	83	estimated to Staley Creek
Coast Fork Willamette River, confluence	57	COE Aerial Photographs to London Springs
Tualatin River	91	Columbia Basin Interagency committee
Yamhill River (both forks)	128	estimated
Santiam River to confluence of N. & S. Forks	19	COE Aerial Photographs
N. Santiam River to vic. Stayton	25	COE Aerial Photographs
S. Santiam River to Foster Lake	60	COE Aerial Photographs
Luckiamute River	48	Columbia Basin
Interagency Committee		
Marys River	19	"
Calapooia River	73	"
Mohawk River	25	"
Muddy Creek (Benton County)	37	"
Muddy Creek (Linn County)	47	"
Long Tom River	85	"
Coyote Creek	37	"
Amazon Creek	20	"
Row River34		"
Estimated total river kilometers	1219	

Table 3: Estimated total river mileage in major rivers and some streams in the Willamette.

Site Source	Date(s)	Total # turtles	Total #	Total trap effort captures	x catch effort (hours)	Hours/turtle
OR 022 W	1954-1959	67	196	3840	19.59	Several
OR 015 W	1963	49	55	2400	43.66	Wilhemi
Butler's Pond	1963-65	25	51	1920	37.6	Several
West Eugene	1993	12	15	1776	118.4	Fishman
West Eugene	1993	10	10	4904	490.4	CH2M Hill
OR 097 W	1993	60	73	16104	220.6	COE
OR 096 W	1993	26	30	7632	254.4	COE
OR 002 U	1993	41	64	1350	21.09	Current

(Umpqua) Study

Table 4: Historical and current trapping-catch effort for western pond turtles in several sites in the Willamette drainage.

Location	adults> 110 mm	adults> 130
OR 022 W	<0.001	<0.001
OR 015 W	<0.001	<0.001
Butler's Pond	<0.001	<0.001
OR003 W	0.005<p<0.001	<0.001
OR 087 W	<0.001	<0.001
OR 097 W	<0.001	<0.001
OR 096 W	0.005<p<0.001	0.025<p<0.01
OR 082 W	0.75<p<0.50	0.75<p<0.50
OR 103 W	0.10<p<0.05	0.05<p<0.025
OR 036 W	0.01<p<0.005	0.05<p<0.025
Willamette Collective	<0.001	<0.001
West Eugene	<0.001	<0.001

Table 5: Chi-square analysis of differences in interpopulation structure in the Willamette drainage as compared to normal population at Site OR 002 U.

Site Number	Years Sampled	Sample Size	% Juveniles (≤110 mm)	% Adults (≥110mm)
OR 002 U	1987-1993	181	37.4	62.6
OR 050 U	1993	97	29.8	70.1
OR 017 U	1987-1993	71	28.1	71.9
OR051 U	1993	38	34.2	63.8
OR 055 R	1993	54	35.2	64.8
CA 014 K	1987-1991	447	29.7	70.3
CA 001 PS	1987-1991	628	62.06	37.9
CA 014 K	1987-1994	620	73.0	27.0
CA 022 CC	1986-1991	78	43.7	56.3

Table 6: Representative juvenile/adult population ratios from several western pond turtle populations in Oregon and California

Year	# turtles observed											
	1	2	3	4	5	6	7	8	9	10+	15+	20+
1991	21	9	8	4	2				1		1	1
1992	8	2	3	5								
1993*	7	4	1	2	2	1						3
1993**	8	5	3	3	2	1						

Table 7: Number of surveys with number of turtles observed per survey, 1991-1993.

* tech surveys

** Holland surveys

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Figure 1: Distribution of survey sites in the Willamette basin, 1991. "Crosshair" circles indicate observatio n(s) of one or more turtles, solid circles indicate that no turtles were observed. Number of sites surveyed = 145.

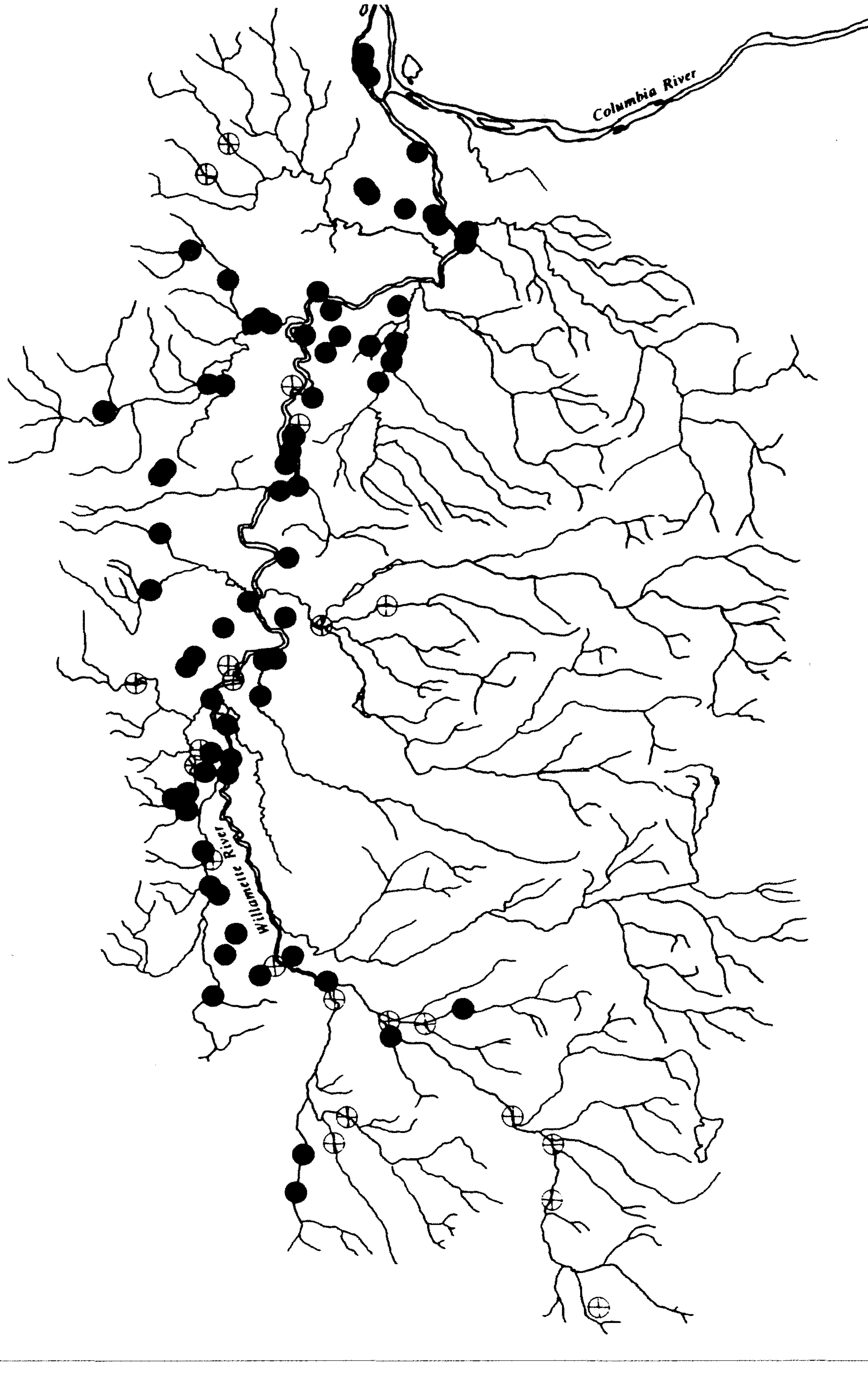


Figure 2: Distribution of survey sites in the Willamette basin, 1992. "Crosshair" circles indicate observation(s) of one or more turtles, solid circles indicate that no turtles were observed. Number of sites surveyed = 111.

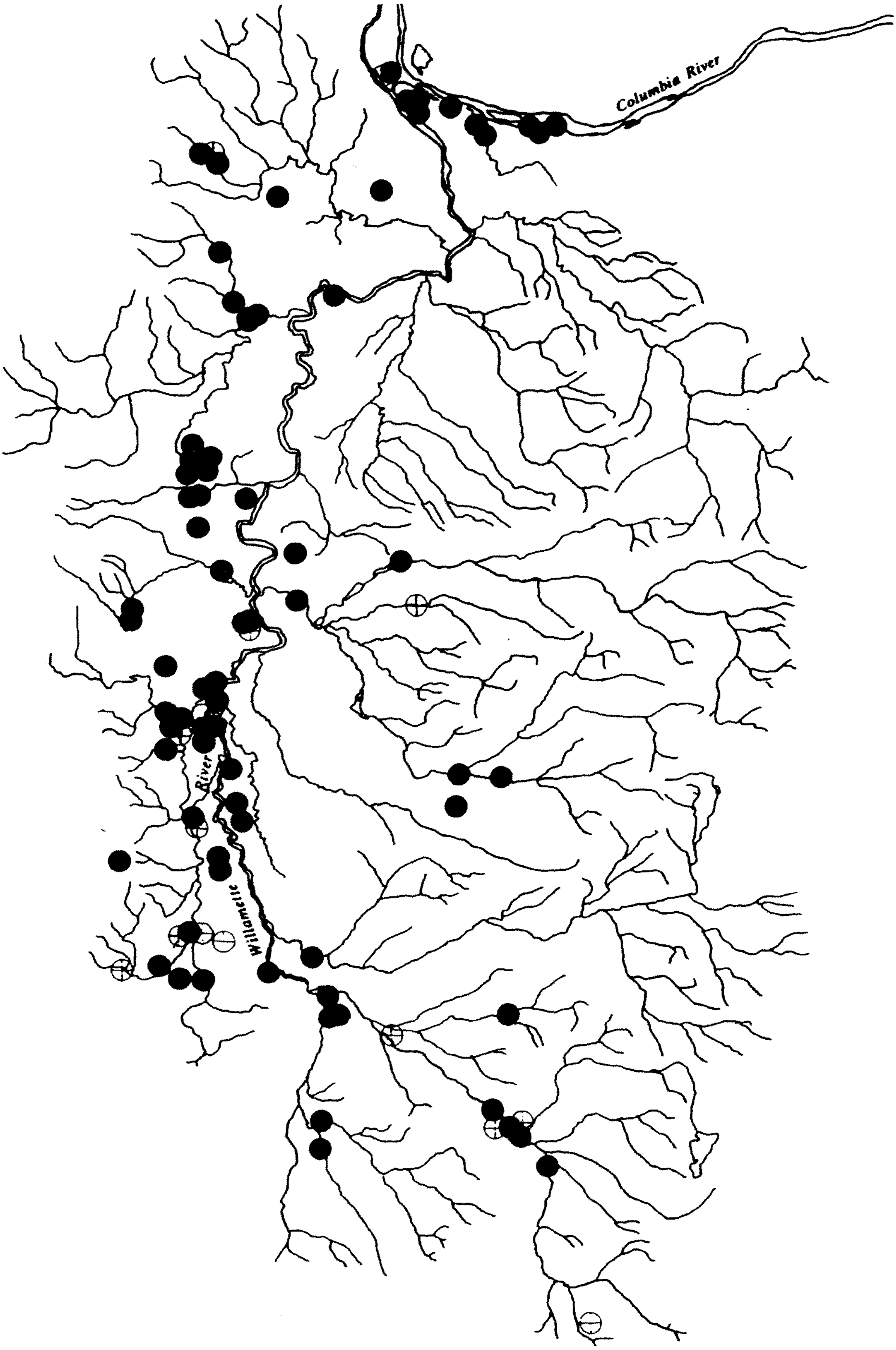
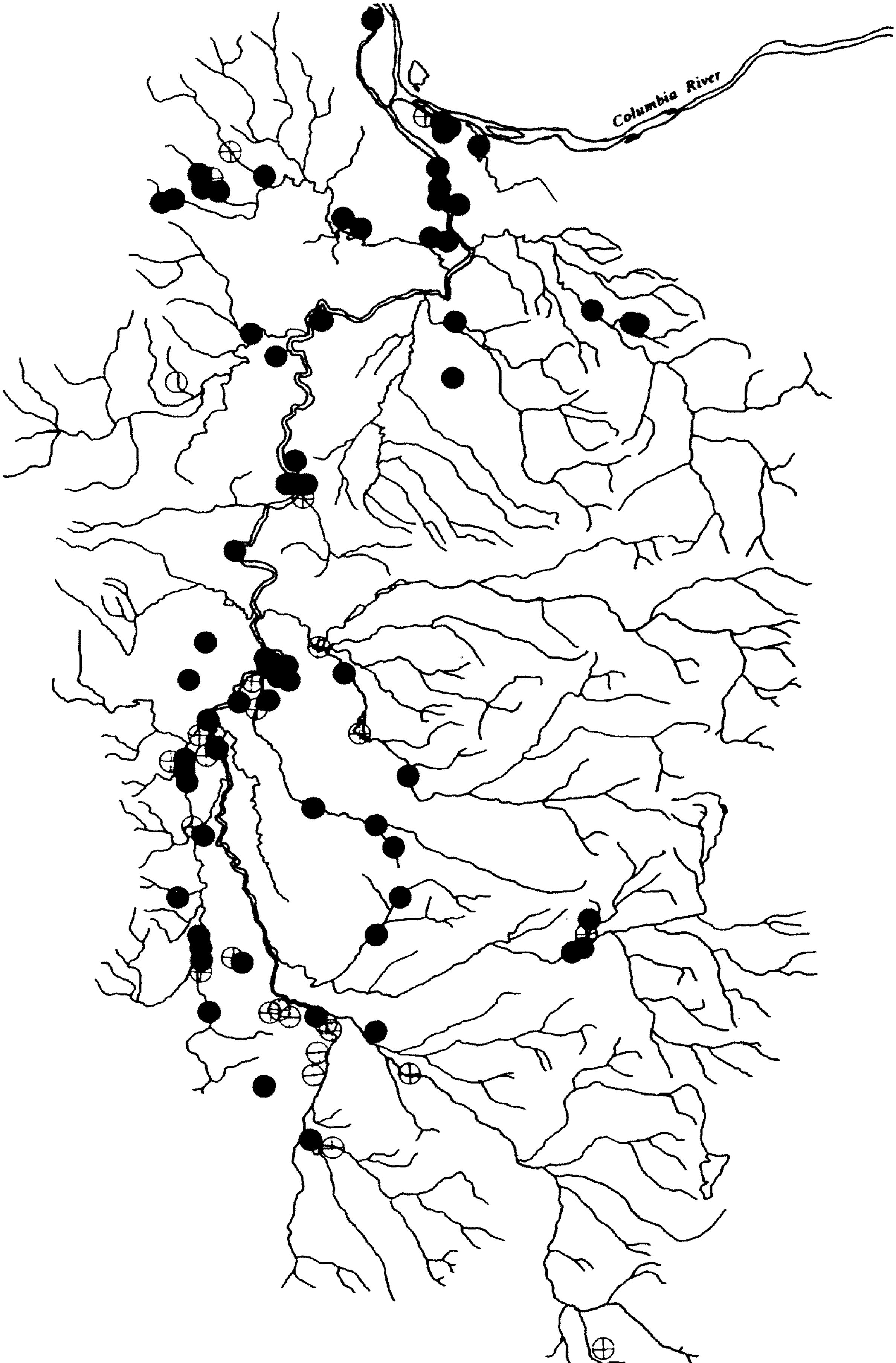
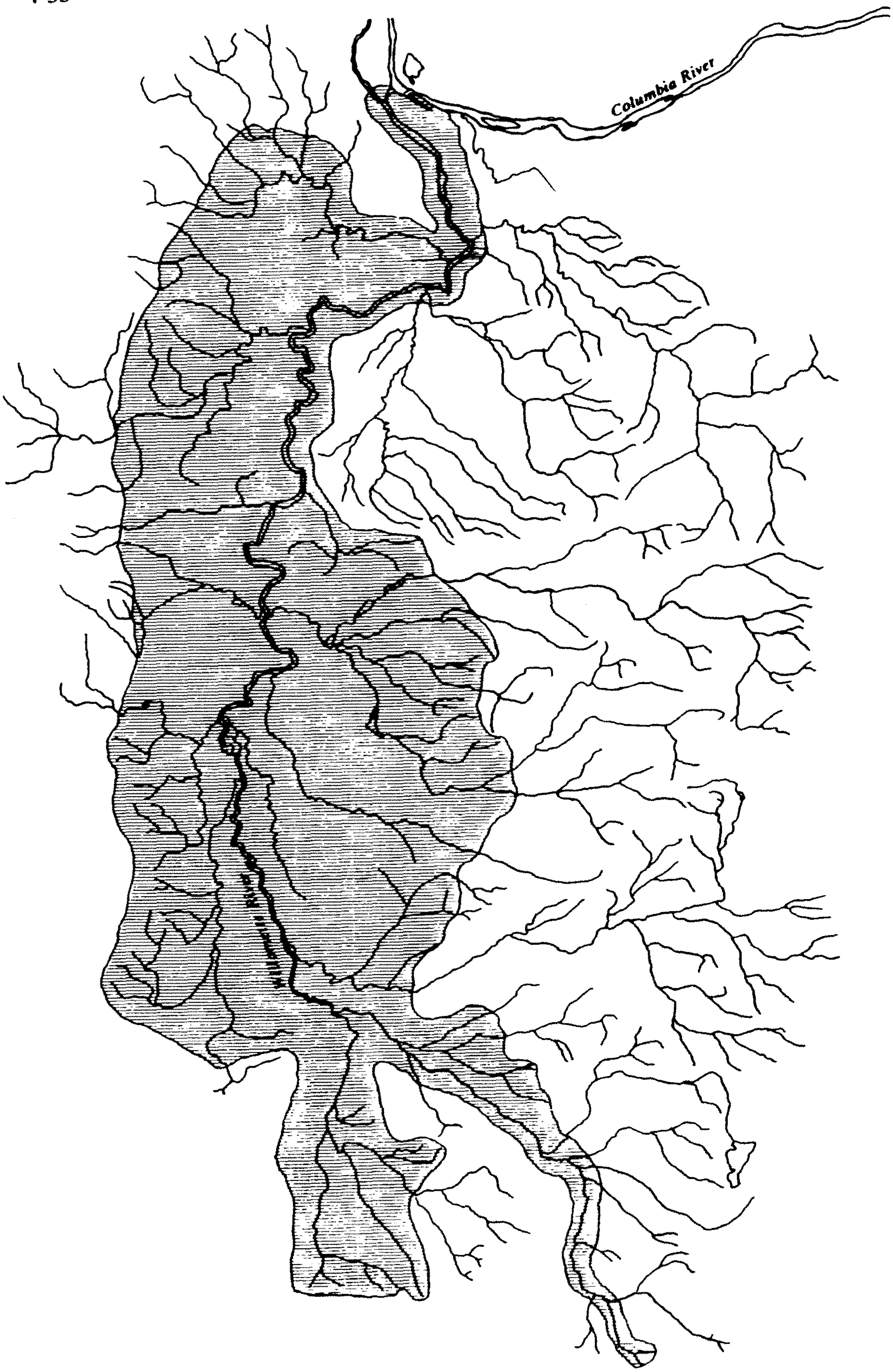


Figure 3: Distribution of survey sites in the Willamette basin, 1993. "Crosshair" circles indicate observation(s) of one or more turtles, solid circles indicate that no turtles were observed. Number of sites surveyed = 119.



4-33 **Figure 4: Historic extent of the distribution of the western pond turtle in the Willamette hydrographic basin.**



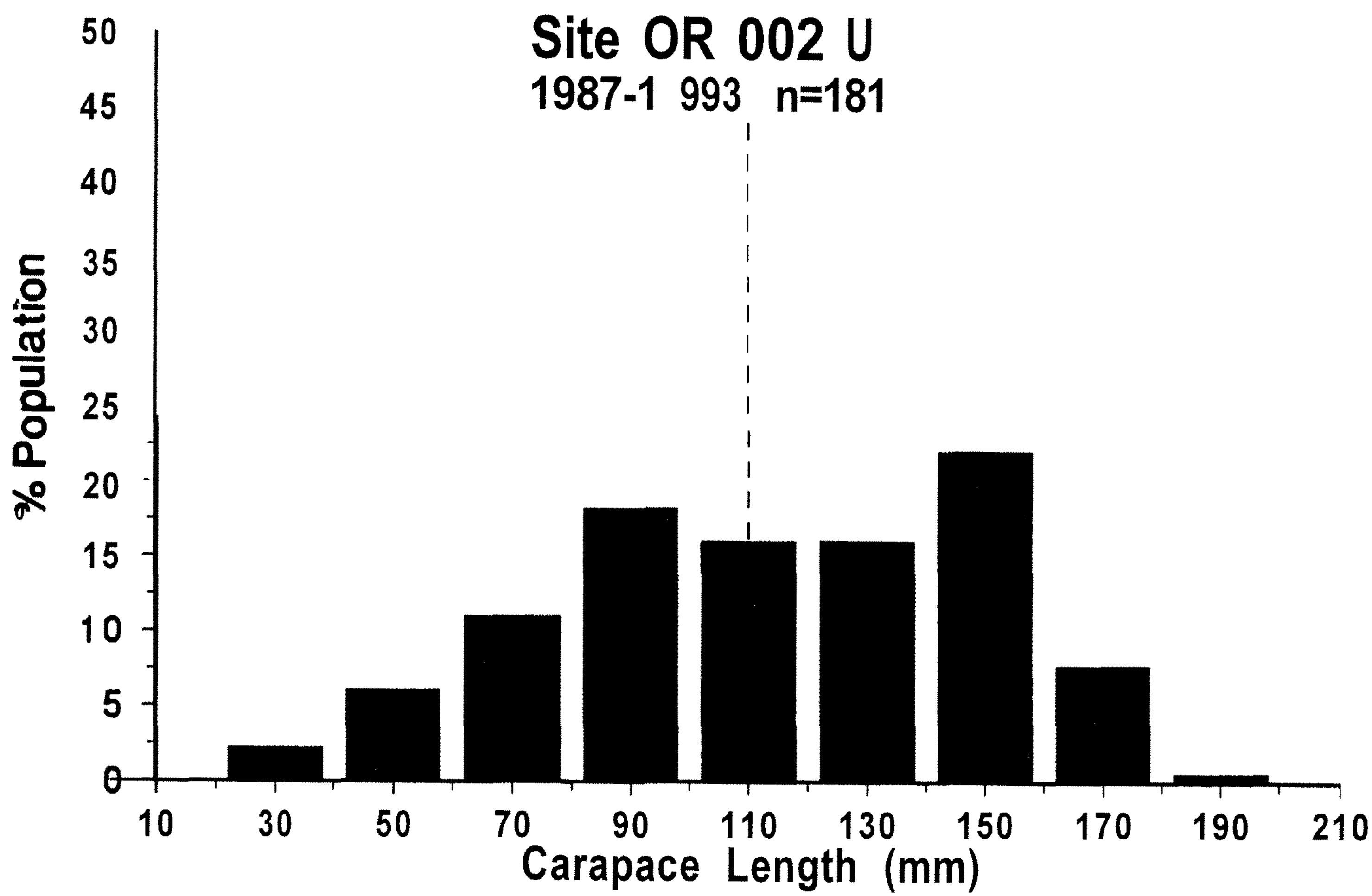


Figure 5: Approximately normal population sire distribution for western pond turtles. Site OR 002 U, Douglas County, Oregon.

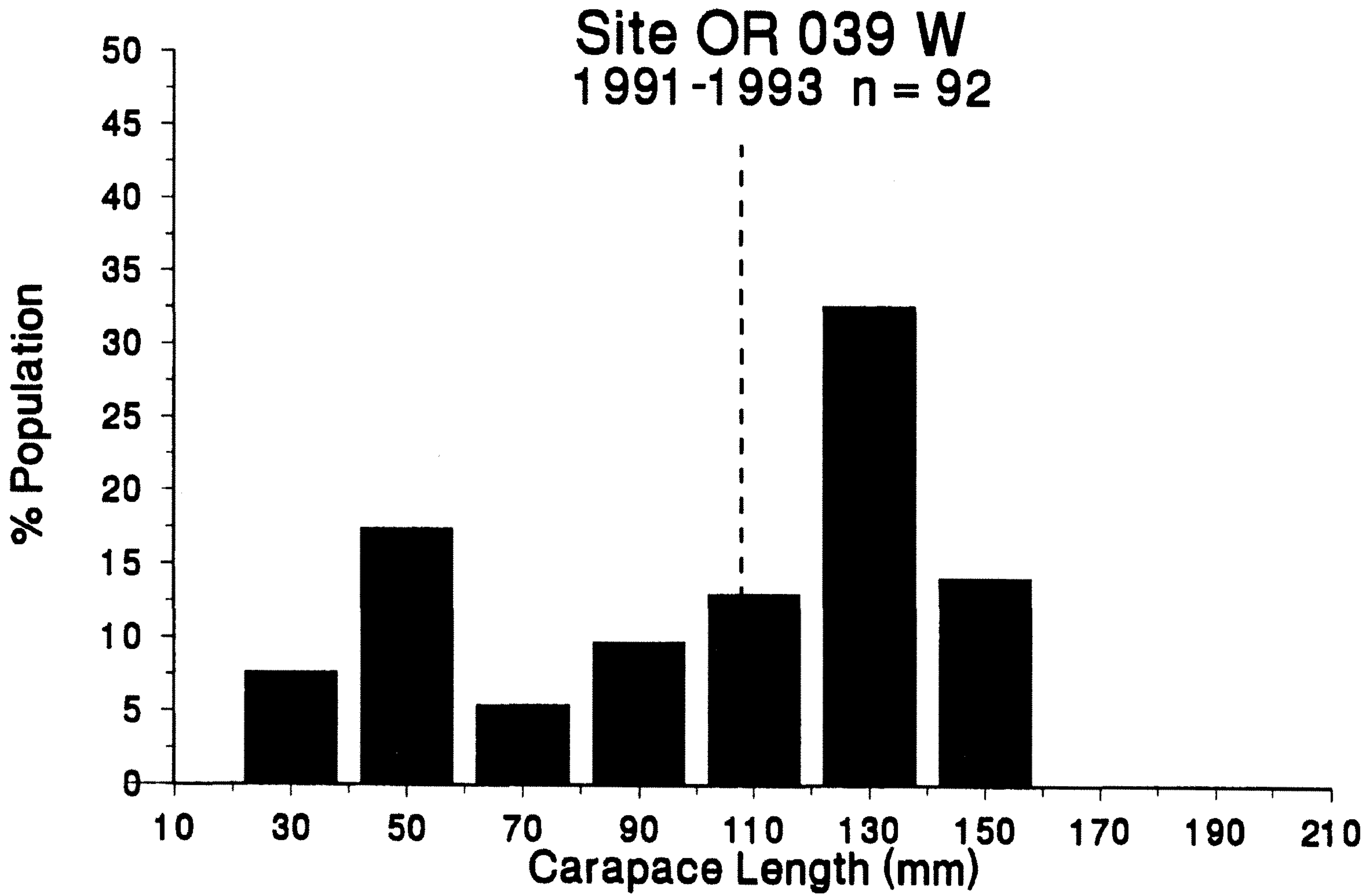


Figure 6: Approximately normal population size distribution for western pond turtles. Site OR 039 W, Lane County, Oregon.

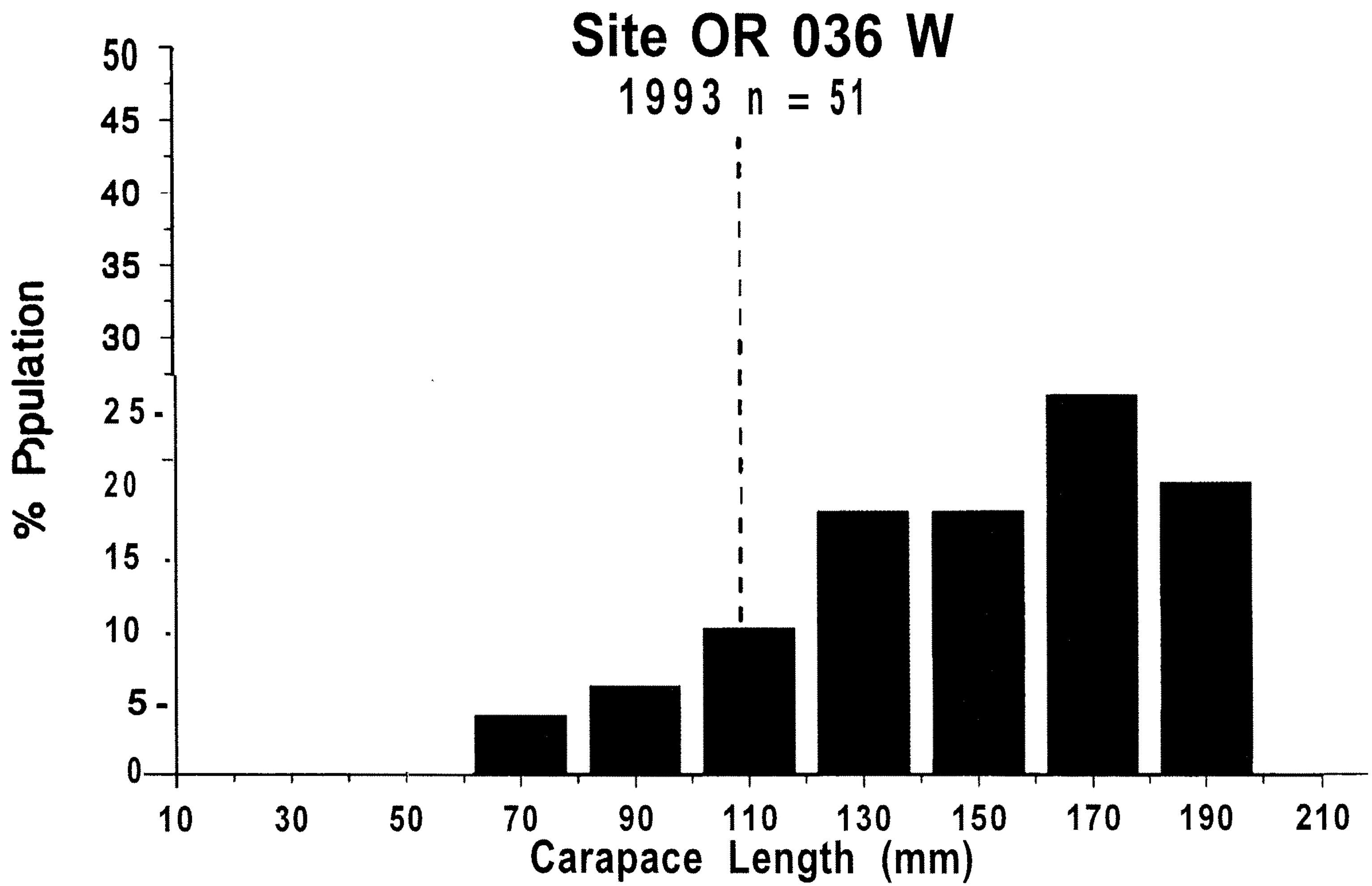


Figure 7: Slightly adult-biased population size distribution for western pond turtles. Site OR 036 W, Lane County, Oregon.

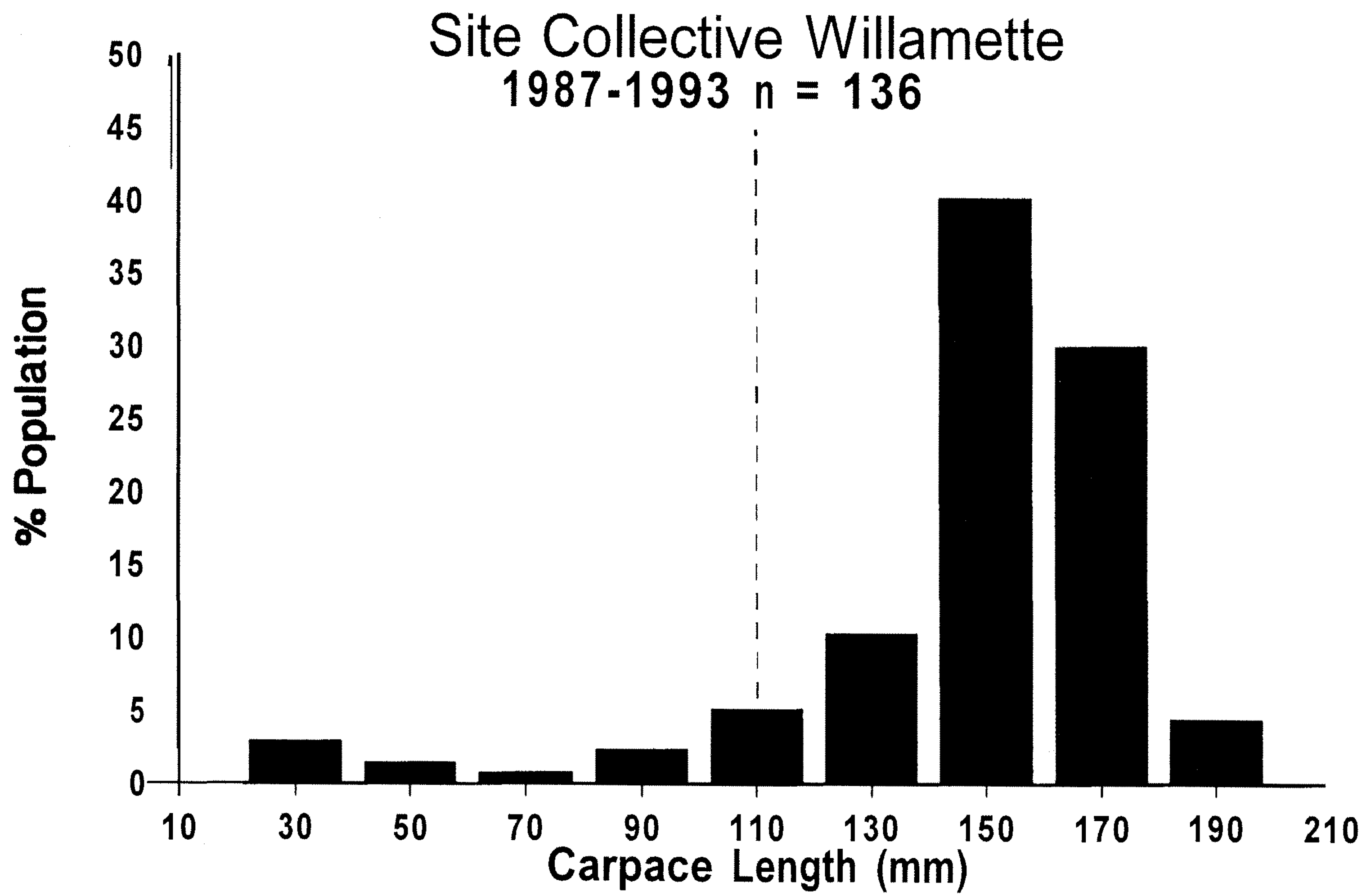


Figure 8: Collective size distribution for all western pond turtles collected in the Willamette drainage between 1987-1993. See text for discussion.

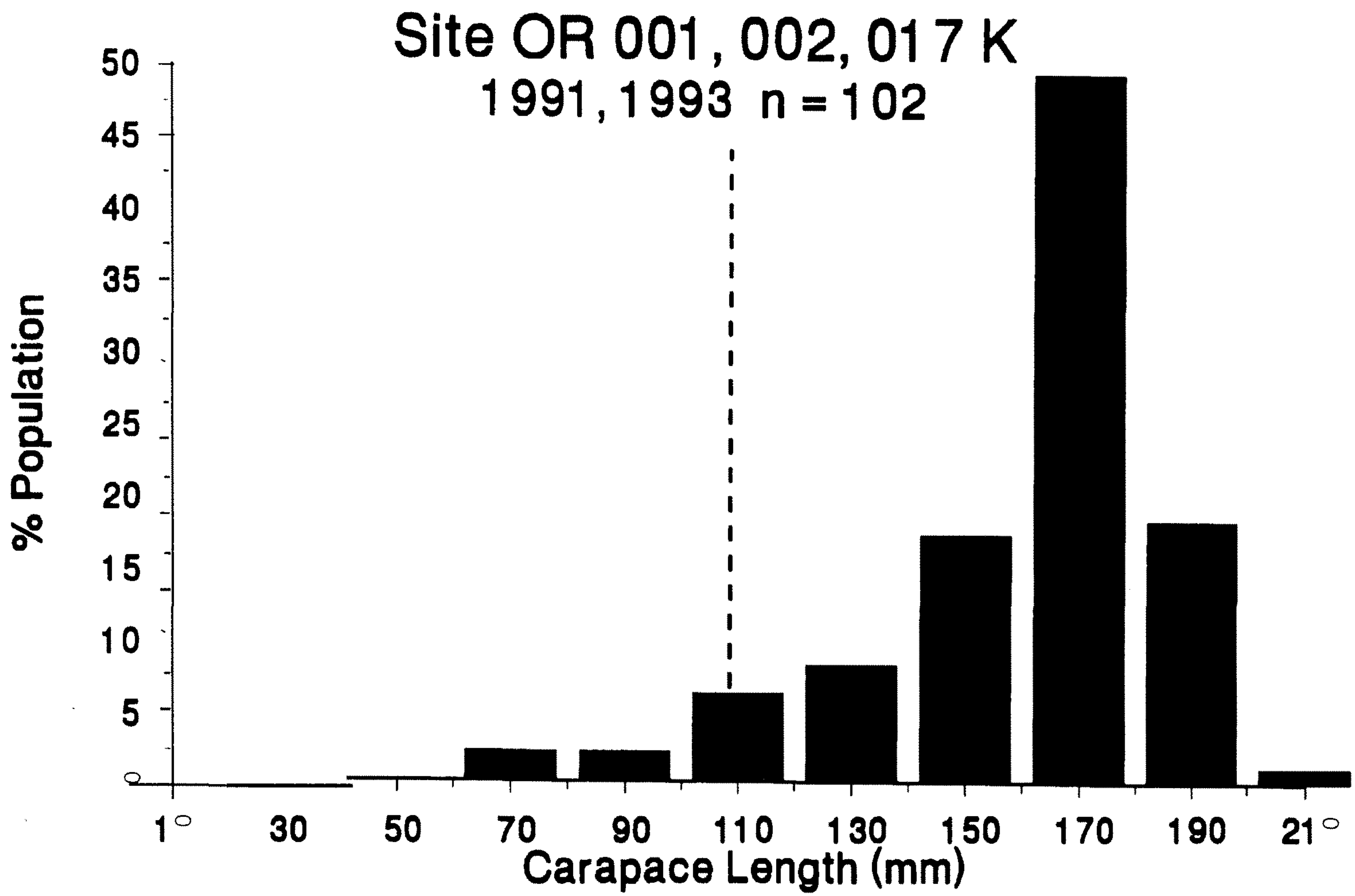


Figure 9: Heavily adult-biased population size distribution or western pond turtles. Sites OR 001, 002 and 017 K, Klamath County, Oregon.

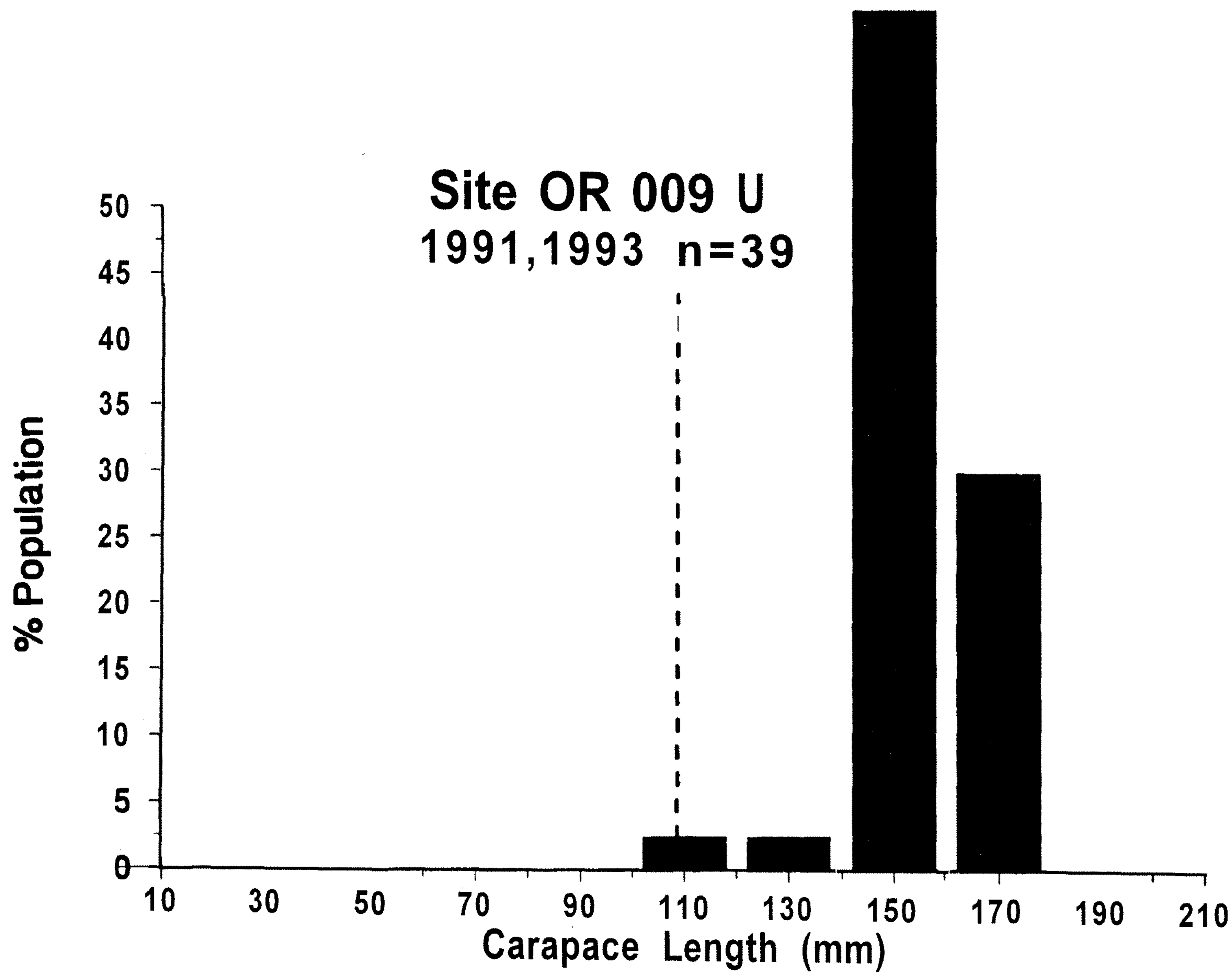


Figure 10: Heavily adult-biased population size distribution for western pond turtles. Site OR 009 U, Douglas County, Oregon.

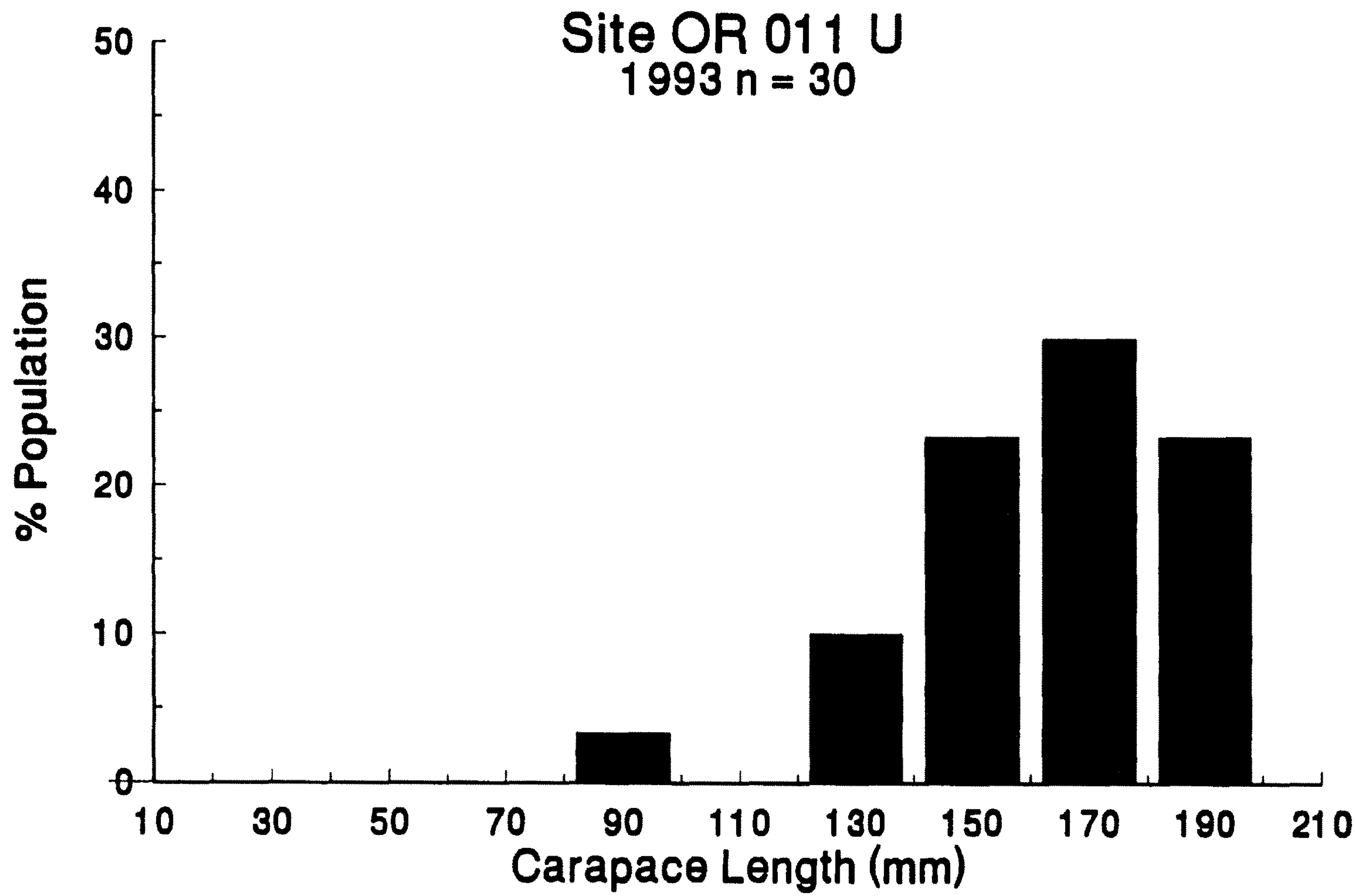


Figure 11: Heavily adult-biased population size distribution for western pond turtles. Site OR 011 U, Douglas County, Oregon.

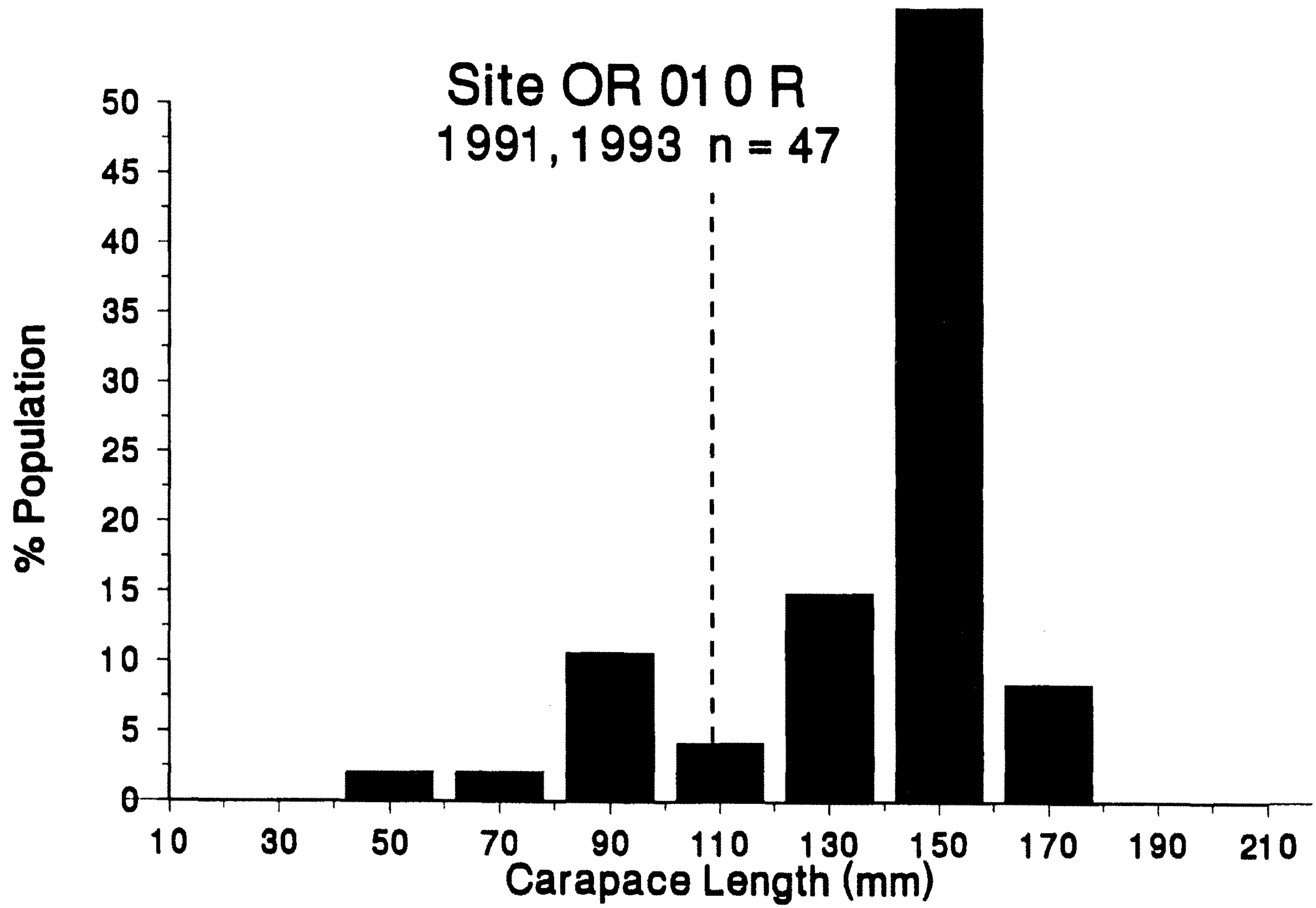


Figure 12: Heavily adult-biased population size distribution for western pond turtles. Site OR 010 R, Jackson County, Oregon.

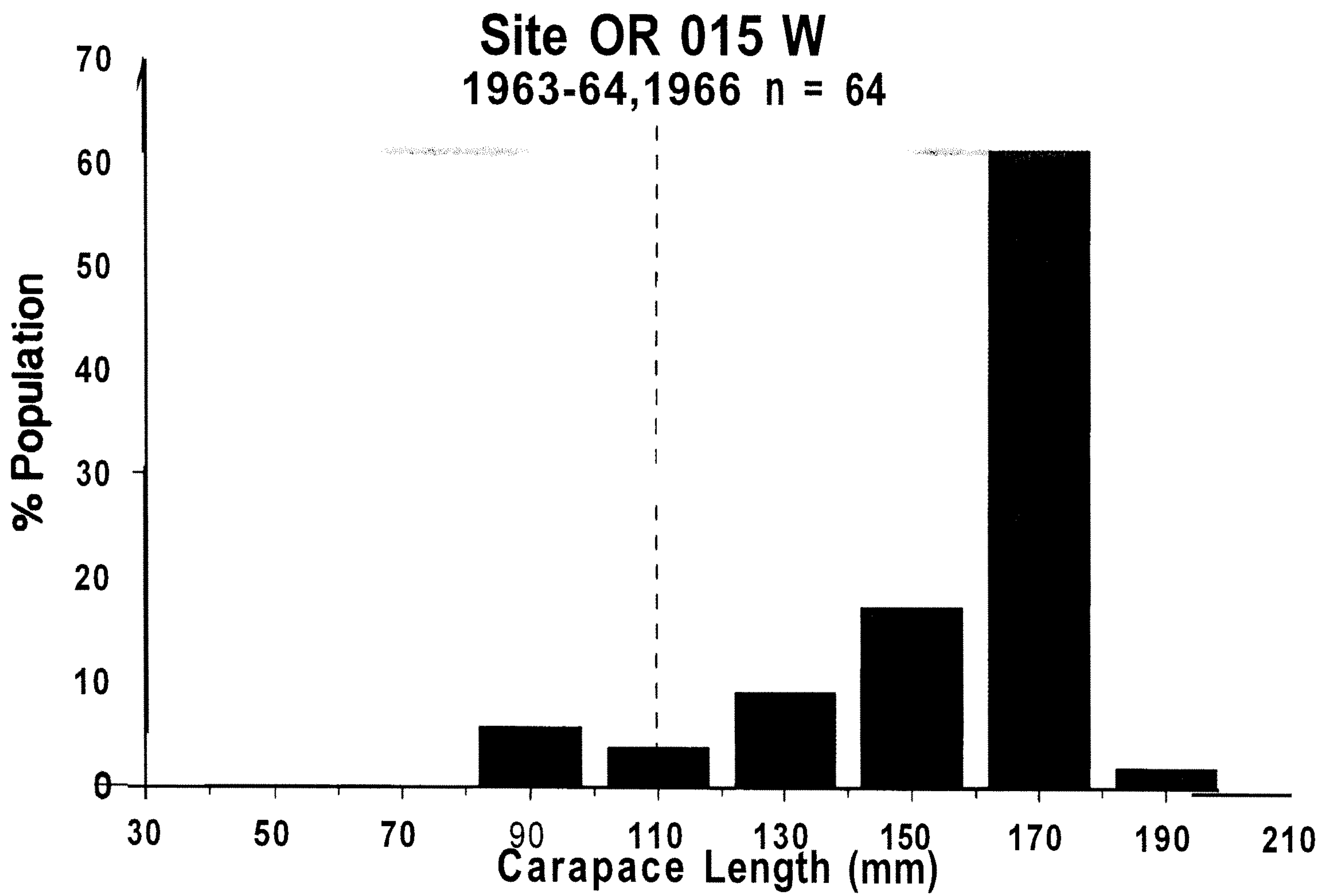


Figure 13: Historical population size distribution of western pond turtles at Site OR 015 W. Marion County, Oregon.

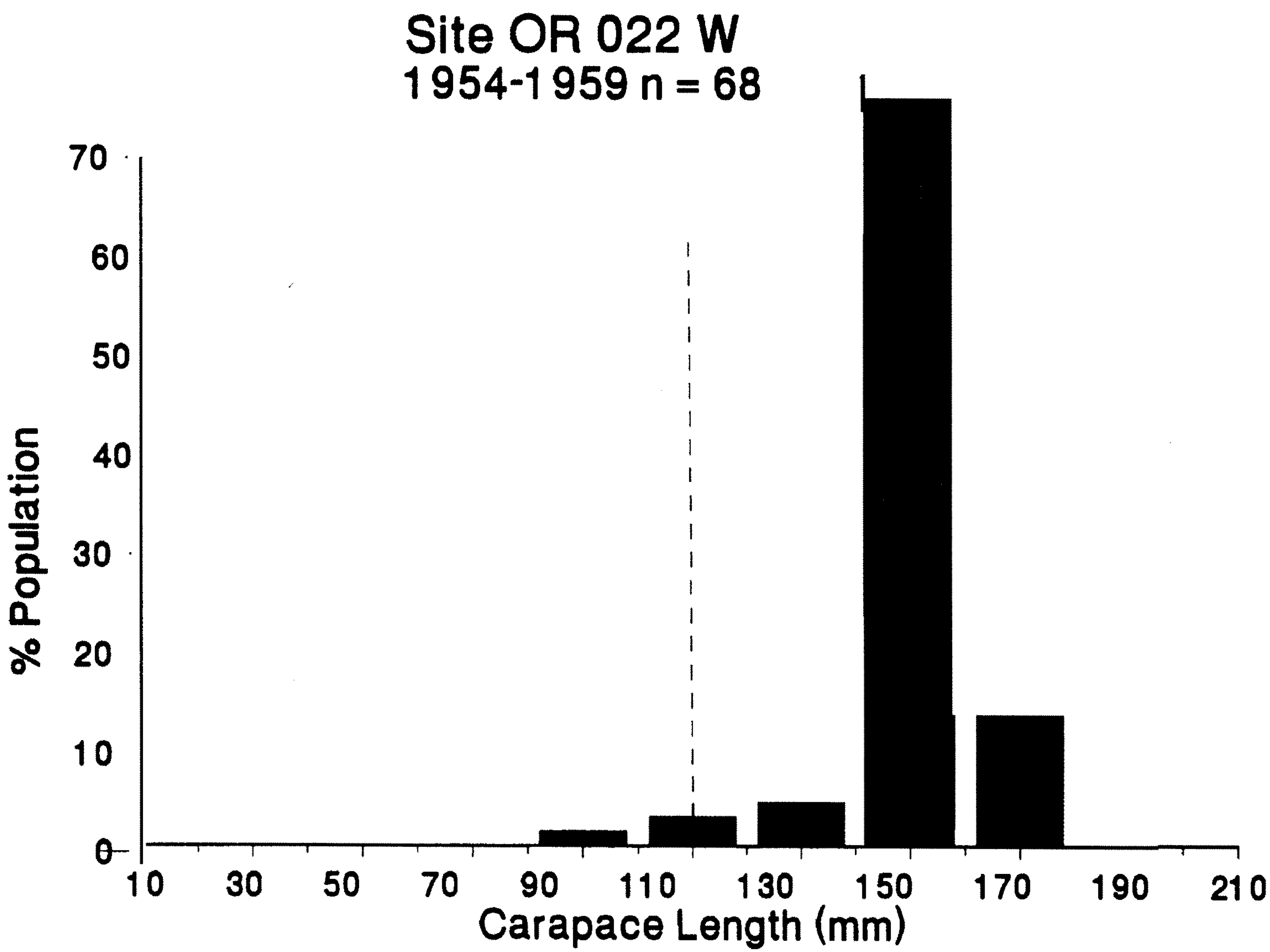


Figure 14: Historical population size distribution of western pond turtles at Site OR 022 W. Benton County, Oregon.

CHAPTER 5

Reproductive Ecology of the Western Pond Turtle

Reproductive Ecology of the Western Pond Turtle

The reproductive ecology of the western pond turtle is one of the many aspects of the species natural history that remains poorly understood. Although some recent information (Rathbun et al., 1992) represents a significant increase in our knowledge in this respect, a great deal of both short- and long-term data remains to be collected to allow for potential management of the species.

Size and presumably age at first reproduction varies geographically and possibly altitudinally within this species. Secondary sexual characteristics are generally apparent by a maximum of 110 mm carapace length throughout the range, and gonadal development closely follows this pattern. Examination of the reproductive status of over 2000 females from throughout the range from 1987-1993 indicates that the smallest known reproductive female is an animal from southern California approximately 111 mm carapace length and probably 6-7 years (minimally) old.Most animals from the remainder of the range do not appear to develop eggs until they are at least 120 mm carapace length and typically 8-10 years of age. In the northern part of the range (Rogue drainage north) the smallest known reproductive female is 13 1.3 mm.The largest known gravid female was a 182 mm animal from the Lost River in Oregon. Age and size at first reproduction for males is not as well known, but animals as small as 90 mm have been observed engaged in courtship in southern California (S. Sweet, pers. comm.). Males from Oregon have well-developed testes at carapace lengths of approximately 110 mm and greater.

In some areas, such as central and southern California, turtles may lay eggs every year and some females may "double-clutch" - laying 2 clutches in a year. However, as noted in Holland (199 l a), the majority of females from most areas examined or dissected during the approximate period when the species is known to be carrying eggs were not gravid. There are several possible explanations for this situation, not all of them mutually exclusive. One is that the majority of females oviposit in alternate years, or possibly even triennially in some cases. Another is that other factors, such as food limitation or stress, may affect interannual fecundity. There is some support for this hypothesis from data collected on females during the drought years 1987-1991 in southern and central California. In several instances, less than 20% of the females of potential reproductive size were carrying eggs during the period in which oviposition is known to occur. Many of these (and other animals in the same system) were well below "normal" weight for the time and area, and thus may not have been able to support development of eggs. A third possibility is that some females are reproductively senescent, most likely those that are larger (and presumably older).While relatively few of the larger females (>170 mm) captured in Oregon have been noted to be gravid, this in and of itself does not furnish evidence of reproductive senescence.

Of 475 females greater than 110 mm carapace length examined between 1987-1993 in Oregon a minimum of 78 animals were found to be carrying eggs (Fig. 1). The smallest gravid animal recorded from Oregon is 13 1.3 mm, and at least 3 other animals <135 mm have been recorded. Of the 78 animals, 12 (15.3%) were less than 150 mm, and 43 (55.1%) were between 151 mmandthan 170 mm. Clutch size in the species ranges from l-13, and known clutch size in Oregon ranges from 3-13. In fact, all females with clutch sizes > 11 are from Oregon. Of35 females of potentially reproductive size captured at site CA 014 K in early June 1992, 16 were observed (by palpation and/or X-ray) to be carrying shelled eggs or large oviducal eggs. Of 12 females of potentially reproductive size captured by the COE at Fern Ridge Reservoir between 06 May and 09 June 1993, only one was gravid. Clutch size is positively correlated (r = .692) with carapace length, and mean clutch size for all specimens (n = 168) is 6.12 (Fig. 2)

Oviposition typically occurs in June-July, although records exist from central and southern California for as early as late April. At least two records exist from Oregon for August - one a female collected from near Muddy Creek (Benton County) in late August that deposited eggs on 01 September (L. Gangle, pers. comm.) and another female from Douglas County that was carrying shelled eggs in early August. Observed oviposition in 1992 at Site OR 039 W occurred on 03 June, 13-15 June, and 18-19 June. In 1992 at site OR 0 17 U on the south Umpqua possible oviposition behavior was noted on 06 June. Most oviposition efforts in 1993 appeared to occur at approximately the same time as in 1992 in the Willamette drainage, but were approximately 3-4 weeks later in the Umpqua system. Surveys by the COE at Fern Ridge Reservoir noted the first evidence of oviposition between 01 and 15 June and the last recorded nesting effort on approximately 16 July. Surveys of known nesting areas in the Umpqua on 17 June and 27 June 1993 produced the first evidence of nesting immediately prior to the latter date (via a predated nest). Local variation in weather and water levels may have a significant influence on the timing of oviposition. For example, in the South Umpqua in 1993 most turtles were still situated in terrestrial habitats by May-mid June, possibly due to high river flows and unseasonably cool and wet weather. Visual surveys at several sites in 1992 in this time period revealed several animals at each site, and most animals had returned to the water by late April in 1994. Two telemetered gravid females were radio-located in the terrestrial habitat on 27 June 1993. One animal was captured on 28 June 4 m from the water and the other animal was located in the river at that time. The first evidence of oviposition (via predated nests) at Site OR 017 U in 1993 was noted on 07 July. A single female was observed excavating a nest in the south Umpqua drainage on 28 July 1993, and there was abundant evidence of oviposition prior to this date, again via predated nests. Although convincing evidence of large-scale "synchronous" nesting (such as occurs in sea turtles) is lacking, on at least three occasions three or more turtles have been observed nesting in the same area on the same date in 1992. Two of these situations occurred at Site OR 039 W, and one at site CA 014 K. In other cases, oviposition is known to have occurred over a period of at least four weeks at a single nesting area.

Female western pond turtles generally leave the water in late afternoon-early evening to move into upland sites to excavate the nest. However, some movement may occur in early morning particularly on overcast days. Rain may serve as a trigger to initiate nesting movements, as noted in eastern mud turtles *(Kinosternon subrubrum)* (Burke et al., 1994). Observations in the Columbia Gorge in Washington in 1990 noted that nesting movements were usually preceded by weather fronts and rain storms moving up the Gorge (Holland, 1991b). A similar situation was noted at site OR 039 W on 04 June 1992 when 3 females were observed excavating nests. The day was heavily overcast and had been preceded by a moderate rain the previous day. On two of the three occasions when females were observed engaged in nesting activities between 04 and 29 June 1992, rain was noted during at least part of the day on which nesting occurred. Rain presumably facilitates excavation in the hard-packed soil in which western pond turtles typically nest. The duration of nesting may vary significantly with local conditions. Observations in Washington in 1990 indicated that females require from two to over ten hours to complete the nesting process once excavation has begun (Holland, 1991b). Observations at site CA 014 K in 1992 indicated that one female required somewhere between six and seven hours to complete the excavation of the nest. All females observed nesting in Washington in 1990 (n=6) completed the nesting process within a 24 hour time span. However, females may occasionally remain out of the water for extended periods of time during nesting efforts. One female observed in 1990 in Washington moved a minimum of 637 m over the course of 4 days before returning to the pond. She made several "false scrapes" in this time period, and emerged several days later to excavate a nest and return to the water within one day. On at least two occasions at Site OR 039 W in 1992 females were observed to remain near the nest site overnight, which was also been noted at Site CA 014 K and along the Trinity River in northern California (D. Reese, pers. comm.). Multi-day nesting efforts appear to occur with some frequency; this situation has been noted at site OR 039 W in 1992, when two females were noted to be out of the water for two days and a single female was on land for three days. Similar situations have also been observed at site CA 014 K, along the Trinity River (D. Reese, pers. comm.) and in central coastal California (Rathbun et al., 1993). It is not clear at this time whether or not this is a normal behavior or represents a response to disturbance (the presence of the observer) or a mixture of both. Multi-day nesting excursions have been reported in several other species of turtles, including *Emydoidea blandingi* (Congdon et al., 1983; Rowe and Moll, 1991), *Kinosternon subrubrum* (Burke et al., 1994) and *Kinosternon flavenscens* (Iverson, 1990).

Female western pond turtles are very wary during nesting movements, often moving a few meters with the head extended and apparently engaged in active "surveillance" of their surroundings. This vigilance continues during the times when the animal "rests". Observations (from field notes) at Site OR 001 W in 1990 (Holland, 1991b), Site OR 039 Win 1992 and OR 050 U in 1992 and 1993 make repeated reference to the alert nature of animals moving out to nesting sites or during the nesting process. Females may return to the watercourse if sufficiently disturbed during this time period (Holland, 199 1 b, 1993). Females may produce one or more "false scrapes" (Fig. 3) - activities that resemble nest excavation or actually result in the excavation of a nest chamber but do not result in the deposition of eggs. In several instances (Holland, 1991b, Rathbun et al., 1992, 1993) seemingly "complete" nest chambers have been excavated but in which the female did not deposit eggs. In other cases the female may excavate until she hits a rock or root, which usually leads to abandonment of the effort. In one instance observed in Washington in 1990 (Holland, 199lb), one female was observed to deposit only five of the six eggs she was known to be carrying in the excavated nest. The possibility exists that turtles may construct more than one nest to deposit an entire clutch.

Typical pre-nesting behavior includes frequent touching of the nose to the soil during the course of overland movements. The female then evacuates the contents of the bladder - often 15-20 cc of fluid in a 150 mm female - onto the soil. Excavation (Fig. 4) is conducted by the hind limbs, often alternating every few strokes. The hind limbs may rotate at least 45 degrees when soil is being excavated from the nest chamber proper, and the material deposited at a distance near the full extension of the limbs. Viewed from a distance, the female seems to "rock" laterally up to 20-30 degrees during this effort. Vertical displacements of the shell of up to 30-40 mm are not uncommon, particularly during the latter stages of excavation. Actual deposition of the eggs may occur rapidly. Observations on one female in Washington in 1990 indicated that five eggs were deposited in approximately nineteen minutes, with the average time between eggs slightly less than five minutes. Average passage time (from initial dialation of the cloaca) was approximately four seconds. Extensive manipulation of the eggs with the hinds limbs occurred after the deposition of the fourth and fifth eggs. Deposition of the fifth egg effectively filled the nest chamber and the sixth egg this turtle was known to be carrying was not deposited in this nest. Observations on another female at site CA 014 K in 1992 indicated that four eggs were deposited in approximately 30 minutes. After deposition of the eggs, the nest is covered by extensive and vigorous scraping of material (using the hind limbs) from the surrounding area into the neck of the nest. The material may be "kneaded" into the neck of the nest with vigorous movements of the hind limbs of the female. This material, which may be either mud, dry soil or vegetation or a combination of these forms an effective "plug" in the neck of the nest, especially after the nest has dried for several days. The appearance of the nest immediately after the nesting process is distinctive and remains so for up to several days, depending upon local conditions. Rainfall after completion of the nest rapidly changes the its appearance and makes locating the nest very difficult. Typically, the nest site is characterized by the flattened appearance of the vegetation - approximately the size and outline shape of a turtle - usually 1 50-200 mm in length and 100-1 50 mm in width. The soil is disturbed within or immediately adjacent to this area, and the most distinctive feature is the presence of a small "clod" of mud or dried soil, between 30-80 mm wide and 60- 150 mm long. This clod is usually located within 10-70 mm of the neck of the nest. The nest chamber proper varies somewhat in shape, but is usually light-bulb or pear-shaped. Measurements indicate a maximum depth of 1 10-120 mm, and the confluence of the "neck" and "body" of the nest (where such a distinction exists) is from 10-40 mm below the soil surface. The "top" edge of the topmost egg may be as far as 50 mm from the soil surface, and in at other instances, has been observed to be within 10-15 mm of the soil surface. In one instance a small portion of the topmost egg was visible after the covering of the nest had been completed. Females that have completed the process of nesting can often be identified by the presence of mud clumped around the anal shields and on the hind feet and limbs (Fig. 5).

The soils in areas utilized as nesting sites by western pond turtles appear to have generally similar physical characteristics although their composition and parent material may vary significantly from area to area. Generally, these soils are compact and often contain a significant clay or silt fraction. Observations in several areas during the period in which oviposition is known to occur (late April-July) indicate that by this time these soils are relatively hard. Turtles have been observed excavating nests in the fill bank of a highway in central California (G. Rathbun, pers. comm.), and adjacent to a compacted dirt-gravel road-bed in central Oregon (Fig. 6). Of over 250 nests examined to date only three (two in the south Umpqua drainage, one in southern California (B. Goodman, pers. comm.)) appear to occur in soils that contain any significant proportion of sand.

The aspect of known nesting areas varies, but most are located on a generally south, southwest or southeast facing exposures. In certain locations, nesting areas may occur which have a primarily east- or west-facing exposure (Fig. 7) (such as some river canyons). Microsite location of the nest within the nesting area may vary, with records for nests on north-, south-, west- and east-facing microslopes. However, most nests occur on generally south-facing microslopes. Slope at the nest site varies, with records for 0-45 degrees known from Oregon, and at least one record for 60 degrees from southern California (B. Goodman, pers. comm.). In several instances, nests have been observed on microsites with O-25 degree slopes on 45 degree "general" slope. In most cases, nests occur on microsites with slopes of 25 degrees or less. The actual extent of the nesting area is difficult to delimit in some areas (such as the Columbii Gorge sites studied in 1990) because of a (subjective) lack of delineation of soil and vegetative types in upland habitats. In the Willamette, the few known nesting areas are somewhat better defined and range in size from approximately 200 square meters (at site OR 039 W) (Fig. 8) to approximately 3 hectares (at Site OR 97 W). In the Umpqua, the smallest known nesting area is slightly over 300 square meters and the largest is approximately 1 ha in extent. The relative extent of nesting areas has not been and may not be possible to determine for most regions; however preliminary analysis indicates that less than 1% of the terrestrial habitat within 100 m of a 50 km stretch of the South Umpqua River constitutes actual nesting habitat. It is likely that the equivalent figure for the Willamette drainage is considerably lower than this at present, due primarily to the massive alteration of habitats adjacent to riparian areas. At present, known nesting habii within the Willamette totals less than 5 ha (see below). Although this figure may in part reflect a limited search effort, it also indicates that very limited suitable habitat exists even in areas that have been intensively surveyed (such as around Fern Ridge reservoir). The total number of known nesting areas in the Willamette is eleven. Two of these sites are represented by single nests, and one other site by three nests. The approximate size of these areas is unknown. Calculation of the total nesting area at a site is somewhat subjective, but based upon the distribution of short-grass/forb habitat, the following figures can be derived. Of the eight remaining sites, one covers an estimated 200 square meters (unnumbered site in Eugene), two locations at site OR 039 W cover 200 and 800 square meters (respectively), another approximately 500 square meters (site OR 041 W), and the remaining sites (all near Fern Ridge reservoir) cover an estimated 2,000, 5,000, 10,000 and 30,000 square meters. Calculation of nesting area by use of a minimum-area polygon (between known nest sites) would probably reduce these figures by over 50%. Of these sites, a minimum of two nests have been located at the unnumbered site in Eugene, a minimum of eleven nests at site OR 039 W, five nests at site OR 041 W, and eleven, nine, five and four nests were found at the various Fern Ridge sites. Surveys conducted concurrently (1993) in the Umpqua revealed seventeen areas along 50 km of rivercourse, with the number of nests ranging from three to seventeen per area.

The Fern Ridge and west Eugene sites are of considerable interest and deserve further discussion. Two of the Fern Ridge sites are located in what were historically cultivated areas adjacent to the reservoir. Both of these sites are now dominated by introduced and native grasses and forbs, and undergoing succession to a mixed conifer/softwood (ash) forest. The time elapsed since the abandonment of cultivation is not known, but is likely to be at least several years. Another site is located on a spoil bank of a watercourse channelized by the COE in the 1950's The soils at this site are very compact and support a very sparse vegetative cover, primarily of grasses and forbs. The last nesting area is adjacent to a pasture on the northwest shore of the lake, and most of the nest sites are in a disturbed area that is periodically mowed. The west Eugene site is located on fill material immediately adjacent to an excavated gravel pit. The actual age of the fill material is not known, but thought to be at least 7-8 years.

Distance of all known nest sites ranges from 3 to 402 m from the watercourse (Fig. 9). Within the Willamette distances range from 3 to 332 m. Mean distance for all known 252 nests is 49.2 m, which includes figures from the Willamette. For this drainage alone, the mean distance in 86.1 m - almost twice the average for all other sites (Fig. 10). Observations in riverine and other areas indicate that most nesting areas are located above the "average" high-water line. Thus, it may be that the use of these areas is a function (via selection) of the probability of periodic flooding. Evidence from the field (Holland, 199 1 b) and lab studies (Feldman, 1982) indicates that western pond turtle eggs that are exposed to significant amounts of moisture in the substrate during development usually fail to develop or produce a lower overall rate of hatching success.

The species composition of the vegetation in known nesting areas varies fiom location to location, but the areas appear to be physiognomically similar. In general, nesting areas are characterized by the presence of short grasses and/or forbs (Fig. 11) . Shrubs and trees are generally uncommon in the nesting area proper, although the nesting area(s) may occur immediately adjacent to forest habitats or as openings in otherwise extensive forests. Most known nesting areas in the Willamette are located in open areas dominated by short grasses, and in at least one instance occur in a formerly cultivated area that now exists as a fallow field. Historically, the open nature of these areas was probably maintained by periodic fires that swept through many areas of the Willamette (see chapter on historical overview). In other areas, the lack of drainage or the nature of the soil may prevent or minimize encroachment by herbaceous vegetation and/or trees. Alteration of these areas (such as via the planting of trees) may decrease both the short- and long-term suitability of the area as nesting habitat. In one unusual instance on the south Umpqua in January 1992, a picnic area (Fig. 12) was being planted with small hardwood trees to increase shade. A USFS employee using a post-hole digger excavated 5 neonate/hatchling pond turtles while preparing to plant a small tree.

Eggs of the western pond turtle are approximately ovoid-elliptical in shape, ranging from 3242 mm in length and 20-25 mm in diameter. Weight ranges from 7 to 11 grams. The shells are off-white with a yellowish tinge when the egg is first laid, and tend to become "whiter" as the egg develops. The shell has a rough bone-china like texture. As previously noted, eggs incubated under moist conditions do not appear to develop or may crack during development due to uptake of water (Feldman, 1982). Incubation time in the lab may be as little as 60+ days (G. Collings, pers. comm.) and Feldman (1982) notes 73-80 days. Data from naturally incubated nests is scarce, but appears to indicate a range of time from approximately 90-126 days.

Hatchlings range from 23-3 1 mm carapace length and weigh 1.5-7 grams. All larger (28 mm +) hatchlings are known from the northern part of the range. The "umbilical" scar on the plastron is obvious for up to several months after hatching, but is generally indistinct after the first year. In southem and central California, some hatchlings may overwinter in the nest and some may leave the nest upon hatching in late summer-early fall. Available data on undisturbed nests in the northern portion of the range (northern California north) does not indicate that hatchlings leave the nest in this time period, although this may be in part due to the small sample size. Although data on hatchling emergence after overwintering in the nest is limited, records exist for early March (1992) at site OR 039 W and late February at a site in northern California (D. Reese, pers. comm.) Five hatchlings were accidentally excavated from a nest along the south Umpqua in February 1992. Essentially nothing is known of post-emergence movement of hatchlings until they appear in the watercourse. The possibility exists that western pond turtle eggs may undergo arrested development. One of a small sample of eggs recovered from nests in the Willamette in December 1993 held a live 10 mm embryo (C. Beal, pers. comm.). Depending upon whether or not this phenomenon is common, there may be very significant implications for management practices in certain areas.

Predation on turtle nests is a common occurrence, with reports of up to 97% of the nests in a given area being lost to raccoons (Christiansen and Gallaway, 1984). In some areas, predation on western pond turtle nests may exceed this figure and may be a primary factor in recruitment declines. Observations in Oregon in 1991 indicated that an estimated 90% of the nests at site OR 039 W were predated by raccoo ns and/or skunks. Similar and more extensive observations at several sites in the Willamette and Umpqua drainages in 1992-1993 confirm the general pattern. Of55 nests noted in the Umpqua in 1992,54 had been predated. Surveys of seventeen nesting areas in the Umpqua drainage in 1993 revealed evidence of predation on over 70 nests (all nests noted were predated). Of 34 nests discovered in the Fern Ridge area in 1992, all had been predated. Similar figures would undoubtedly exist for 1993, had not the COE engaged in an intensive effort to locate and protect nests with exclosures. Of32 nests discovered, 24 were protected and eight were predated. Extensive searches for hatchlings in 1993 at all known nesting areas at Fern Ridge totaling 4 1.5 hours yielded two hatchlings at one site. Based upon an average of seven eggs/nest, this yields a total of 224 eggs deposited in 1992 with estimated minimum survival rate of 0.84%. As such, previous estimates of the effective loss of 100% of the reproductive effort at these sites appear to be approximately accurate. Of 106 nests discovered throughout the range of the turtle in 1992,97 (91.6%) had been predated. Survey information indicates that the time between deposition of the eggs and the predation event may be very short, and in at least one case is known to be less than 12 hours. Rathbun et al. (1993) note a time of nine days post-oviposition for a predation event on a nest in central California. Observations from site OR 017 U in 1993 indicate that the time between oviposition and predation may be less than 24-48 hours. Data from studies on other species such as *Chrysemys picta* (Tinkle etal., 1981) indicate that the majority of nest site predation occurs within 48 hours of egg deposition. Nets that have been predated by raccoons and/or skunks typically display a "shotgun" pattern, where the nest hole is open and the remnants of eggshells are scattered - usually in a fan-like fashion, up to 1 - 2 m from the hole (Fig. 13, Fig. 14).

Known and suspected predators on western pond turtle nests are numerous. Known predators include coyote *(Canis latrans),* raccoon *(Procyon lotor)* and spotted skunk *(Spilogale putorius).* Suspected predators include opossum *(Didelphis* *virginianus),* red fox *(Vulpes fulva),* grey fox *(Urocyon cinereoargenteus),* raven *(Corvus corax),* common crow (Corvus *brachyrhynchos),* yellow-bellied racer *(Coluber constrictor),* gopher snake *(Pituophis melanoleucus),* common kingsnake *(Lampropeltis getulus)* and California mountain kingsnake *(Lampropeltis zonata).* It is also possible that small rodents such as gopher (*Thomomys* spp.) and various mice or microtines may prey on eggs, although evidence is lacking. Loss of eggs through invasion by plant roots or fungal hyphae may also occur, but definite evidence is lacking at this time. Observations at site OR 017 U in 1993 indicate that a racer may have predated at least one nest at this site, and kingsnakes in the eastern United States are well-known predators on eggs of various species of turtles. Red fox, an introduced species in many areas, are also well-known predators on turtle eggs.

One of several critical questions related to short- and long-term management of the western pond turtle is whether or not nest-site philopatry occurs. Nest-site philopatry is defined as the regular return of a female to a given nesting area, if not an approximate nest site.This phenomenon has been observed in *Emydoidea blandingii* (J. Congdon, pers. comm.), *Chrysemys picta belli* (Lindemann, 1992), *Graptemys ouachitensis* and *G. psuedogeographica* (Vogt and Bull, 1982).Observations and preliminary analysis of data from studies in the Willamette in 1991-1993 and the Umpqua in 1991-1994 indicate that western pond turtle nests are not randomly distributed within a nesting area, and nests noted in 1991 were often within a few meters of nests located in 1992, which in turn were often located within a few meters of 1993 and 1994 nests. However, as the identity of the females that produced these nests is not known, no definitive statement can be made at this point as to whether or not these observations represent true nest-site philopatry. The management considerations of this situation are important both in the short-term and the long-term, and several questions must be answered before a definitive and adequate protection effort can be formulated. Some of these questions would be: If existing nesting areas are altered or destroyed, do females possess the abiity to “switch” to other potential nesting areas? If so, what percentage of the females engage in this behavior? What is the relative nesting success of females in these two (or more) groups? What is the time frame over which this situation occurs? Does the situation vary between habitats or areas? Obviously, the ability to “switch” nesting areas must occur on some level (relative to evolutionary time) or the species would not occur over the range of areas and habitats that it presently occupies. However, it is important to consider that the spread of this species throughout its current range has probably occurred over the last 1.5-2 million years (Holland, 1992), and that the interaction of phenomena (such as selection) on ecological and evolutionary time scales often constrain many management options. The interactive situation with the population dynamics of spotted owls, habitat patch size, the nature and timing of disturbance, and potential ecosystem regeneration time frames is a classic example of this situation. Many of these considerations apply to other species. In western pond turtles, for example, if one female per generation has the ability to “switch” nesting areas, then to maintain a viable population of turtles in the long run under optimal conditions, the discovery, utilization and "fixation" of new nesting areas must occur at a more rapid pace than the alteration or elimination of existing nesting sites - in essence a “Red Queen” situation in an ecological time frame. Obviously other factors, such as the size of the population, fecundity, the extent and nature of nesting areas, and the relative proportion of females exhibiting nest-site philopatry would all interact and affect the outcome of the situation. On a related note, it is likely that historically nesting areas in many regions were probably established and maintained by periodic fires (see discussion in previous chapters) - in essencemaintaining the nesting area in an early successional stage. While fire suppression will undoubtedly accelerate advancement of succession in some areas, consideration must also be given to the extent and nature of "unmanaged" successional processes on a regional scale and their influence on metapopulation dynamics of turtles.

Another critical question is the potential interaction of the distribution, size and structure of nesting areas and their effect(s) on survival of nests. Temple (1987) has shown that for three species of turtles in Wisconsin, the likelihood of nest survival is directly related to distance from an ecological edge. Ten of twelve nests in this study located near (<50 m) an edge were destroyed, whereas only four of ten nests >50 m away from an edge were predated. At present, over 95% of all known nesting sites for western pond turtles are within 50 m of an ecological edge - usually a forest/grassland edge. Reitsma (1992) has indicated that an experimental test of the effect of density on predation rate in artificial quail nests yielded no statistically significant difference in predation levels among densities, but that there was a trend toward increased predation at the highest density. However, for a variety of reasons these results should be interpreted with caution. Determination of the effect of density and relative distance on frequency of predation in turtle nests - in particular western pond turtle nests - will be very difficult for a variety of reasons. However, from a management standpoint, this information is vital to the design of management and recovery plans for this species in a given area and as a whole.

At present, although the gross physiognomy of known nesting areas is apparently similar, a more detailed characterization will be necessary to identify both the general and site-specific characteristics not only within an area but across a wider region such as a drainage basin. For example, soils in known nesting areas appear to be generally compact and often have a significant clay or silt fraction - essentially a broad description of alluvium. However, the parent materials may vary significantly from region to region - the soils in nesting areas in the Umpqua may well have different characteristics than soils in the Willamette. Determination of characteristics such as density, compactness, porosity, seasonal water-holding capabilities, age and associated vegetation (among others) will produce not only valuable short-term management information, but may also guide long-term efforts to restore or potentially create nesting areas in sites where they do not presently occur. Furthermore, as an extensive data base already exists on the distribution of soil types (and in some cases vegetative associations), integration of this information with known nesting area characteristics would facilitate determination of the extent and location of both major and minor nodal areas for a plan to recover the species.

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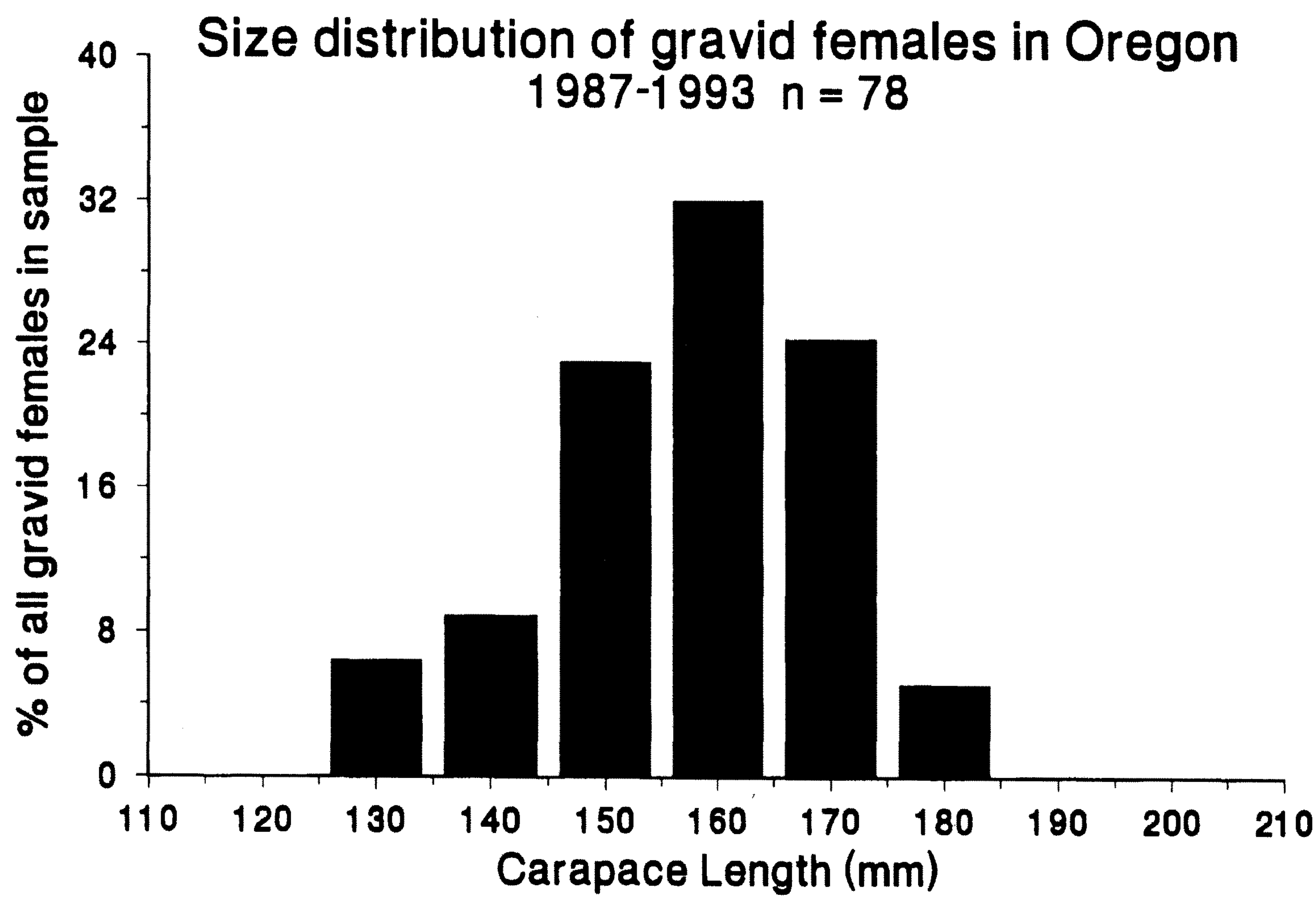

Figure 1: Size distribution of gravid females captured in Oregon 1987-1993.

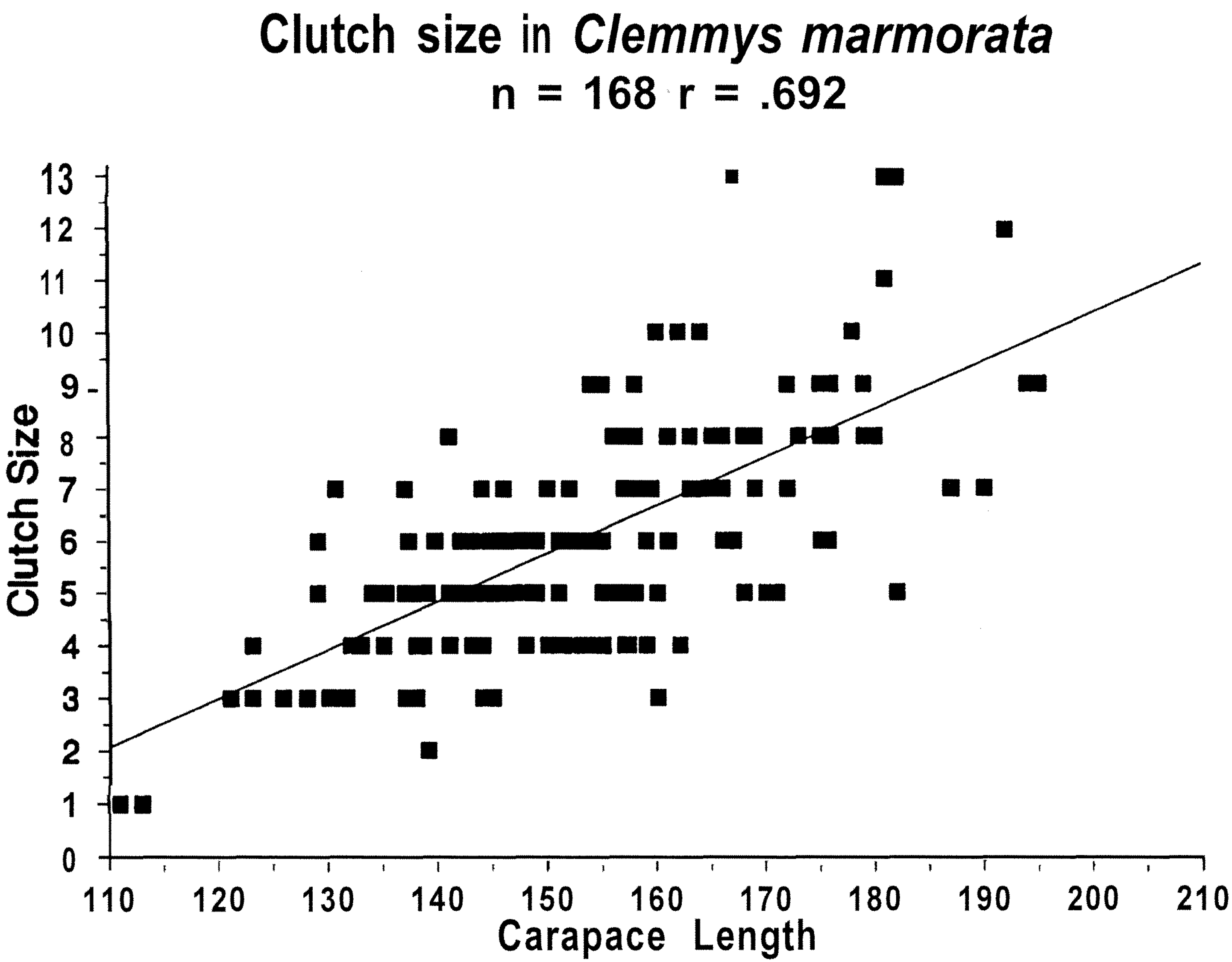

Figure 2: Clutch size in the western pond turtles.

Figure 3: "False scrape" (nest. with no eggs), excavated by female turtle in June 1992. Lane County, Oregon. (Site OR 039 W)

Figure 4: Female western pond turtle excavating nest in June 1992. Lane County, Oregon, (Site OR 039 W)

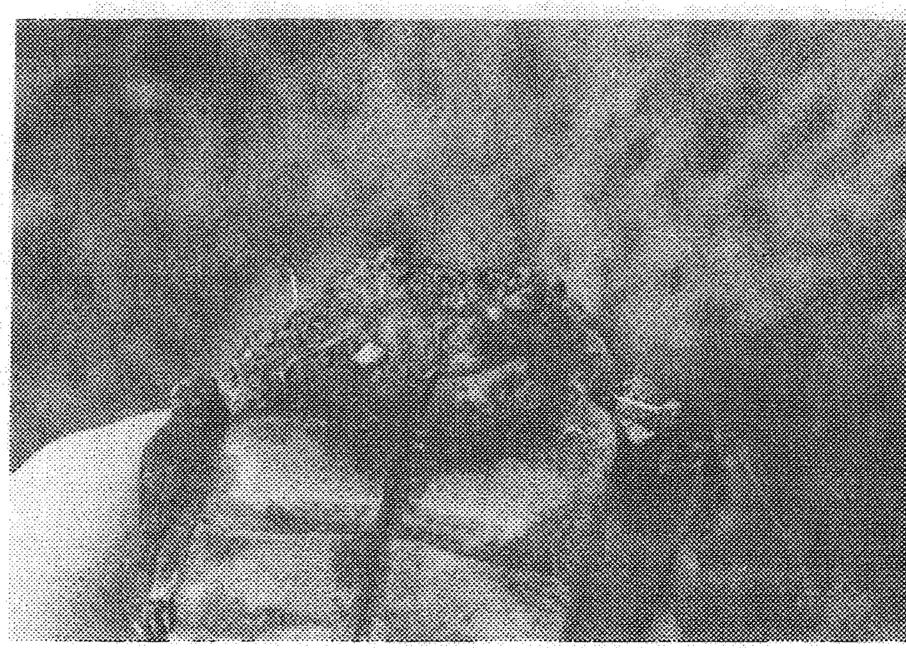

Figure 5: Female western pond turtle after excavation of nest. Note mud caked on anal shields and hind limbs, Lane County, Oregon. (Site OR 039 W)

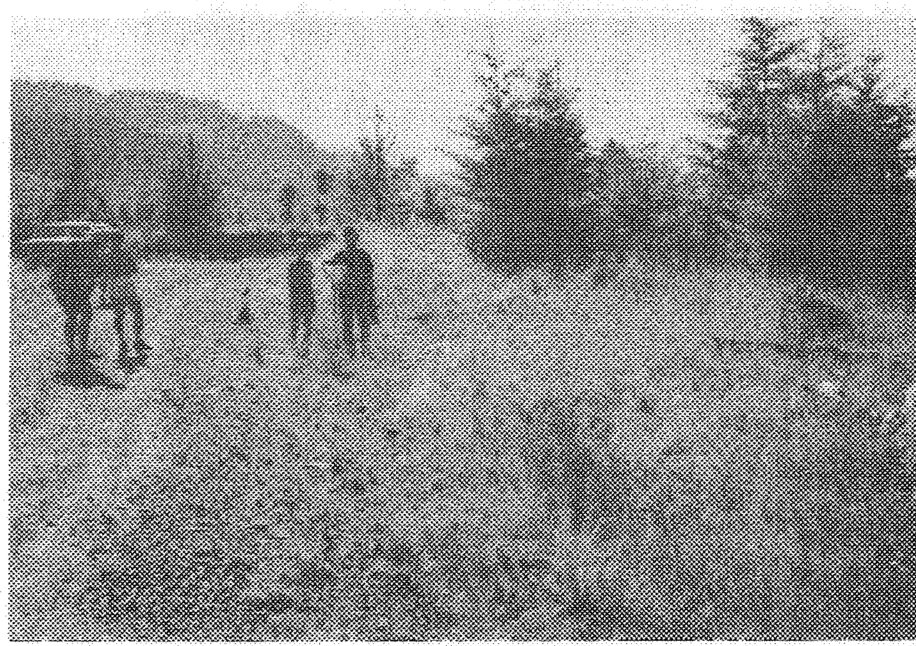

Figure 6: Nesting area (to right of road) at Site OR 039 W in June 1992. Lane County, Oregon.

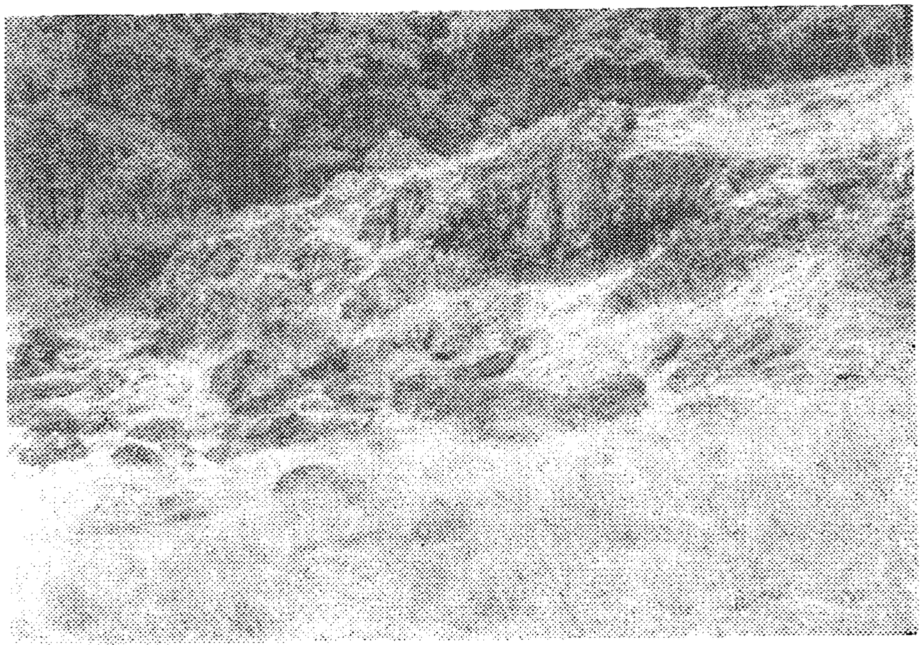

Figure 7: Nesting area at Site OR 017 U (grassy area above rocks and at base of rocks). Douglas County, Oregon.

Figure 8: Nesting area at Site OR 039 W (immediately east of road). bane County, Oregon.

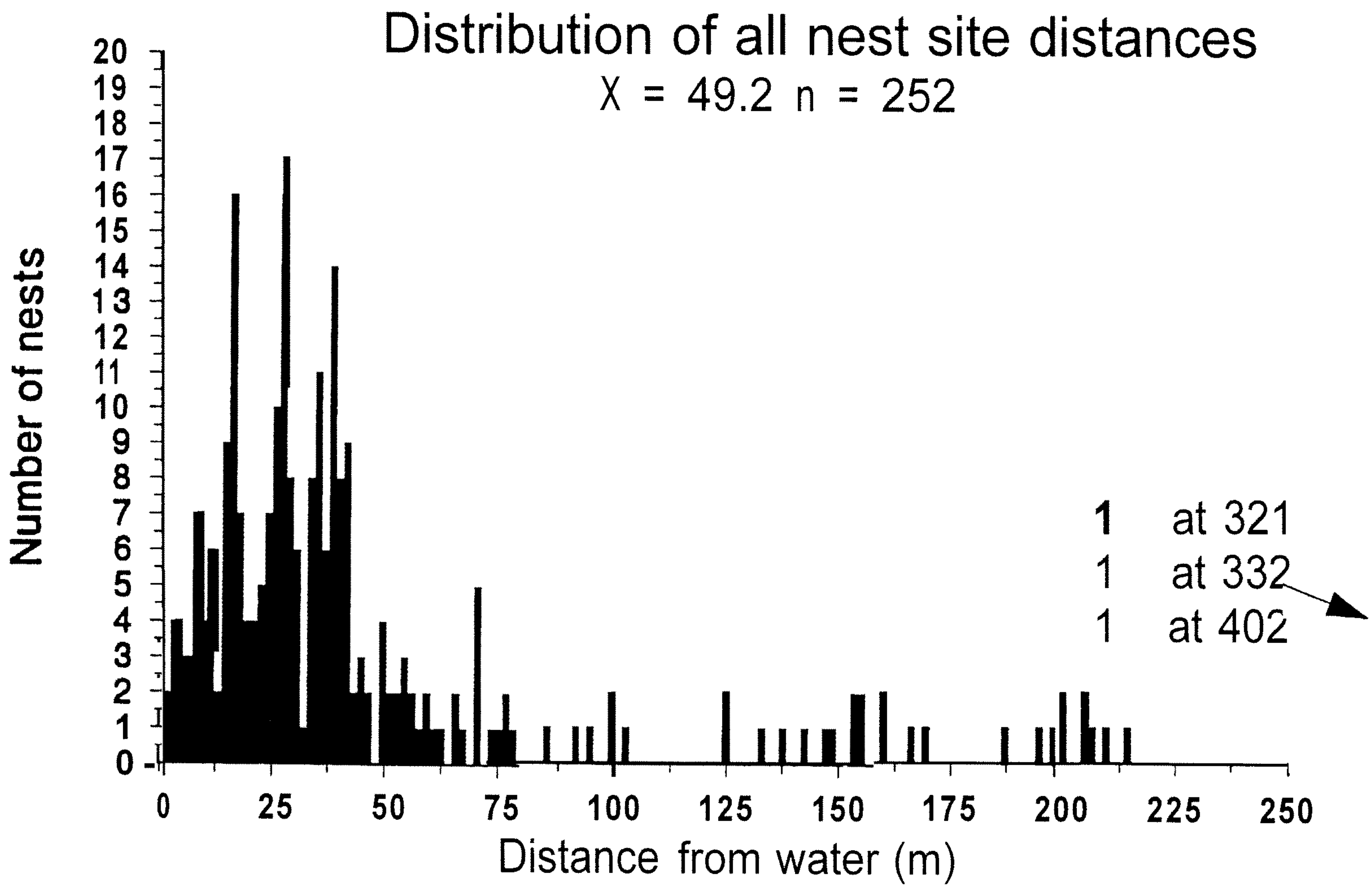

Figure 9: Distribution of rangewide nest site distances in the western pond turtle.

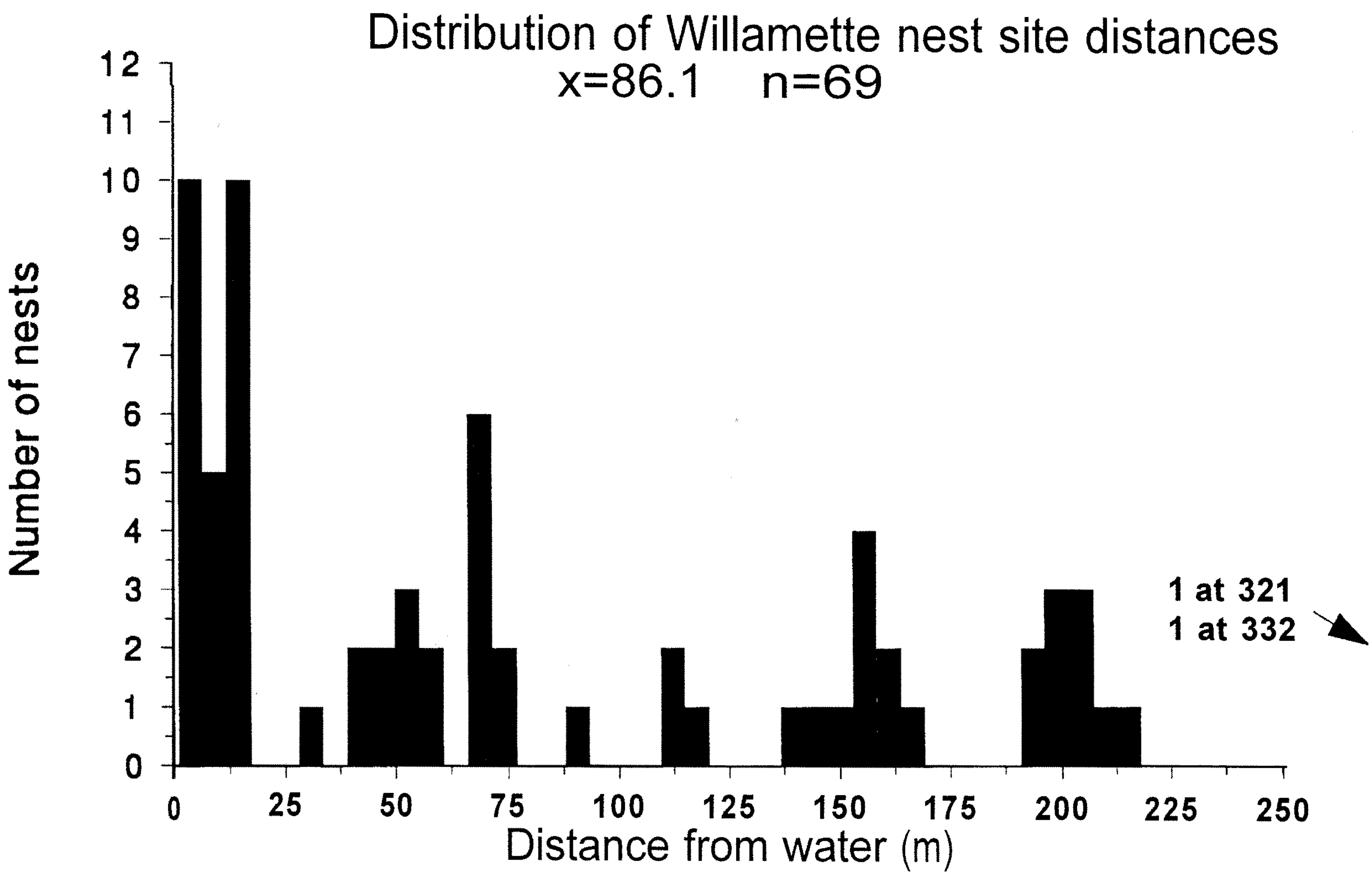

Figure 10: Distribution of nest site distances in the western pond turtle from the Willamette drainage, Oregon.

Figure 11: Typical western pond turtle nesting area along the south Umpqua River in 1994. Note sparse grassy vegetation. Douglas County, Oregon.

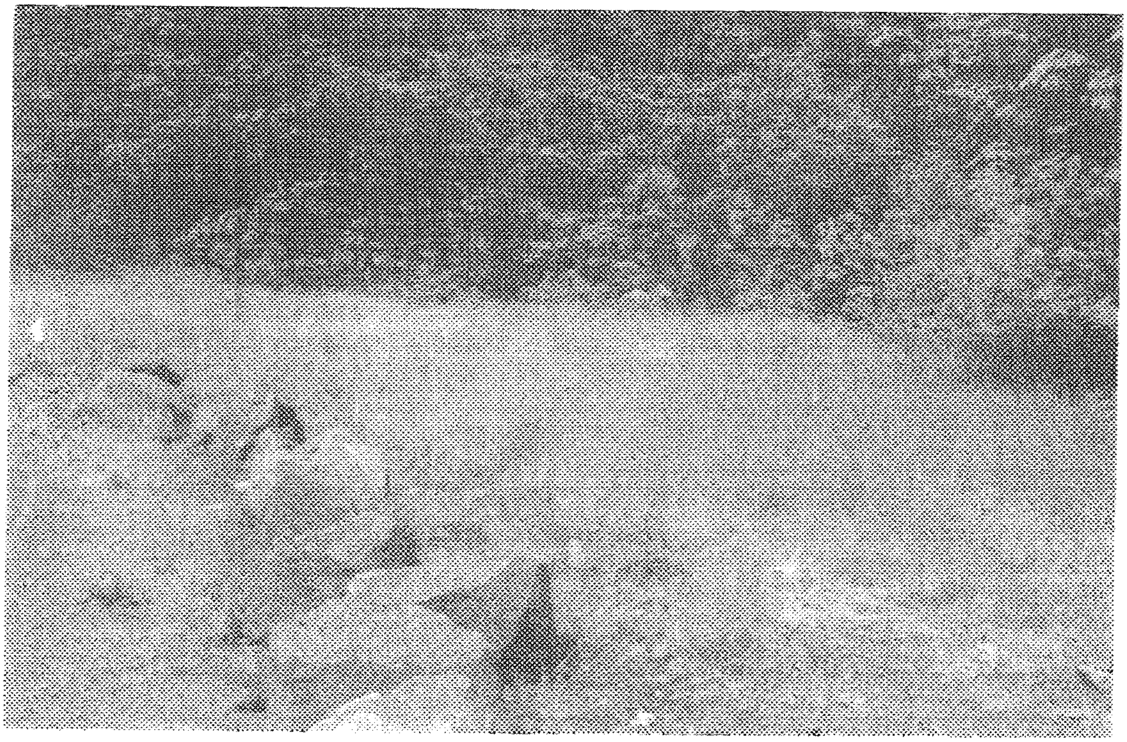

Figure 12: Site of excavated overwintering hatchling western pond turtles along south Umpqua River, Douglas County, Oregon.

Figure 13: Typical appearance of excavated and predated western pond turtle nest, South Umpqua River, Douglas County, Oregon.

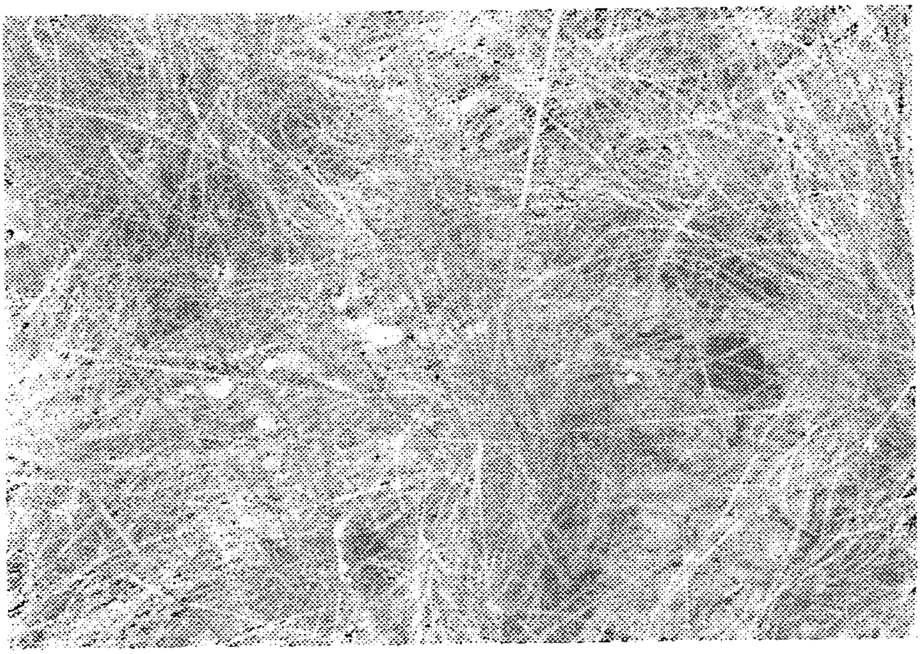

Figure 14: Typical appearance of excavated and predated western pond turtle nest. South Umpqua River, Douglas County, Oregon.

CHAPTER 6

Description of Study Sites

Description of Study Sites

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Description of Study Sites

The study sites utilized in this project were chosen to represent the range of habitats known to be utilized by western pond turtles and to attempt to gain insight into potential differences in movement and population structure among these sites. Because of the sensitive nature of this information presented here, exact site locations are not described.

Site CA 010 K - This site, classified as a riverine, upper perennial system under USFWS classification (USFWS, 1979) is located in northwestern California. The study area was located along a 2.4 km stretch of this system. The system averages 20-30 m in width, and consists of a series of pools, glides, riffles and small rapids. The substrate is a mixture of rock, cobble, silt and sand. Riparian vegetation along this stretch is relatively undisturbed, with dominant tree species consisting of white alder *(Alnus rhombifolia),* yellow willow *(salix lasiandra).* Upland species include Douglas Fir *(Psuedotsuga menziesii),* ponderosa pine *(Pinusponderosae),* madrone *(Arbutus menzieseii)* and black oak *(Quercus kelloggii).* Understory elements include poison oak *(Toxicodendron diversiloba),* manzanita *(Arctostaphylos* spp.) and blackberry *(Rubus* spp.). Turtles are most common in pool habitats, but may occur in many areas depending upon flow regimes. Turtles in this system are frequently found in "backwater" areas or side channels, which may or may not be connected to the main stem of the river most of the year. The turtle population in this system is essentially continuously distributed within this system, although densities may vary significantly from area to area.

Site CA 014 K - This site, classified as a riverine, upper perennial system under the USFWS classification (USFWS, 1979) is located in northwestern California in the same hydrographic basin as Site CA 0 10 K. The study area was located along a 3.5 km stretch of a perennial second-third order stream. This stream averages less than 10 m in width and consists of a series of pools and riffles. The pools are generally of moderate depth, averaging 2-3 m in most places. Current velocity is low, averaging l-2 kph. The substrate is a mixture of rock, cobble, silt and sand. Riparian vegetation along this stretch is relatively undisturbed, with dominant tree species consisting of white alder *(Alnus rhombifolia),* yellow willow *(Salix lasiandra).* Upland species include Douglas Fir *(Psuedotsuga menziesii),* ponderosa pine *(Pinusponderosae),* madrone *(Arbutus menzieseii)* and black oak *(Quercus kelloggii).* Understory elements include poison oak *(Toxicodendron diversiloba),* manzanita *(Arctostaphylos* spp.), deerbrush *(Ceanothus* spp.) and buckthorn *(Rhamnus* sp.). As in the larger system, turtles are most common in pool habitats but have been found in all areas of the stream. The turtle population in this area is continuously distributed within this drainage, and densities in this system represent the upper end of the spectrum, often over several hundred animals/ha of water surface. Representative sections of this site are shown in Fig. 1 and Fig. 2.

Site OR 002 U - This site would probably be classified as a lacustrine, limnetic system under the USFWS classification (USFWS, 1979. Although the size (2 ha) does not fit into this category, it meets all other criteria, This system is a lake, approximately 2 ha in size, located in the Cascade Range in central Oregon. This system represents a former wetland formed by beaver activity that was enlarged by construction of a dike, resulting in an estimated doubling or tripling of its former size. Maximum water depth at high water exceeds 4 m, and the majority of the system is over 2 m in depth. The substrate is a mixture of fine silts and decaying vegetation. The lake typically freezes over in the winter, but patches of open water are typically present by February or March. Surrounding vegetation is a mixture of old growth and mature second growth, with Douglas Fir *(Psuedotsuga menziesii)* being the dominant species. Aquatic vegetation is abundant in the lake, with pond lilies *(Nuphar* sp.), *Potamogeton* sp., and *Lemna* covering an estimated 60-80% of the lake surface by late summer. This lake is the largest of several lakes and ponds in the area, and this metapopulation probably constitutes the largest remaining population of western pond turtles in a limited area in Oregon. Turtles are known to utilize the entire lake and move overland between the different watercourses in this system. Representative portions of this site are shown in Fig. 3 and Fig. 4.

Site OR 017 U - This site would be classified as a riverine, upper perennial system under the USFWS classification (USFWS, 1979). The study site is a 1 km stretch of the river and is located in a drainage in the central Cascade range. This stretch averages just over 10 m in width and consists of a series of pools, riffles and small rapids. The depth of the pools varies from 1 to over 7 meters. The substrate is a mixture of rock, cobble, and small amounts of sand. Little or no emergent vegetation is present along the shore. The riparian fringe is thin and consists of occasional white alder *(Alnus rhombifolia)*. The upland vegetation is a mixture of old growth and mature second growth elements, with occasional patches of black oak *(Quercus kelloggii)* and madrone *(Arbutus menziesii)*. . Turtles are continuously distributed throughout the majority of this drainage, but in varying densities. In this area, turtles are known to make extensive use of upland habitats for overwintering and possibly summer dormancy. Representative sections of this site are shown in Fig. 5 and Fig. 6.

Site OR 050 U - This site would probably be classified as palustrine under the USFWS classification (USFWS). The study area is located in the central Cascade range and consists of two small (1200 and 3000 square meters) ponds created by the USFS in the late 1980s. The upper pond (Pond B) in this system is spring-fed and the water level remains relatively constant. Pond depth varies, but most of the ponds are shallow (<1 meter) and the deepest portion is slightly less than 2 meters. These ponds typically freeze over in the winter, but have open water in some areas by February or March. The substrate is a mixture of mud and decaying vegetation, and averages slightly over 1 m in depth. This site is located in a clear-cut and the vegetation at present consists primarily of a brushy understory with small conifers in the process of regenerating. In time, it is likely that this will return to an old-growth system. These ponds at present have a few willows *(Salix* sp.) around the edges, and a cattail *(Typha* sp.) fringe may be in the process of developing. Relatively few rooted macrophytes are present, but this may be due in part to the age of the system. Turtles were translocated to this system in 1992 and 1993, which is estimated 20+ km from the nearest naturally occurring population. These two ponds are shown in Fig. 7 and Fig. 8.

Site OR 039 W - This site would probably be classified as palustrine under the USFWS classification (USFWS, 1979). The study area is located in the upper end of the Willamette drainage in the central Cascade range and consists of a small (est. 1200-1400 square meters) pond. Pond depth varies, but almost all of the system is less than 1 m deep. The substrate is a mixture of silt, mud and decaying vegetation. This pond typically freezes over in the winter, and often dries by late August. The pond is located in the middle of a clear-cut, and the surrounding vegetation is a mixture of shrubs and early-growth conifers. Small patches of willows *(Salix* sp.) are present on the north and east shores, and a few large black cottonwoods *Populus trichocarpa)* occur on the fringes. Emergent vegetation, primarily cattail *(Typha* sp.) cover an estimated 60-70% of the water surface and form an effectively impenetrable mat in much of the area. The origin of the turtles at this site is unclear; some anecdotal evidence indicates that they may have been translocated to this site by native Americans passing between the Umpqua and Willamette drainages. However, turtles are known from within a few kilometers of this site in the Willamette drainage, and turtles move back and forth between this pond and a nearby perennial stream and thus this population may be naturally-occurring. Representative areas of this site are shown in Fig. 9 and Fig. 10.

Site OR 082 W - This site would be classified as lacustrine, limnetic and littoral under the USFWS classification (USFWS, 1979). This is a reservoir site located on the middle fork of the Willamette River and covers 1664 ha. Water depth varies with reservoir level, but averages over 2 m for most of the study area. The substrate is a mixture of inundated solid, silt and rock. Ice may form in sheltered areas during the winter, but the entire system does not freeze over. Aquatic vegetation is scarce, consisting of occasional patches of rooted macrophytes. Along the shore reed canary-grass *(Phalaris arundinaceae)* is a common dominant. Upland areas are modified to various degrees by timber harvest, recreational activities and development but probably consisted of a mixture of riparian, oak woodland and old-growth elements prior to inundation by the waters of the reservoir. Current dominants include Douglas fir *(Psuedotsuga menziesii)* and occasional Oregon oak *(Quercus garryana).* Turtles are patchily distributed in this system, occurring most commonly around the "bays" of the reservoir where small streams drain into the system.

Site OR 097 W - This site would be classified as lacustrine, limnetic and littoral under the USFWS classification (USFWS, 1979). This is a reservoir site located on a tributary of the Willamette and covers 4137 ha at full pool. Water depth varies with reservoir level, but averages over 2 m for much of the study area. However, there are extensive shallow-water (<1 m) areas in the study area as well. Ice may form in sheltered areas during the winter, but the entire system does not freeze over. The substrate is largely mud or decaying vegetation. Aquatic vegetation may be locally abundant, with some areas displaying extensive beds of cattail *(Typha* sp.) and bulrush *(Scirpus acutus)* The most abundant vegetation is extensive beds of reed canary-grass, which covers dozens of hectares in the area of the study site. Upland vegetation consists of a mixture of bottomland forest dominated by Oregon Ash *(Fraxinum latifolia),* with encroachment by conifers such as ponderosa pine in many areas. Large Oregon oaks are present along some river channels in older alluvial soils, and shrubs consist a mixture of native elements such as wild rose (Rosa sp.) and exotic species such as Himalayan blackberry *(Rubus discolor).* Turtles are patchily distributed within this system, often in sheltered areas where the reservoir joins with the smaller drainages that feed it. Representative portions of this area are shown in Fig. 11 and Fig. 12.

Site OR 103 W - This site would be classified as lacustrine, limnetic and littoral under the USFWS classification (USFWS, 1979). This is a reservoir site located on a tributary of the Willamette and covers 736 ha at full pool. Water depth varies with reservoir level, but averages over 2 m for most of the study area. Shallow-water areas are typically limited to the arms of the reservoir, as with Site OR 082 W. The substrate consists of mud, silt, inundated soils and some decaying vegetation. The surrounding upland habitat is similar to Site OR 082 W. As with this system, turtles are patchily distributed in the smaller "bays" along the reservoir arms.

Site OR 163 W - This site would be classified as riverine, lower perennial under the USFWS classification (USFWS, 1979). The study site is located in the Willamette drainage and consists of an approximately 6-8 km stretch of a third-fourth order perennial stream. Stream width averages approximately 10 meters, and the channel is moderately to extremely sinuous. The substrate is mud and silt, with numerous downed logs both in the substrate and channel. The average water depth varies seasonally, but approximates l+ m. The deepest portions of the stream are slightly over 2 m in depth. This system flows through a mature gallery forest, and many parts of the stream are shaded for much of the day. As such, aquatic vegetation is scarce. The gallery forest is dominated by Oregon Ash, although other typical bottomland elements occur. Adjacent upland areas are a mixture of native grassland, oak woodland and mixed conifer forest. Turtles are patchily distributed along this system, often concentrated in areas where breaks in the riparian canopy allow sunlight to penetrate to basking sites.

Site OR 001 C - This site would be classified a lacustrine, littoral under the USFWS classification (USFWS, 1979). The study site is an artificial pond that resulted from the damming of a stream below a probably ephemeral wetland. This has resulted in the development of a pond which holds permanent water. The pond covers approximately 6400 square meters and averages approximately 2 m in depth. The substrate is silt, mud and some decaying vegetation. Water level fluctuates an estimated 0.5 m seasonally. There is a moderately thick (1.5 m) band of emergent vegetation, primarily cattail and bulrush, around an estimated 85-90% of the perimeter of the pond. Adjacent upland areas are a primarily an oak grassland, with dominants consisting of Oregon oak and ponderosa pine. Scattered black cottonwoods and willows occur on the perimeter of the pond. turtle make year-round use of this system, and also move between this area and adjacent ephemeral and permanent watercourses. Representative portions of this site are shown in Fig. 13 and Fig. 14.

West Eugene Site(s) - These sites are described in reports produced by ODOT consultants (CH2M Hill, 1994; Fishman Environmental Services, 1994). This area consists of a series of altered wetland habitats, both artificial and natural, connected by a series of altered watercourses and drainage canals. The largest site (Golden Gardens) is a borrow pit several hectares in size. Danebo pond is a shallow-water wetland dominated by exotic vegetation, and Bertelsen Pond is a created pond an estimated 0.3 ha in size. Finn Pond is a very small borrow pit <1000 square meters in size. Several of these areas are connected by a series of drainage ditches and altered natural watercourses (such as Amazon Creek). Although the area is dominated by exotic vegetation such as reed canary-grass *(Phalaris arundinceae),* the vegetation consists of a mixture of native and introduced elements. Trees are generally scarce, but occasional small willows *(Salix* sp.) and larger cottonwoods occur in the area.

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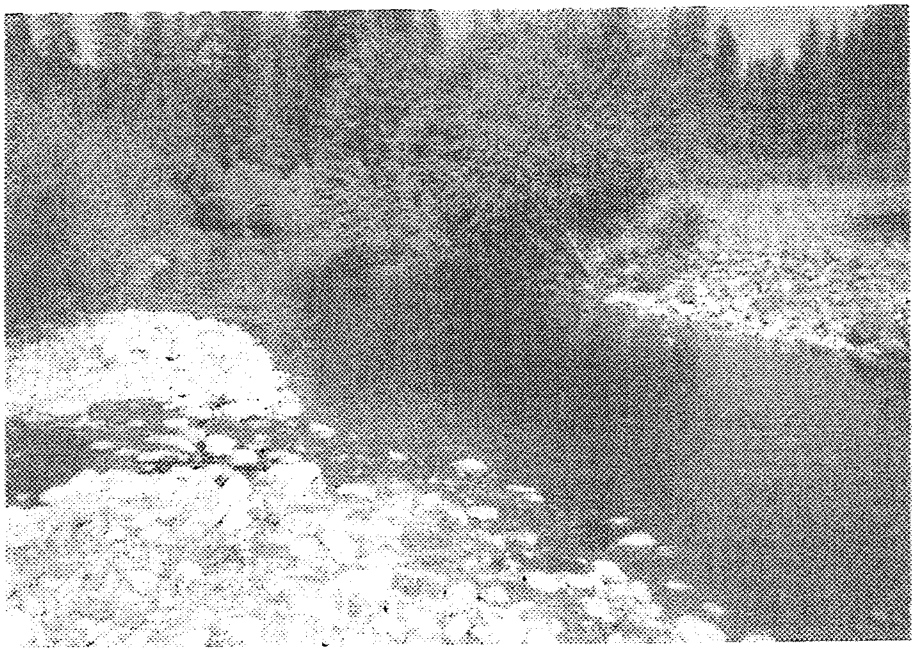

Figure 1: Pool 4 D area, Site CA 014 K, Trinity County, California.

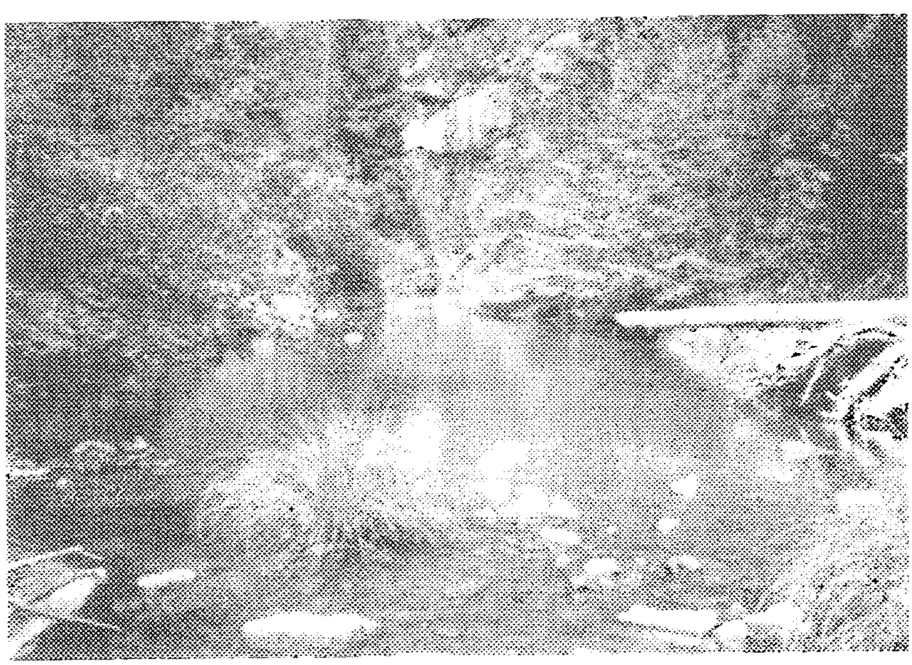

Figure 2: Pool 22 U area, Site CA 014 K, Trinity County, California.

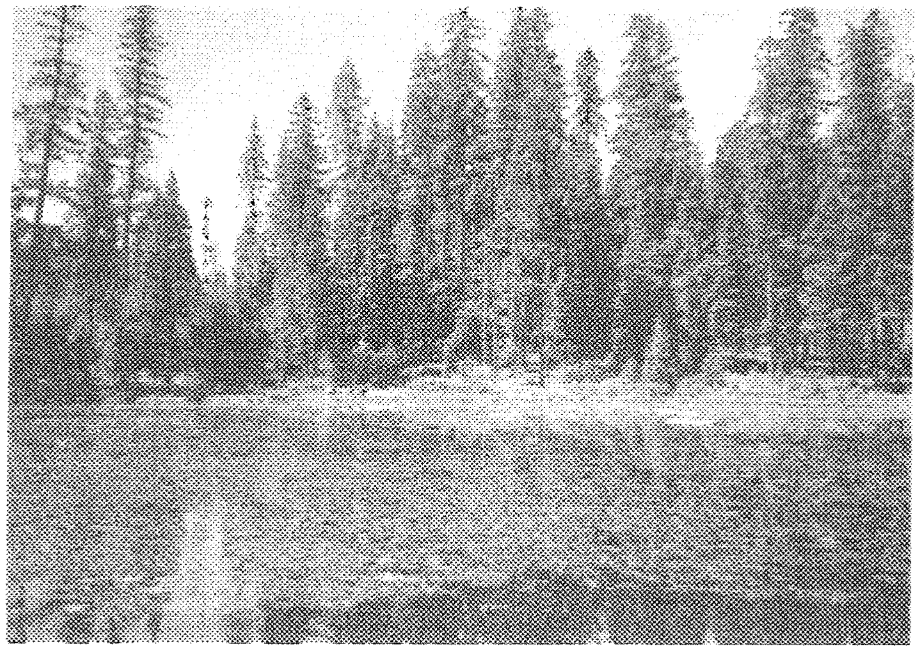

Figure 3: Site OR 002 U, looking west Boughs County, Oregon.

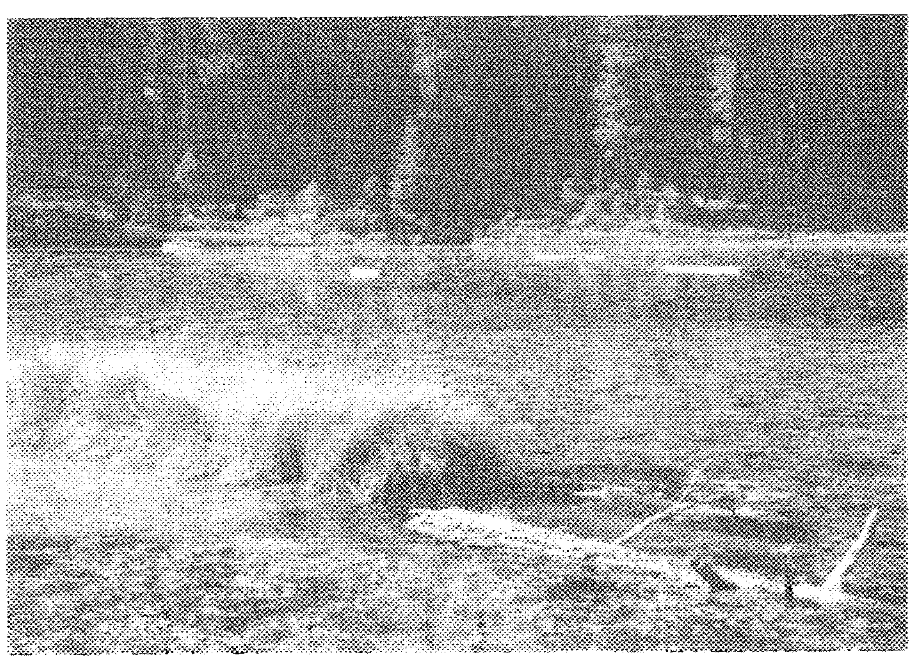

Figure 4: Site OR002 U, looking northwest. Douglas County, Oregon.

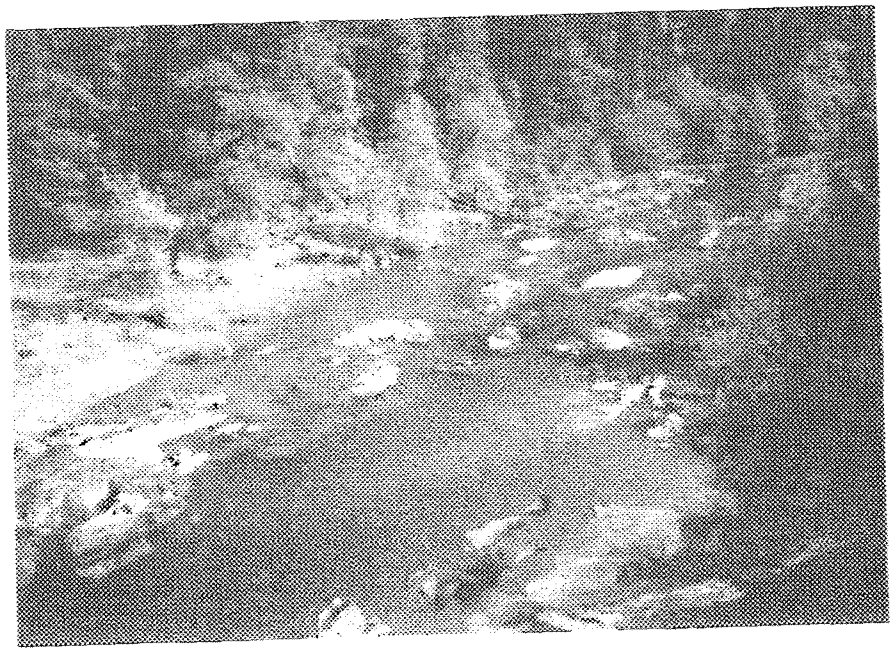

Figure 5: Site OR 017 U, looking downstream. Douglas County, Oregon.

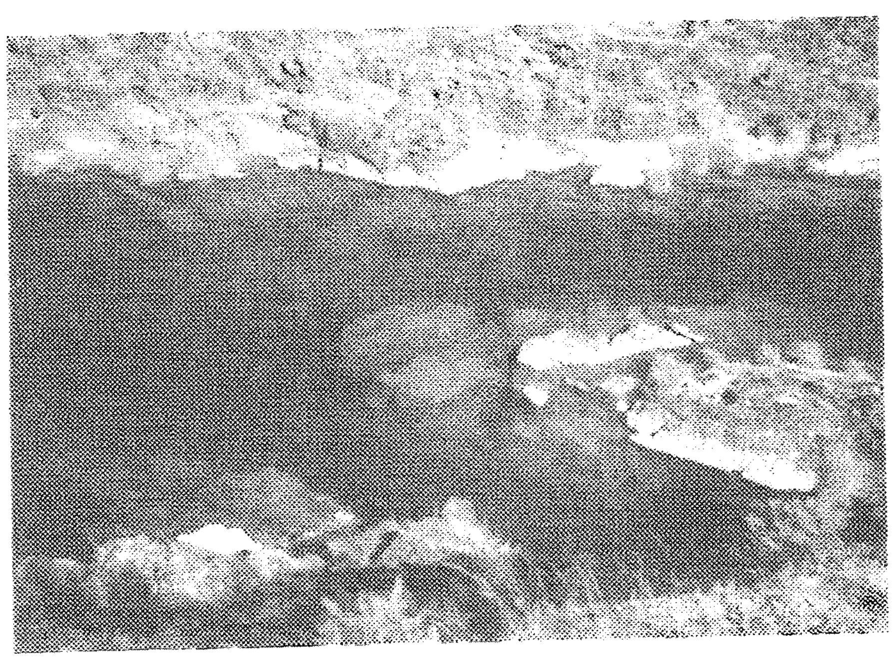

Figure 6: Main pool at Site OR 017 U, looking approximately east. Douglas County, Oregon.

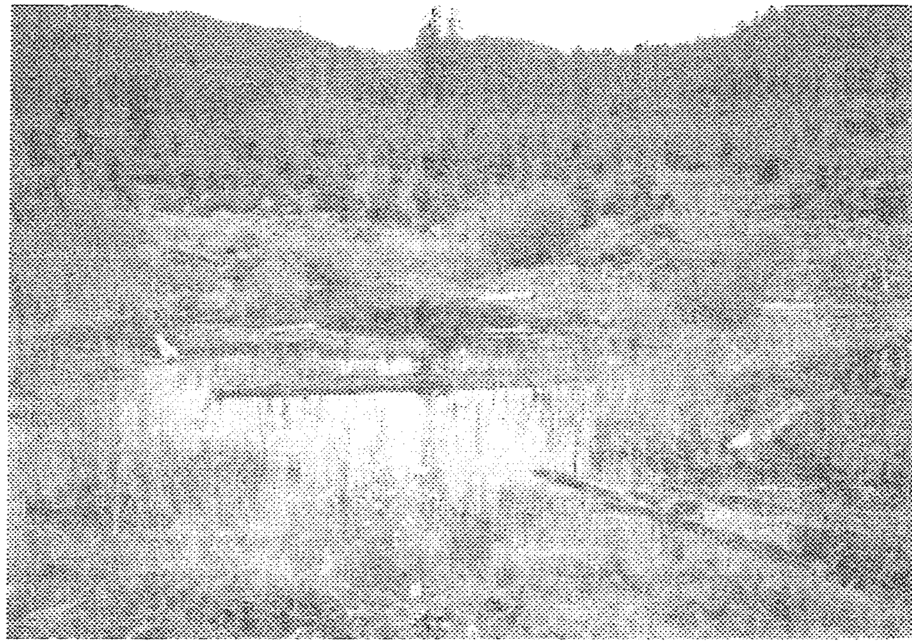

Figure 7: Pond A at Site OR 050 U, looking northeast. Douglas County, Oregon.

Figure 8: Pond B at Site OR 050 U, looking west. Douglas County, Oregon.

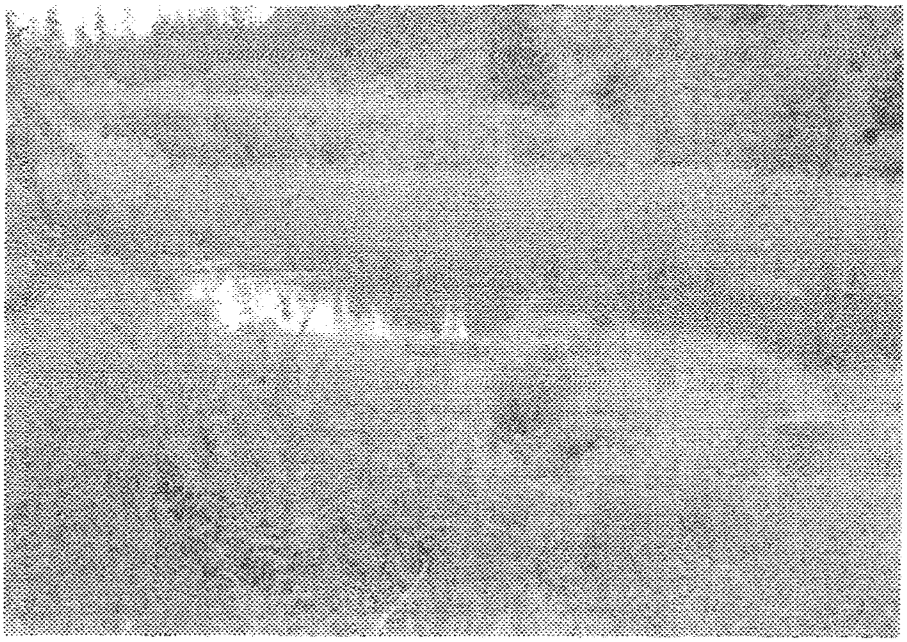

Figure 9: Pond at Site Or 039 W, looking approximately northwest. Lane County, Oregon.

Figure 10: Pond at Site OR 039 W, looking approximately east. Lane County, Oregon.

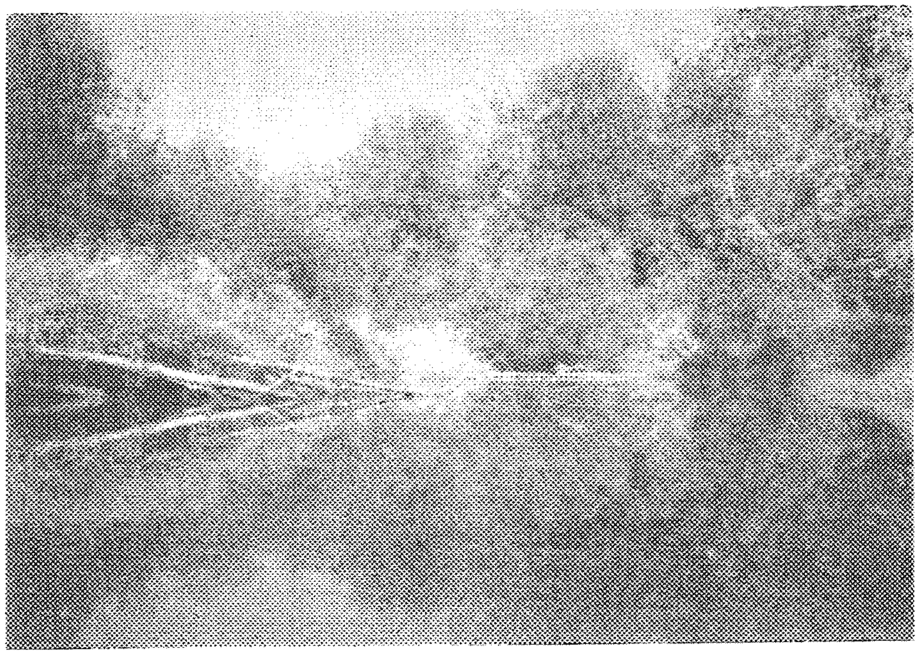

Figure 1 1: General area of Site OR 097 W, looking west/southwest. Lane County, Oregon.

Figure 12: General area of Site OR 097 W, looking west. Lane County, Oregon,

Figure 13: Pond at Site OR 001 C, looking west in late winter. Wasco County, Oregon.

Figure 14: Pond at Site OR 001 C, looking east in late winter. Wasco County, Oregon.

CHAPTER 7

Aquatic Movements of the Western Pond Turtle

Aquatic Movements of the Western Pond Turtle

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Introduction

The daily, seasonal and long-term movements of a species within a given area constitute an important part of its natural history. For western pond turtles, these movements are often tied to foraging, thermoregulatory and/or reproductive behaviors, response to changing environmental conditions and/or a variety of other factors. From the standpoint of management considerations, determination of the extent, frequency and nature of movements of individuals is of critical importance in formulating practices and strategies designed to maintain and/or enhance populations. As described elsewhere in this report, western pond turtles not only make extensive use of aquatic habitats, but are tied to terrestrial habitats as well. The observations and interpretations discussed below focus primarily on movements within a variety of aquatic habitats in Oregon in 1992-1 994 and northern California in 1992-1993.

Methods

Movements of western pond turtles were monitored at a total of seven sites in 1992 and eight sites in 1993 (see previous chapter). Turtles were monitored at 3 sites during 1994. Studies at sites CA 010 K and CA 014 K were conducted in cooperation with the United States Forest Service, with the United States Army Corps of Engineers at sites OR 103 W, OR 097 W and OR 082 W , and with the United States Fish and Wildlife Service and US Forest Service at site OR 002 U, the USFS at Site OR 050 U and the USFWS at site OR 163 W. Studies at sites in the west Eugene area were conducted co-operatively with the Oregon Department of Transportation. Turtles were equipped with small directional transmitters operating on a frequency on 148 Mhz (one site in California) or 150-152 Mhz (sites in Oregon). The transmitters had a straight-line range under optimal conditions of slightly more than 400 m. However, normal signal range was 200-300 m. Signal attenuation was apparent in many circumstances, and ranged from slight to total. This problem was most noticeable in conditions where water turbidity was high or the habitat was rocky (such as in sites OR 017 U and CA 014 K). In several cases, loss of signal occurred for extended periods of time when the animal swam into an area where a large rock mass blocked or attenuated the line-of-sight signal. To facilitate tracking efforts, transmitters were dipped in a colored plastic coating ("Plasti-Dip"®) which allowed for identification of individuals without recourse to use of the receiver. This technique allows for validation of telemetry results by visually locating the animal and cross-checking the telemetry location (as determined by the signal received). Because battery life in the receiver is limited (typically ten to twelve hours of use between charges), this method allows for location of some animals without using the receiver. All animals so marked were identified by a two or three color code in field notes. Colors were "read" from the anterior end of the carapace to the posterior end, thus a transmitter package dipped in black and then partially re-dipped in green was read as "Green-Black" and entered in the field notes as G/BK. Colors used were Blue, Green, Yellow, Red and Black, yielding several possible combinations. Two caveats are worth noting for possible future studies. First, bright primary colors (such as yellow or red) should only be used in areas where visually oriented predators (such as river otters) do not exist. These colors may make the animal more conspicuous and thus more likely to suffer predation. Second, color combinations should be carefully chosen. Observations in the field indicate that the blue color used tends to fade over a period of several months and resembles green. Possible confusion as to the identity of a given animal can be avoided by judicious arrangement of the colors used on the transmitters. Another consideration is the use of small amounts of primary colors to increase the range of options on transmitter identification and decrease the general visibility of the transmitter package. For example, "Blue-Red Dot" was a gravid female with a blue transmitter package with a small (fifteen mm diameter) red dot on the dorsal surface of the battery. Transmitters were attached with a variety of adhesives, only two of which proved satisfactory. Use of fast-setting (five minute) and medium setting (two-hour) epoxy (varieties commonly available) resulted in the loss of transmitters at several sites. Although the exact mechanism is unknown, the epoxy often degrades to a gel/rubber-like consistency over a period of several weeks to a few months, and often becomes partially or completely dislodged from the carapace of the turtle. We used both dental acrylic and a commercial epoxy mix (PC-78) to attach transmitter packages. Of the two, dental acrylic is the preferred material due to its rapid setting time (less than ten minutes under warm conditions). This allows for minimum handling time and thus presumably minimizes stress on the animal. The compound produces a small amount of heat when setting and curing, and to minimize stress on the turtle the animal should be placed in a bucket or other container with fifteen to twenty mm of water to serve as a heat sink. While use of PC-7®allows greater flexibility in terms of short-term repositioning of the transmitter package and antenna, a disadvantage is the extended time required for the compound to set and cure (over 24 hours in some instances), thus extending handling time and stress on the animal. It should be noted that the color of the adhesives vary and need to be considered in relation to the conspicuous nature of the telemetry package. PC-78 is and dries grey, and the dental acrylic is pink. We coated the PC-78 mounted packages with black Plasti-Dip® to "blend" with the dark color of the carapace. For the dental acrylic, we mixed a dark powder (powdered watercolors or similar material) to achieve an overall dark grey.

The transmitter package consisted of the transmitter, battery and antenna. The entire unit weighed approximately twelve to fifteen grams and was attached to the carapace. The "battery" end of the package was oriented to the anterior end of the carapace, and the package was mounted approximately in the position of the 3rd (middle) vertebral shield. This arrangement was chosen to minimize the possibility of interference with mating or other activities, and to minimize any changes in the center of gravity on the animal. Other arrangements designed to minimize drag (such as mounting on the fourth or fifth vertebral) were considered to be inferior to the arrangement used. Antenna length and mounting arrangement on some transmitters used in this project changed between 1992 and 1993. Transmitters used in 1992 were equipped with a 20 cm antenna attached by use of fast-setting epoxy, and later PC-7®. The mounting arrangement generally followed the mid-dorsal line from the transmitter (3rd-4th vertebral) posteriorly to the mid-point of the fifth vertebral and then curved right or left and followed the general contour of the carapace between the lateral edge of the costals and the medial edge of the marginals. Except on very large animals (>170 mm), this arrangement led to the antenna extending around 50-70% of the perimeter of the carapace. This arrangement proved unsatisfactory for a variety of reasons. First, because of the degradation of the adhesive, several instances were observed of the antenna coming loose and all or a portion being exposed outside the adhesive. In at least two and possibly three cases (two at site OR 050 U, one possibly at site OR 002 U), this led to the entanglement of the turtle in aquatic vegetation and its subsequent mortality. To rectify this situation, several changes were made. First, the material used as an adhesive was changed in 1993. Second, all new transmitters ordered were equipped with a four or eight cm antenna to minimize problems with attachment. Third, existing transmitters with the 20 cm antennae were rebatteried and the antennae wrapped helically around the package in the adhesive such that no part of the wire was exposed. Although this decreases the range over which the signal can be received, the possibility of entanglement is dramatically decreased. Only one instance of protrusion of a portion of the antenna has been noted since these measures were taken, a reduction of over 90% from the previous year. The general arrangement of the antenna around a majority of the perimeter of the carapace was also unsatisfactory because of the amount of the adhesive required to completely cover the unit. In some cases, it was estimated that the weight of the telemetry package was increased by 40-60% by this factor. Total package weight in these situations was 20-24 grams, which approached the generally accepted limit of five to seven percent of the animals mass.

Battery life was rated at approximately twelve months; however in at least four cases transmitters were still functional up to seventeen months after initial attachment. The failure rate of transmitters approximated ten percent and did not seem to follow any set pattern. Batteries were replaced on most units (where the animals could be captured) and transmitter packages reattached between June and October 1993. Transmitter pulse rate was preset at the factory for each unit, and typically varied between 60 and 80 pulses/minute among a set of units. Although transmitter frequencies were generally identical to specifications supplied by the vendor, in several cases frequency drift over a range of one to four kHz was observed. Intermittent and atypical operation of a few units was noted, and failure of the unit was in some cases preceded by a continuous signal (a whine-like noise without pulses).

Three brands of receivers (AVM, Telonics and Wildlife Materials) were utilized in this study. Although reception range and quality were similar between these units, most of the technicians felt that the bulk and size of the AVM unit was a considerable inconvenience in many areas, and preferred the Telonics and/or Wildlife Materials units. On the other hand, the factory supplied H antennae with the Telonics unit was significantly inferior to the three-element Yagi unit from AVM or Wildlife Materials in relation to sensitivity. However, the AVM antenna was more difficult to handle in brush and over the course of the day due to its greater size and weight. The Wildlife Materials antenna is collapsible and considerably less awkward in both use and storage. Future studies should note that receivers need to be well-protected from moisture by use of a clear plastic bag or similar material, and the unit dried thoroughly (where possible) between uses. Unexpected rain showers (such as typically occur during telemetry sessions) may damage or preclude the use of equipment for extended periods of time. In some cases, the unit can be dried out in the field by placing it on the heater vent of an automobile and running the heater for 20-30 minutes. Coaxial cables, particularly when attached to the large antenna, wear quite rapidly and need to be replaced every six weeks- two months when in daily use.

Attempts were made to locate animals every two hours by use of telemetry and/or visual methods at sites OR 002 U, OR 017 U, OR 050 U, OR 039 W and OR 001 C. At these sites telemetry monitoring in 1992 began at 0800 and concluded at 2000. In 1993 readings began at 1000 and concluded at 2200 during the nesting seasons, and occurred from 1000 to 1800 beginning in August. Turtles were located on an intermittent basis at the west Eugene sites and at Site OR 163 W. At sight CA 014 K readings began at 0800 and terminated at 2000, but the time between readings averaged three-four hours due to the distances involved in moving between telemetered turtles (up to two and one half km). Surveys were initiated on differing dates from site to site, but generally began in early June 1992 and ran continuously for up to 60 days, terminating in mid-late August at most sites (CA 014 K, OR 002 U, OR 017 U, OR 050 U, OR 039 W, OR 001 C). In 1993 surveys began in late June-early July at sites OR 002 U, OR 017 U, OR 050 U and the west Eugene sites and terminated in mid-August. Surveys at site CA 010 K followed the same general seasonal pattern for 1992-1993, and surveys at sites OR 082 W and OR 097 W began in June 1993 and continue at this time. Monitoring at Site OR 163 W began on a limited basis in September 1992 and continues at present. Locations using telemetry were determined by triangulation, using the azimuth from the strongest signal at one point as one vector and a similar estimate from another point. Minimum interpoint distance varied from site to site, but was usually 20+ m. The point at which the two vectors intersected was assumed to represent the approximate position of the transmitter. The distance from observer to the turtle varied with locality and conditions. At site OR 002 U, distances typically ranged from 50-120+ meters. At site OR 050 U, distances were typically less than 50 meters. Elevated line-of-sight readings were possible from many locations at site CA 010 K, CA 014 K, OR 017 U, OR 050 U and OR 082 W. In instances where bi-hourly readings were not possible, an attempt was made to locate every animal at least once/day. Observers utilized available cover (trees, shrubs, rocks) to the greatest extent practical to screen the observer from the view of the turtles. Also, to the greatest extent possible, triangulation points were standardized. Observations from the field and cross-verification by visual means indicated that triangulation accuracy in most systems was at least +/- ten meters, and often +/- five meters. However, for the purposes of this report, the greater figure is used throughout. All estimates of movement are therefore in general conservative. To the greatest extent possible, we utilized no more than two observers at a given site to minimize inter-observer variation. However, in some instances this was impractical and three-four observers were used at one site. Signal intensity was variable across transmitters, but by adjusting the volume of the receiver it was often possible to locate the general azimuth of a signal on the basis of signal strength alone. Comparison of tabulated results generally indicate that there was little variation among most observers, and that patterns of recorded movement were consistent both among and within observers.

Turtle locations were plotted in the field on an acetate overlay of an aerial photograph of the site (Sites OR 002 U, OR 017 U, OR 0163 W, OR 001 C) or on prepared maps of the sites (OR 050 U, OR 039 W, OR 082 W, OR 097 W, CA 014 K, CA 010 K, west Eugene sites). All lake and pond sites were divided into 10 m x 10 m quadrats thus creating an X-Y grid system. For river and stream systems at sites OR 163 W, OR 017 U and CA 014 K, the length of the watercourse was divided into ten meter sections. For site CA 010 K, the interval was 25 m due to the length of the system in which turtle movements were monitored (several km). For reservoir sites (OR 082 W and OR 097 W), measurements were made directly from plotted locations on maps derived from aerial photos. Because of the size of the area, 25 m grids were used at the West Eugene sites. Most locality data was then transcribed into a data base manager (Quattro Pro ©) and sorted by date, time, turtle mark number and/or frequency. For most sites, several data points exist per turtle/day. However, because of the differing project goals and practical considerations, there may be only a single datum/day or per sampling interval for some sites (such as OR 097 W and OR 082 W). Distance moved with pond and lake systems was calculated by a minimum distance method involving the use of the Pythagorean theorem, as illustrated in Fig. 1. Distance moved between stream or river segments was determined by addition or subtraction from point to point. Distance moved within reservoirs was calculated by a minimum interpoint distance tracking shoreline contours.

Telemetry readings were interrupted by several factors, including monitoring of movements of nesting females, thunderstorms, disturbance by activities of other people and equipment failure. However, for most sites we obtained between 40 and 60 days of continuous readings for several animals at each site.

For the purposes of standardization, where possible the data was reduced to mean distance moved/day and mean distance moved per move. Overnight movements (where tracked) were considered to be the distance between the last recorded position of the sampling day (usually at 2000 hours) and the position at the first reading of the day following (usually at 0800 hours). In the event that no data was available for a given day (i.e. a > 24 gap in readings) the overnight movements were not plotted on the following figures.

Results - Site CA 014 K

Fourteen turtles - twelve gravid females and two males - were equipped with transmitters and monitoring began at this stream site on 21 June 1992. All animals were released in the pools in which they were originally captured. Signals were immediately lost on four animals (both males and two females) and it is suspected that they moved outside of the area surveyed. Of the remaining ten females, one was found dead on 08 July, apparently predated by a mink or river otter. Signals were obtained on an intermittent basis from several other animals, but at least 5 were tracked on a regular basis from late June to early August.

Turtle # 7624 was released in Pool 26 on 21 June. On 26 June she was located an estimated 100 m east of pool 25 on a steep (45 o) slope under a bush. The animal was observed to remain in this general area on 27 June, and moved back to pool 26 sometime between 1620 on 27 June and 1320 on 28 June. The animal was again observed out of the water 30 m northeast of pool 25 on 30 June. She apparently remained out of the water until at least 02 June, when she was palpated and noted to be gravid. On 06 July she moved upstream 68 m to pool 26. On 08 July she was observed excavating a nest but abandoned the effort after she apparently hit a rock in the course of excavation. On 09 July, she returned to pool 26, possibly to rehydrate as she had emptied the contents of her bladder during the previous nesting effort. In the late afternoon of 09 July she was observed moving away from the pool and upslope. The turtle was checked periodically during the day on 10 July, and was observed to be in the process of excavating a nest at 2200. Nest excavation was apparently complete by 0500 on 11 July, and she deposited 4 eggs within approximately 30 min. Two eggs were apparently unable to fit in the nest, and were extensively manipulated by the hind limbs. At 0630 she scraped material (oak duff and dirt) over the nest and moved toward pool 26. This animal returned to pool 26 and made one small (34 m) movement to pool 27 on 15 July. Other than a small (34 m) upstream movement on 02 August and a 34 m downstream movement on 03 August, there was no apparent movement out of pool 26. The average distance moved per day was only 5.9 m, and the greatest single movement was 68 m.

Turtle # 1870 was released in pool 18 on 2 1 June. On 25 June she moved 147 m upstream to a pool (# 19). Although her nesting effort was not observed, it is likely that she moved out to the oviposition site between 25 and 26 June. On 27 June she moved 147 m downstream to the pool she had originally moved from (pool 17) and remained at that site for three days. On 02 July this animal was captured and found to have deposited her eggs. Following this she made minor movements upstream and downstream not exceeding 75 m in any one direction. The pattern of movement over the next month was largely consistent, with intervals of 2-3 days non-movement in one pool interspersed with small-scale (<75 m) movements over 2-3 days upstream and downstream from that pool. The average distance moved per day was 26.1 m, and the single greatest movement was 147 m. A single downstream movement of 95 m was recorded on the last day of monitoring,

Turtle # 5211 was released in pool 8 on 21 June, and was located on land on 24 June an estimated 60 m from the stream between pools 4 and 5. Observations over the next several days indicated that she apparently remaining on land until 01 July. In several instances she was observed under cover burrowed into leaf litter under shrubs. The animal was relocated in pool 5 on 02 July and the signal was lost until 07 July, when she was again found out of the water 536 m downstream from the previous location. The animal was palpated and found to be not gravid on 08 July. I assume from the pattern of movement and other data that she nested somewhere between 03 and 07 July. On 09 July she was back in the stream at the original emergence site of 07 July and engaged in only minor upstream or downstream movements (approximately 68 m) from this pool over the next three weeks. On 02 August she made a large (163 m) upstream movement, but returned to the same pool the next day. The average distance moved per day was 36.9 m.

Turtle # 7621 was released in pool 25 on 22 June and the signal was lost on 24 June. The animal made a downstream movement of 301 m on 30 June, and was tracked to a terrestrial location approximately 100 m NE of pool 28. One small movement (<10 m) within the terrestrial habitat was noted. On 02 July the animal was palpated and found to be carrying eggs. The animal was located in the terrestrial habitat on 03 and 04 July. On 08 July she was palpated and found not to be gravid. On 09 July she made a 340 m movement downstream and on 12 July her transmitter was removed and reattached to a male. Oviposition was estimated to occur sometime between 02 and 08 July. The greatest distance moved in one movement was 301 m.

Turtle # 641 was released in pool 23 on 23 June. Her signal was intermittent until 30 June, when she was found out of the water near pool 23. On 02 July she was palpated and found to be "partially gravid". As it is difficult to determine even approximate clutch size in large females by palpation, it is likely that she was still carrying all eggs at this point. This animal was re-examined on 08 July and found to have deposited her eggs. Movements after this point were moderate-scale (usually <70 m) up and downstream until 28 July, when an upstream movement of approximately 158 was made over 2 days. On 30 July a downstream movement of 110 m was made and there were no further recorded movements after this date until monitoring terminated on 04 August. This turtle moved an average of 26.1 m/day during the time she was tracked.

Turtle # 555 was released in pool 18 on 23 June. On 26 June she was found out of the water approximately 60 m northwest of pool 17 (near pool 18). Small-scale movements (usually < 10 m) were observed between 26 June and 08 July. She was palpated on 02 July and noted to be not gravid. The exact
date of oviposition is not known, but presumably occurred between 26 June and 02 July.

Turtle # 109 was released in pool 4 on 24 June and was located upstream 629 m upstream on 25 June. The turtle was 100 m east-northeast of pool 14 on land at 10050. Between 1050 and 1930, she was noted to have moved at least another 120 m. The animal was relocated on 26 June 30 m from the previous location, and proceeded to move another 240 m between 1230 on 26 June and 1230 on 27 June. At 1900 on 27 June she was observed excavating a nest, but had abandoned the effort by 2030, apparently disturbed by the observer. She was observed to make very limited movements (ca: 1 m) on 28 June, and returned to pool 14 by 0915 on 29 June. On 30 June she was observed 25 m from the stream between pools 13 and 14. She was captured on 08 July and found to have deposited her eggs. The greatest distance moved in one movement was 629 m The transmitter was removed on 12 July and placed on a male.

Turtle # 5 12 was released in pool 15 on 2 1 June and made one upstream movement (72 m) on 23 June. The turtle was palpated on 08 July and found to have deposited her eggs. The approximate date cannot be determined with any certainty. This turtle moved an average of 11.36 m/day, and the greatest distance moved was 72 m.

Turtle # 7663 was released in pool 29 on 23 June. She was located out of the water an estimated 30 m east of pool 29 on 26 June, burrowed under a shrub. By 06 July the turtle could not be located and it is probable that the transmitter failed. Upstream and downstream movements of 88 m were recorded on 3 occasions prior to transmitter failure.

Turtle # 508 was released in pool 12 on 21 June and located a estimated 20 m from pool 14 at 0850 on 26 June. She returned to the water by 1200. She was observed on the shoreline on 30 June moved rapidly back into the pool on noting the observer. On 01 July she was observed on land 10 m from the location noted on 26 June. On 03 and 04 July she was observed in the same location. On 08 July she was found dead, apparently as the result of predation. The transmitter was moved to a male on 12 July.

Turtle # 100 was a male, released in pool 5 on 23 July. This turtle made an upstream movement of 434 m on 25 July, and moved extensively between that date and 04 August, when monitoring was terminated. Extensive movements both upstream and downstream were noted, always involving distances of > 100 m. On only 4 days were no movements noted. The average distance moved was 128 m/day, and the greatest distance moved in any single movement was 434 m.

Turtle # 101 was a male, and was released in pool 2 on 22 July. Upstream and downstream movements of 176 m were noted on 6 occasions between 24 July and 03 August. On 6 days, the turtle remained in one pool (usually pool 2). Average distance moved/day was 88 m, and the greatest distance moved in any single movement was 176 m.

Results - Site CA 010 K

This study was conducted in cooperation with the United States Forest Service at a river site in northern California. Between 1992 and 1993, a total of 23 turtles were equipped with radio transmitters, released at the site of capture and tracked on a regular basis. Of these, six were males and seventeen were females. Two of the females were non-gravid, the remainder were known to be carrying eggs at the time they were equipped with transmitters. One female died during the study in September 1992, and was replaced with another female. In the following data, it should be noted that since many animals were tracked only on an approximately weekly basis, estimates of average daily rates of movement are necessarily very conservative (see discussion below).

Turtle # 415A was a gravid female and was tracked on a daily basis between 15 May and 12 August 1992. She was first observed out of the water on 15 May and remained out of the water for 15 days. On 06 June she was observed on land, and remained there for 1 day. On 08 June she again was discovered on land and remained in a terrestrial habitat for 4 days. On 17 June she again left the water and remained on land for 3 days. As of 17 June, the turtle was still gravid. Movements within the watercourse from 04 May to 23 August averaged 13.67 m/day. The greatest distance moved in any one week was 231 m.

Turtle # 377A was a gravid female and was tracked on a daily basis from 05 June to 03 July 1992. She was observed on land 10 occasions between 07 June and 28 June. All but the last movements lasted one day or less. The animal was examined by palpation on 26 June and may have deposited her eggs by that point. Movements within the watercourse averaged 9.97 m/day, and the greatest distance moved was 115 m in one week.

Turtle # 215 was a gravid female and was tracked from 06 June 1992 to 01 August 1993. She was observed on land on 10 June 1992 and made 4 terrestrial excursions between 10 June and 22 June, and was effectively terrestrial during this time. She was still gravid on 22 June but the approximate date of oviposition is not known. Movements within the watercourse from 25 May to 13 September averaged 9.94 m/day, and the greatest distance moved was 163 m in one week. This turtle moved onto land to apparently over-winter on 08 September, and remained on land until sometime between 10 and 16 May 1993.

Turtle # 456 was a gravid female tracked daily between 09 June and 30 August 1992. She was observed on land on 3 occasions between 20 June and 26 June, each time for a single day except for 26 June when she remained for 2 days. She was still gravid on the latter date and the date of oviposition is not known. Movements within the watercourse from 09 June to 30 August averaged 9.33 m/day, and the greatest distance moved was 385 m in one week.

Turtle # 544A was a gravid female tracked daily between 05 June and 03 July 1992. She was observed on land on 4 occasions between 12 June and 30 June, with the time ranging from less than 1 day to 7 days. She was palpated on 30 June and found to be non-gravid. Movements within the watercourse between 25 May and 05 July averaged 12.35 m/day, and the greatest distance moved was 263 m in one week.

Turtle # 698 was a gravid female tracked between 09 June 1992 and 03 October 1993. She was observed on land on 3 occasions between 10 June and 29 June 1992. She was still gravid on the latter date and the approximate date of oviposition is not known. She moved to a terrestrial over-wintering site on 14 September 1992 and emerged sometime between 16 and 20 June 1993. Movements within the watercourse from 09 June to 20 September 1992 averaged 15.1 m/day, and the greatest distance moved was 314 m in one week. In 1993, movements within the watercourse were tracked between 21 June and 12 September. No movements onto land were noted during the summer of 1993. Movements within the watercourse averaged 14.42 m/day, and the greatest distance moved was 280 m in one week.

Turtle # 713 was a gravid female tracked from 27 June to 12 July 1992. She was observed on land on 3 occasions between 27 June and 08 July, for intervals of 1 to 3 days. The animal was noted to be gravid on 01 July, but had apparently deposited eggs by 08 July. Movements within the watercourse in this time period averaged 19.66 m/day, and the greatest distance moved was 265 m in one week.

Turtle # 395A was a gravid female tracked between 08 June and 12 July 1992. She was first observed on land on 18 June and between that date and 12 July spent between 1 and 12 days on land. She was still gravid on 28 June and the approximate date of oviposition is not known. Movements within the watercourse averaged 46.3 m/day, and the greatest distance moved was 328 m in one week.

Turtle # 949 was a gravid female monitored between 25 May and 08 September 1992. She was first observed on land on 08 June and remained on land for 11 days. Nesting activity was noted on 19 June, and was noted to be non-gravid on 12 August. Movements within the watercourse in this time period averaged at least 7.16 m/day, and the greatest distance moved was 107 m in one week. This animal was found dead on land on 08 September 1992.

Turtle # 749 was a gravid female tracked between 08 June 1992 and 03 October 1993. She was first observed on land on 09 June 1992 and spent at least 9 days in the terrestrial habitat between 09 and 27 June. She was still gravid on 23 June, but not gravid by 27 June, thus furnishing an approximate date of oviposition. Movements within the watercourse fi-om 08 June to 08 September averaged 5.87 m/day, and the greatest distance moved was 65 m in one week. This animal moved into a terrestrial over-wintering site on 08 September, and remained at that site until 0 1 April 1993 (204 days). On 0 1 April she was found in a small vernal pool, and moved to the river on 24 April. Movements in the watercourse between 24 April and 10 September 1993 averaged 7.13 m/day, and the greatest distance moved was 120 m in one week. This animal was observed on land on 01 June, and remained in the terrestrial habitat for 7 days. This animal moved to an overwintering site on 10 September.

Turtle # 335A was a nongravid female tracked between 04 May and 19 July 1992. She was observed on land on 19 May 1992 for one day. Movements within the watercourse averaged 28.56 m/day, and the greatest distance moved was 718 m in one week.

Turtle # 868 was a nongravid female and was tracked from 25 May 1992 to 03 October 1993. This turtle made one movement onto land on 02 July 1992, and remained there for one day. Movement onto land for overwintering was observed on 23 September 1992, and the animal remained on land until at least 14 May 1993, when the signal was lost. The signal was recovered on 02 August 1993, and the animal again moved onto land for overwintering between 13 and 19 September 1993. Movements within the watercourse in 1992 were noted between 25 May and 27 September. Daily movements averaged 4.44 m/day, and the greatest distance moved was 120 m in one week.

Turtle # 335B was a male that was tracked from 20 July 1992 to October 3 1993. Movements within the watercourse from 20 July to 08 September 1992 averaged 58.9 m/day, and the maximum distance moved was 8 12 m in one week. This animal was observed in a terrestrial habitat on 08 September and remained on land until approximately 08 May 1993 (244 days). Movements within the aquatic habitat were tracked from 10 May to 26 September 1993, and averaged 24.12 m/day. The greatest distance moved was 502 m in one week. This animal moved onto land to overwinter on 03 October 1993.

Turtle # 678 was a male that was tracked from 18 May 1992 to 03 October 1993. Movements within the watercourse from 18 May to 01 November 1992 averaged 7.71 m/day, and the greatest distance moved was 259 m in one week. This animal was observed on land on 04 November 1992, and remained (overwintering) in the terrestrial habitat until approximately the week of April 19, a total of 162 days. In 1993, movements within the watercourse were tracked from 19 April to October 3. Movements within this period averaged 22.12 m/day, and the greatest distance moved was 720 m in one week.

Turtle # 725 was a male that was tracked from 18 May 1992 to 03 October 1993. Movements within the watercourse between 18 May and 18 October averaged 14.8 m/day and the greatest distance moved was 321 m in one week. This animal moved into a terrestrial over-wintering site on 18 October 1992, and remained in the terrestrial habitat until the week of 24 May 1993, a total of 194 days. Movements in the watercourse between 24 May and 03 October averaged 23.44 m/day, and the greatest distance moved was 780 m in one week. This animal was observed in a terrestrial situation on 26 July 1993 for 1 day, possibly basking.

Turtle # 528 was a male that was tracked from 11 May 1992 to 03 October 1993. Movements within the watercourse between 11 May and 13 September averaged 27.5 m/day, and the greatest movement was 1116 m in one week. This turtle moved into a terrestrial site on 08 September, and was observed overwintering on 04 November 1992. This animal returned to the watercourse between 10 and 16 May 1993. Movements within the watercourse in the period from 10 May to 03 October averaged 18.93 m/day, and the greatest distance moved was 585 m in one week. This animal died sometime in November 1993.

Results - Site OR 017 U

Nine turtles - two males, four non-gravid females and three gravid females were equipped with transmitters and monitored on a daily basis from 26 June to 04 August 1992. Five turtles - one male, one non-gravid female and three gravid females, were monitored from 28 June to 20 August 1993. Turtles were released at the site of capture. The signal from one male was immediately lost in 1992, and the transmitter was later located (but not recovered) over 1 km downstream. Thus, it is likely that this animal immediately moved out of the area of coverage.

Turtle # 5511 was a gravid female tracked daily from 30 May to 04 August 1992. In this time period she made numerous small-scale movements, ranging from 10 to 70 m. On only 9 days were no movements recorded. Movements within the watercourse between 26 June and 04 August averaged 29 m/day, and the greatest distance moved in one day was 90 m. This animal moved into the terrestrial habitat sometime between 06 October and 07 November, and was presumably overwintering on the latter date.

Turtle # 7216 was a gravid female tracked daily from 30 May to 04 August 1992. In this time period she made numerous small-scale movements, ranging from 10 to 30 meters. This animal was originally captured in a large pool approximately 250 m downstream from the nesting area, and moved into a pool adjacent to the nesting area between 30 May and 06 June. No movement was observed on 16 days, indicating that she was more sedentary than # 5511. This animal moved primarily within a limited stretch of the river approximately 50-90 m north of the nesting areas, and spent most of her time in one of two large pools in this area. This animal was observed returning to the river on 06 June at 1900 from the general nesting area and it is likely that she oviposited prior to this. This turtle moved upstream from the nesting area and spent most of the remaining monitoring period in a pool near the confluence of the river and a small stream. Movements within the aquatic habitat between 26 May and 04 August averaged 26.82 m/day, and the greatest distance moved in any one day was 180 m. This movement followed (by 2 days) an overnight movement of 200 m. Aside from 2 overnight movements in late July of 50 and 60 meters, no other movements exceeded 30 m. This animal moved into the terrestrial habitat between 06 October and 07 November, and remained on land until approximately 27-28 June 1993.

Turtle # 7217 was a gravid female tracked daily from 30 May to 24 July 1992, when the signal was lost. This turtle was captured in the same pool as # 7216, and moved into the pool nearest the nesting area at approximately the same time. This animal made relatively few movements, ranging from 20 to 110 meters. On 18 of the days monitored, no movements were noted. On the last day the signal was received, and upstream movement of 150 m was observed. Movements between 26 June and 24 July averaged 35 m/day, in large part because of several day and overnight movements of 100 m or more. No data is available of date of oviposition, and similarly no data is available on overwintering. This animal was recaptured in 1993 and re-equipped with a different transmitter. Movements in the watercourse between 29 June and 19 August 1993 averaged 17 m/day, and the greatest distance moved was 80 m in one day. No data is available on possible nesting efforts.

Turtle # 3 111 was a gravid female tracked from 05 July to 20 August 1993. This turtle was captured in the largest pool at the study site, and engaged in a few moderate-distance movements. No movement was noted on 60% of the days monitored. Most other movements were between 10 and 30 meters, but one movement of at least 190 m was noted. Daily movements averaged 3 1.1 m/day, and the greatest distance moved was 190 m in one day. Most movements noted were between 2000 and 0800, and movement was noted on over 80% of the nights. This animal was observed out of the water in the nesting area on 07 July and it is likely that she deposited eggs that morning or the previous evening. This animal was recaptured on 19 July and was not gravid.

Turtle # 8080 was a gravid female tracked from 05 July to 19 August 1993. This turtle was captured along with turtle # 8087 in a refugium adjacent to the largest pool at the study site. Movements of this animal were more slightly less extensive than those of # 3 111, although movement was noted on almost 50% of all days monitored. Movements averaged 29.1 m/day, and the greatest distance moved was 160 m in one day. As with # 3 111, overnight movements were frequent, noted on over 72% of the days surveyed. Most were small scale (20 m of less). As with # 3 111, the exact date of oviposition is not known, but likely to have occurred in the same time period.

Turtle # 8087 was a gravid female tracked from 05 July to 19 August 1993. This turtle was captured with turtle # 8080 (see above). Movements of this animal were more extensive than either # 3 111 or # 8087. Movements averaged 35.1 m/day, and the greatest distance moved was 180 m in one day. Movements were noted on only 41% of the days monitored. Overnight movements were noted on over 73% of the days surveyed. Most were small scale, but four involved movements of 100 m or more. This animal was observed moving out of the water 07 July, but rapidly (<10 min) moved back into a small pool adjacent to the nesting area. Other small scale movements onto land were noted on this date. It is likely that this animal and possibly # 3 111 and # 8080 nested on or slightly before 07 July, as three predated nests were found on 08 July. Based upon the appearance of the eggs, it is likely that they were predated within the previous 24-48 hours.

Turtle # 5568 was a non-gravid female tracked from 12 July to 04 August 1992. Movements of this animal were less than any other animal at this site, averaging only 21.6 m/day. The greatest distance moved was only 80 m in one day. However, an overnight movement of 140 m was noted. Movement was noted on less than 50% of the days monitored, and on over 63% of the nights.

Turtle # 72 15 was a non-gravid female tracked from 26 June to 04 August 1992. This animal was captured in the largest pool at the study site. Movements of this animal were extensive, and averaged 5 1 m/day. The greatest distance moved was only 90 m, indicating that movements were frequent and moderate in scale. Movement was noted on 85% of the days monitored. Overnight movements were noted on 66% of the days surveyed.

Turtle # 3 105 was a non-gravid female tracked daily from 30 May to 04 August 1992, and intermittently between then and July 1993. Continuous monitoring was initiated in July 1993 and continued until mid-August, and is now conducted on a once/week basis (early 1994). This animal engaged in numerous small-scale (10-30 m) from June-August 1992, and made one large (320 m) movement in this time period. Daily movements from 26 June to 04 August 1992 averaged 40.8 m/day, and the greatest movement was 320 m in one day. This animal moved into the terrestrial habitat to overwinter between 06 October and 07 November. She was noted back in the river in late May 1993, but may have moved back into the terrestrial habitat between that point and June 28, when she was observed in the river. Movements in the watercourse between 29 June and 19 August 1993 averaged 27.8 m/day, and the greatest distance moved was 70 m in one day.

Turtle # 7219 was a male tracked from 30 May to 04 August 1992. This animal was captured in the same refugium as females # 8080 and 8087. Movements of this animal were extensive, and averaged 44.6 m/day. The greatest distance moved was 110 m in one day. Movement was noted on 83% of the days surveyed, and on 78% of the nights. Overnight movements were generally small-scale (<30 m).

Although several other turtles were monitored at this site in both 1992 and 1993, these were often equipped with transmitters "late" in the season and so very limited data (< l-2 weeks) is available. Tracking of several of these animals continued through late 1993 and early 1994 (see section on overwintering).

Results - Site OR 002 U

Fourteen turtles - seven males, two gravid females and five non-gravid females - were monitored at this lake site in the summer of 1992. Two and possibly three of the animals - all males - moved out of the lake within 1 week of their initial capture and moved overland an estimated 1 km to another lake. Six animals (two males and four non-gravid females) were tracked in the summer of 1993. All of these animals remained in the lake during the monitoring period.

Turtle # 7246 was a gravid female tracked from 11 June to 03 August 1992, and again from 03 July to 11 August 1993. Movements of this animal were extensive, and averaged 202 m/day during the monitoring period in 1992. The greatest distance moved was 4 11 m in one day. Movements were observed on 100% of the days monitored, and overnight movements were noted on 94% of the days monitored. No nesting movements were observed by this animal in 1992, and she was not gravid when captured in early July 1993. While it is possible that she may have oviposited prior to this date, the earliest known date of oviposition in the Umpqua in 1993 was approximately 27 June and most oviposition occurred after that date. Movements of this animal in 1993 averaged 117.7 m/day, and the greatest distance moved was 299 m in one day. Movements were noted on 88.5% of the days monitored, and overnight movements were noted on 91.4% of the days monitored. The signal on this animal was lost in mid-August, but re-established by late September in another lake 1 km away. The radio-determined location has not apparently shifted since late September, and it may be that the transmitter has become detached or the animal has died. The total distance moved by this animal in 1992 was almost 11 km in 54 days, and 4.2 km in 36 days in 1993.

Turtle # 1786 was a gravid female tracked from 11 June to 03 August 1992. Movements of this animal were less extensive than turtle # 7246, and averaged 169 m/day. The greatest distance moved was 323 m in one day. Movements were observed on 100% of the days monitored. Overnight movements were noted on 88.5% of the days surveyed, and distances of up to 94 m were observed. Interestingly, the greatest overnight movement for this animal and turtle # 7247 came immediately after release. No nesting movements were observed in this animal. The total distance moved by this animal in 1992 was almost 9 km in 53 days.

Turtle # 7247 was a non-gravid female tracked from 11 June to 03 August 1992 and from 03 July to 20 August 1993. In 1992, movements of this animal were extensive, and averaged 217 m/day. The greatest distance moved was 486 m in one day. Movements were observed on 100% of the days monitored. Overnight movements were noted on over 94% of the days surveyed, and distances of up to 125 m were observed. In 1993, movements were less extensive, and averaged 13 1.7 m/day. The greatest distance moved was 246 m in one day. Movements were observed on 93.4% of the days surveyed, and overnight movements were observed on approximately the same number of days. This animal has continued to be monitored in the winter of 1993-94, but the signal was lost in late 1993. The total distance moved by this animal in 1992 was 11.5 km in 53 days, and 6 km in 46 days in 1993.

Turtle # 1789 was a non-gravid female tracked from 11 June to 03 August 1992 and 03 July to 20 August 1993. In 1992, movements of this animal were the most extensive of any animal monitored, and averaged 240 m/day. The greatest distance movement was 497 m in one day. Movements were observed on 100% of the days monitored, and overnight movements on 96% of the days surveyed. This animal was noted in a terrestrial over-wintering site an estimated 150 m from the lake on 07 November. The date of return to the lake in 1993 is not known. In 1993, daily movements averaged 117 m/day, and the greatest distance moved was 419 m in one day. Movements were observed on almost 98% of the days monitored, and overnight movements were observed on 89% of the days monitored. This animal was monitored through the fall of 1993, and the signal was lost sometime in September. Extensive surveys of the area surrounding the lake out to a distance of 200+ m have failed to reveal this animal. While it is possible that the battery or transmitter has failed, it may also be that this animal has moved outside the normal detection range of the equipment (approximately 400 m). The total distance moved by this animal was 12.7 km in 53 days, the greatest total distance recorded for any animal at this study site, and greater than at all but one other study site.

Turtle # 7201 was a non-gravid female tracked from 11 June to 03 August 1992, and from 03 July to 20 August 1993. Movements in 1992 were extensive, averaging 23 5 m/day. The greatest distance moved was 378 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were noted on 92% of the days surveyed. This animal exhibited the greatest total distance moved in the 1992 survey period, moving a total of 12.5 km within the lake in the course of 53 days. In 1993, the animal was again not gravid, and movements averaged only 73.8 m/day. The greatest distance moved was 207 m in one day. Movement was noted on only 57% of the days monitored, and overnight movements were observed on 68% of the days surveyed. The total distance moved by this animal in 1993 was only 3.2 km in 44 days.

Turtle # 5524 was a non-gravid female tracked from 07 June to 03 August 1992. Movements were the least extensive of any animal at this site, and averaged 106 m/day. The greatest distance moved was 225 m in one day. Movements were noted on 96% of the days monitored, and overnight movements occurred on 94% of the days surveyed. As previously noted with # 1786, the greatest overnight movement occurred shortly after release. The total distance moved by this animal was 5.5 km in 52 days.

Turtle # 7200 was a non-gravid female tracked from 10 June to 05 July 1992. Movements were extensive in the time period monitored, and averaged 237 m/day. The greatest distance moved was 460 m in one day. Movement was observed on 100% of the days monitored, and overnight movements occurred on 96% of the days surveyed. The signal was lost on this animal on 08 July, and it is likely that the transmitter failed or that the animal emigrated from the study area. The total distance moved by this animal was 5.9 km in 25 days.

Turtle # 727 1 was a non-gravid female tracked from 13 July and 02 August 1992. Movements were moderate, and averaged 197 m/day. The greatest distance moved was 368 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were also observed on 100% of the days surveyed. The signal from this animal was lost by September 1992. The total distance moved by this animal was 4.1 km in 21 days.

Turtle # 7270 was a male tracked from 12 July 1992 to 03 August 1992, and from 05 July to 20 August 1993. Movements of this animal in 1992 were intermediate between those of other males, and considerably less than most females. Movements averaged 164 m/day, and the greatest distance moved was 219 m in one day. Movement was observed on 100% of the days monitored, and overnight movements on over 95% of the days surveyed. The signal was lost on this animal during the fall of 1992, and it was recaptured and equipped with another transmitter in 1993. Movements of this animal in 1993 averaged slightly less than those observed in 1992. Movements averaged 125.5 m/day, and the greatest movement was 272 m in one day. Movement was observed on over 90% of the days monitored, and overnight movements were observed on 100% of the days surveyed. The total distance moved by this animal in 1992 was 3.7 km in 23 days of survey. In 1993, the total distance moved was 5.4 km in 43 days.

Turtle # 5522 was a male tracked from 11 June to 03 August 1992. Movements were moderate in this time period, and averaged approximately 200 m/day. The greatest distance moved was 332 m in one day. Movements were observed on 100% of the days monitored, and overnight movements were observed on 98% of the days surveyed. The total distance moved by this animal was 10.6 km in 53 days.

Turtle # 7202 as a male tracked from 10 June to 03 August 1992. Movements were moderate to extensive, and averaged 225 m/day. The greatest distance moved was 418 m in one day. Movements were observed on 100% of the days monitored, and overnight movements were observed on over 94% of the days surveyed. The total distance moved by this animal was 12.2 km in 54 days.

Turtle # 9909 was a male tracked from 05 July to 20 August 1993. Movements were limited, and averaged only 94.9 m/day The greatest distance moved was 304 m in one day. Movements were observed on over 8 1% of the days monitored, and overnight movements were noted on approximately 83% of the days surveyed. The total distance moved by this animal was 4.08 km in 43 days.

Turtle # 7205 was a male tracked from 11 June to 15 July 1992. Based upon field notes, it is likely that this animal moved out of the lake and overland (approximately 1 km) to another lake sometime between 04 and 05 June.

Turtle # 7203 was another male that was tracked from 11 June to 06 July 1992. Based upon field notes, it is likely that this animal moved out of the lake to the same lake inhabited by # 7205 sometime between 04 and 05 June.

Turtle # 7239 was another male tracked from 11 June to 15 July 1992. As with the other two animals, it is likely that this animal left the lake at approximately the same time.

Tracking continued on three animals at this and a nearby site in late 1993 to determine overwintering habits and habitat (see section on overwintering).

Results - Site OR 050 U

Fourteen turtles - eight males, three gravid females and three non-gravid females, were translocated to the two ponds at this site on 02 June 1992. One signal (a male) was lost within 2 weeks of the movement and not subsequently observed. It is likely that this animal moved away from the area outside of detection range. One of the gravid females was crushed by a logging truck while moving out to nest, and another drowned when the antenna came loose and tangled in vegetation. Movements of the other animals are summarized below.

Turtle # 7232 was a gravid female tracked from 03 June to 04 August 1992, This animal left the water on 06 June and moved into the terrestrial habitat to oviposit. Although she was observed engaged in nesting behavior on several occasions, several of these apparently were "false scrapes" and her nest was not located. The animal returned to the water by 08 June. Movements averaged 42.8 m/ day, and the greatest distance moved was 115 m in one day. Movements were observed on 96.5% of the days monitored, and overnight movement were noted on almost 95% of the days surveyed. The total distance moved by this animal was 3.2 km in 57 days.

Turtle # 723 7 was a gravid female tracked from 03 June to 15 July 1992. This animal left the water on 15 July and moved over 100 m away in a possible nesting attempt. In crossing a road uphill from the study site, she was run over by a logging truck and killed. As eggs were still present in the body cavity, it is likely that this movement was a nesting effort. Movements between 03 June and 15 July averaged 38.87 m/day, and the greatest distance moved was 106 m in one day. Movements were observed on 97.5% of the days monitored, and overnight movements were noted on 87.5% of the days surveyed. The total distance moved by this animal was 2.07 km in 40 days.

Turtle # 7239 was a gravid female tracked from 03 June to 09 July 1992. This animal left the water between 05 and 06 June and remained out of the water until at least 07 June. Her nest was not located. The transmitter antenna on this animal came loose and tangled in vegetation. The animal likely drowned sometime after 09 July, when the last recorded movement was noted. Prior to 09 July, movements averaged 51.6 m/day, and the greatest distance moved was 106 m in one day. Movements were observed on 96% of the days monitored, and overnight movements were noted on 83.8% of the days surveyed. The total distance moved by this animal was 1.8 km in 31 days.

Turtle # 7240 was a non-gravid female tracked from 03 June to 04 August 1992. The signal was lost from this animal from 04-08 June. The average distance moved was approximately 34 m/day, and the greatest distance moved was 111 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were also noted on 100% of the days surveyed. The total distance moved by this animal was 2.4 km in 56 days.

Turtle # 7234 was a non-gravid female tracked from 03 June to 04 August 1992. The average distance moved was 46.2 m/day, and the greatest distance moved was 190 m in one day. Movement was observed on 94.6% of the days monitored, and overnight movements were noted on 81.8% of the days surveyed. The total distance moved by this animal was 3.2 km in 55 days.

Turtle # 5560 was a non-gravid female tracked from 03 June to 09 July 1992. The average distance moved was approximately 56.3 m/day, and the greatest distance moved was 139 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were also noted on 100% of the days surveyed. The total distance moved by this animal was 2.3 km in 33 days. The signal was lost on this animal on 10 July as the transmitter had malfunctioned.

Turtle # 7233 was a male tracked from 03 June to 21 July 1992. The average distance moved was 34.6 m/day, and the greatest distance moved was 84 m in one day. Movement was observed on 97.8% of the days monitored, and overnight movements were noted on 89.1 % of the days surveyed. The total distance moved by this animal was 2 km in 46 days. The signal from this animal was lost on 21 July when it was determined that the transmitter had come loose and fallen off.

Turtle # 7241 was a male tracked from 03 June to 08 July 1992. The average distance moved was approximately 47.6 m/day, and the greatest distance moved was 120 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were noted on 97% of the days surveyed. The total distance moved by this animal was 2.08 km in 34 days. The signal from this animal was lost on 09 July, when the transmitter was noted to be detached (as with # 7233).

Turtle # 7235 was a male tracked from 03 June to 07 July 1992. The average distance moved was approximately 40.3 m/day, and the greatest distance moved was 88 m in one day. Movement was observed on 87.5% of the days monitored, and overnight movements were noted on 93.3% of the days surveyed. The total distance moved by this animal was 0.77 km in 15 days. The signal from this animal was lost 21 June and 06 July, and it is likely that this animal moved into the terrestrial habitat. The signal was recovered on 08 July when the animal apparently returned to the pond. The signal was once again lost on 08 July when the transmitter was noted to be detached (as with # 7233).

Turtle # 7242 was a male tracked from 03 June to 28 July 1992. The average distance moved was 30.85 m/day, and the greatest distance moved was 82 m in one day. Movement was observed on 97.8% of the days monitored, and overnight movements were noted on 89.3% of the days surveyed. The total distance moved by this animal was 1.7 1 km in 47 days. The signal from this animal was lost on 29 July, when the transmitter was noted to be detached (as with # 7233).

Turtle # 723 8 was a male tracked from 03 June to 01 July 1992. The average distance moved was approximately 35.4 m/day, and the greatest distance moved was 62 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were noted on 87.5% of the days surveyed. The total distance moved by this animal was 1.1 km in 25 days.

The signal from this animal was lost on 02 July, when the transmitter was noted to be detached (as with # 7233).

Turtle # 5558 was a male tracked from 03 June to 04 August 1992. The average distance moved was approximately 32.6 m/day, and the greatest distance moved was 91 m in one day. Movement was observed on 100% of the days monitored, and overnight movements were noted on 96.4% of the days surveyed. The total distance moved by this animal was 2.4 km in 57 days.

Turtle # 7236 was a male tracked from 03 June to 04 August 1992. The average distance moved was approximately 42.1 m/day, and the greatest distance moved was 137 m in one day. Movement was observed on 96% of the days monitored, and overnight movements were noted on 89.6% of the days surveyed. The total distance moved by this animal was 3.1 km in 58 days.

Tracking on several animals continued through the winter of 1993-1994 at this site (see section on overwintering).

Results - Site OR 039 W

Five turtles - all gravid females - were tracked at this site beginning in early June 1992. Two of these animals (# 7500 & 7501) were translocated from a degraded urban habitat near Oakridge. The signal from turtle # 4855 was lost on 07 July.

Turtle # 4854 was a gravid female tracked from 10 June to 24 July 1992. This animal was located out of the pond between 1200 and 1500 on 13 June and moved to the "major" (western) nesting area at this study site, approximately 71 m from the edge of the pond. She remained in this general area for at least 48 h and was observed within 10 m of the edge of the pond at 0800 on 16 June. The next telemetry reading at 1000 located this animal in the pond. It is likely that she nested sometime on the evening of 13 June based upon observations in the field. Movements within the watercourse averaged 28.1 m/day, and the greatest distance moved was 138 m in one day. Movements were observed on only 58% of the days monitored, and overnight movements were noted on only 20% of the days surveyed. The total distance moved by this animal was 0.95 km in 34 days.

Turtle # 4855 was a gravid female tracked from 10 June to 06 July 1992. This animal was located out of the water on 13 June at 1405, but she returned to the pond 1500. This animal was also located on land at 1000 on 16 June, but returned to the water by 1200. The animal was again located out of the pond on 18 June at 1800, moving toward the "major" nesting area. Nesting activity was noted on 18 June and possibly on the morning of 19 June. By 1200 this animal had moved back into the pond. Thus, it is likely that this animal nested sometime between 18 and 19 June. Movements within the watercourse averaged 44.6 m/day, and the greatest distance moved was 126 m. Movements were observed on 73.9% of the days monitored, and overnight movements were noted on only 33% of the days surveyed. The total distance moved by this animal was 1.02 km in 23 days. The signal was lost from this animal on 07 July and it is possible that she moved out of the watercourse after that time, as there are no records of sightings past that date.

Turtle # 4851 was a gravid female tracked from 10 June to 24 July 1992. This animal was located out of the water at 1620 on 14 June, moving to the "minor" (eastern) nesting area 16 m from the pond. Obvious nesting activity was noted by at least 1743, and the animal remained near the "nest" site overnight. Additional nesting activity was noted on 15 June at 1724. Observations indicated that the animal remained on the site until at least 2120. On 16 June at

0800 she was part-way between the nest site and the pond, and by 1000 she had re-entered the pond. Movements in the watercourse averaged 48.8 m/day, and the greatest distance moved was 159 m in one day. Movements were observed on 85.2% of the days monitored, and overnight movements were noted on only 44.8% of the days surveyed. The total distance moved by this animal was 1.6 km in 34 days.

Turtle # 7500 was a gravid female tracked from 10 June to 25 July 1992. This animal was located out of the water on 30 June an estimated 250 m from the pond. She was not gravid at this time, and based upon field notes it is likely that she moved out to this site between 28 and 29 June. Movements within the watercourse averaged 36.2 m/day, and the greatest distance moved was 138 m in one day. Movements were observed on 74.2% of the days monitored, and overnight movements were noted on only 40% of the days monitored. The total distance moved by this animal was 1.2 km in 35 days.

Turtle # 7501 was a gravid female tracked from 09 June to 24 July 1992. This animal was located out of the water at 2000 on 18 June at the major (western) nesting site. Nesting activity was observed over an extensive time period on 18 June and the animal was noted to have moved back to the pond by 1120 on 19 June. Movements within the watercourse averaged 46.7 m/day, and the greatest distance moved was 138 m in one day. Movements were observed on 78.3% of the days monitored, and overnight movements were noted on only 45.1 % of the days surveyed. The total distance moved by this animal was 1.6 km in 35 days.

Intermittent tracking continued at this site in late 1993 to examine overwintering habits and habitat (see section on overwintering).

Results - Site OR 103 W

This study was conducted by the Army Corps of Engineers at a reservoir site in the Willamette drainage in 1993. Six turtles - three males and three gravid females - were tracked between 15 June and 11 August 1993. Tracking has continued beyond the latter date, but for the purposes of comparison with other sites only the period specified is discussed below. One of the males and one of the non-gravid females were found dead during the course of this project. The turtles in this project were tracked on a approximately weekly basis, and as such movements noted below should be considered as minimally conservative estimates.

Turtle # 8801 was a gravid female captured on 17 June 1993 and tracked from 04 July to 11 August. The exact date of oviposition is not known, but occurred between 17 June and 01 July. Movements within the watercourse averaged 76.5 m/day, and the greatest distance moved was 806 m in six days. The total distance moved in this time period was 2.9 km.

Turtle # 88 10 was a gravid female captured on 15 June 1993 and tracked from 15 June to 11 August. The exact date of oviposition is not known, but occurred between 16 June and 25 June. Movements within the watercourse averaged 53 m/day, and the greatest distance moved was 1,391 m in eight days. The total distance moved in this time period was 3.02 km.

Turtle # 8803 was a gravid female captured on 16 June 1993 and tracked from 16 June to 11 August. The exact date of oviposition is not known, but may have occurred between 16 June and 24 June. Movements within the watercourse averaged 76.5 m/day, and the greatest distance moved was 494 m in one day. The total distance moved in this time period was 2.9 km.

Turtle # 8807 was a male captured on 09 June 1993 and tracked from 16 June to 11 August. Movements within the watercourse averaged 5 1.5 m/day, and the greatest distance moved was 1365 m in seven days. The total distance moved in this time period was 2.93 km.

Turtle # 88 13 was a male first captured on 07 July 1993 and tracked 08 July to 09 August. Movements within the watercourse averaged 31.3 m/day, and the greatest distance moved was 585 m in twelve days, The total distance moved in this time period was 1.0 km.

Results - Site OR 082 W

This study was conducted by the Army Corps of Engineers at a reservoir site in the Willamette drainage in 1993. Six turtles - four males and two non-gravid females were tracked between 17 June and 13 August. As with the study at Site OR 103 W, surveys were conducted on an approximately weekly basis.

Turtle # 8836 was a non-gravid female captured on 22 June 1993 and tracked from 25 June to 10 August. Movements within the watercourse averaged 8.1 m/day, and the greatest distance moved was 90 m in four days. The total distance moved in this time period was 0.38 km. This animal was found dead on 10 August.

Turtle # 8842 was a non-gravid female tracked 07 July and 13 August 1993. Movements within the watercourse averaged 8.1 m/day, and the greatest distance moved was 90 m in three days. The total distance moved in this time period was 0.3 km

Turtle # 8841 was a male first captured on 07 July 1993 and tracked from 07 July to 13 August 1993. Movements within the watercourse averaged 23.3 m/day, and the greatest distance moved was 348 m in twelve days. The total distance moved in this time period was 0.86 km.

Turtle # 8844 was a male first captured on 14 July 1993 and tracked 14 July to 10 August. Movements within the watercourse averaged 68.8 m/day, and the greatest distance moved was 1,560 m in fourteen days. The total distance moved in this time period was 1.86 km.

Turtle # 883 1 was a male first captured on 17 June 1993 and tracked 17 June to 10 August 1993. Movements within the watercourse averaged 13.6 m/day, and the greatest distance moved was 153 m in seven days. The total distance moved in this time period was 0.74 km.

Turtle # 8840 was a male first captured on 02 July 1993 and tracked 02 July to 10 August. Movements within the watercourse averaged 59.2 m/day, and the greatest distance moved was 960 m in six days. The total distance moved in this time period was 2.3 km.

Results - Site OR 097 W

This study was conducted by the Army Corps of Engineers at a reservoir site in the Willamette drainage in 1993. Nine turtles - two males, one non-gravid and six gravid females were tracked between 27 April and 27 December 1993. As with the study at Site OR 103 W, surveys were conducted on an approximately weekly basis. The data presented here overlap and exceed the time frame reference discussed at the other sites.

Turtle # 8934 was a gravid female first captured on 29 May 1993 and tracked from 30 May to 30 June. Movements within the watercourse averaged 125.4 m/day, and the greatest distance moved was 370 m in one day. The total distance moved in this time period was 0.89 km.

Turtle # 8935 was a gravid female first captured on 25 June 1993 at a nesting site and tracked from 26 June to 27 December. Movements within the watercourse averaged 3.2 m/day, and the greatest distance moved was 24.3 m in one day. The total distance moved in this time period was 0.55 km.

Turtle # 8938 was a gravid female first captured on 15 June 1993 and tracked from 16 June to 27 December. Movements within the watercourse averaged 36 m/day, and the greatest distance moved was 380 m in one day. The total distance moved in this time period was 1.03 km.

Turtle # 8967 was a gravid female first captured on or about 14 July 1993 and tracked from 14 July to 09 October. Movements within the watercourse averaged 28.3 m/day, and the greatest distance moved was 75 m in one day. The total distance moved in this time period was 1.69 km.

Turtle # 8941 was a gravid female first captured on 16 June 1993 at a nesting site and tracked from 17 June to 27 December. Movements within the watercourse averaged 23.2 m/day, and the greatest distance moved was 130 m in one day. The total distance moved in this time period was 1.79 km.

Turtle # 8950 was a gravid female first captured on 28 June 1993 and tracked from 30 May to late December. Movements within the watercourse averaged 26 m/day, and the greatest distance moved was 600 m in one day. The total distance moved in this time period was 1.98 km. The signal was lost from this animal on 29 July and not relocated until 26 days later.

Turtle # 7437 was a non-gravid female translocated to this site on 27 April and tracked from 27 April to 26 July. Movements within the watercourse averaged 4.8 m/day, and the greatest distance moved was 13.5 m in one day. The total distance moved in this time period was 0.27 km. The signal from this animal was lost on 04 August.

Turtle # 8936 was a male first captured on 05 June 1993 and tracked from 07 June to 16 August. Movements within the watercourse averaged 7.7 m/day, and the greatest distance moved was 38 m in one day. The total distance moved in this time period was 0.62 km.

Turtle # 8958 was a male first captured on 04 July 1993 and tracked from 05 July to 04 November. Movements within the watercourse averaged 8 m/day, and the greatest distance moved was 26.7 m in one day. The total distance moved in this time period was 1.04 km.

Results - Site OR 001 C

Thirteen turtles - six males, six non-gravid females and one gravid female were tracked at this site between 07 June and 09 August 1992. Because a limited number of transmitters were initially available, some turtles were not equipped with transmitters until late July. Overnight movements were not determined for this population. One male was found dead on 12 September 1992.

Turtle # 7405 was gravid female tracked from 07 June to 09 August 1992. The animal was noted in the watercourse (pond) at 1056, and observed returning to the pond at 1945, apparently having deposited her eggs in the interim. The nest site was not found, but was at least 50+ m away from the watercourse. Movements within the watercourse averaged 68.9 m/day, and the greatest distance moved was 274 m in one day. Movements were observed on 86.5% of the days monitored. The total distance moved by this animal was 3.3 km in 52 days.

Turtle # 4913 was a non-gravid female tracked from 10 June to 09 August 1992. The average distance moved was 118.2 m/day, and the greatest distance moved was 273 m in one day.

Movements were observed on 79.1% of the days monitored. The total distance moved by this animal was 5.5 km in 48 days.

Turtle # 4925 was a non-gravid female tracked from 06 July to 09 August 1992. The average distance moved was 62.5 m/day, and the greatest distance moved was 235 m in one day. Movements were observed on 76% of the days monitored. The total distance moved by this animal was 1.06 km in 17 days.

Turtle # 4928 was a non-gravid female tracked from 22 July to 09 August 1992. The average distance moved was 74 m/day, and the greatest distance moved was 219 m in one day. Movements were observed on only 50% of the days monitored. The total distance moved by this animal was 0.88 km in 16 days.

Turtle # 4916 was a non-gravid female tracked from 22 July to 09 August 1992. The average distance moved was 82.8 m/day, and the greatest distance moved was 155 m in one day. Movements were observed on 100% of the days monitored. The total distance moved by this animal was 0.58 km in 8 days.

Turtle # 7420 was a non-gravid female tracked from 10 July to 09 August 1992. The average distance moved was 117.4 m/day, and the greatest distance moved was 286 m in one day. Movements were observed on 70% of the days monitored. The total distance moved by this animal was 1.7 km in 20 days.

Turtle # 4906 was a male tracked from 14 June to 09 August 1992. The average distance moved was 73.6 m/day, and the greatest distance moved was 218 m in one day. Movements were observed on 79.1% of the days monitored. The total distance moved by this animal was 2.28 km in 44 days.

Turtle # 49 17 was a male tracked from 30 June to 09 August 1992. The average distance moved was 114.5 m/day, and the greatest distance moved was 320 m in one day. Movements were observed on 97% of the days monitored. The total distance moved by this animal was 4 km in 43 days.

Turtle # 7401 was a male tracked from 10 June to 09 August 1992. The average distance moved was 90 m/day, and the greatest distance moved was 276 m in one day. Movements were observed on 96.8% of the days monitored. The total distance moved by this animal was 2.7 km in 33 days.

Turtle # 4958 was a male tracked from 24 July to 09 August 1992. The average distance moved was 87.2 m/day, and the greatest distance moved was 112 m in one day. Movements were obsetved on 62.5% of the days monitored. The total distance moved by this animal was 0.35 km in 8 days.

Turtle # 4924 was a male tracked from 22 July to 09 August 1992. The average distance moved was 97 m/day, and the greatest distance moved was 140 m in one day. Movements were observed on 87.5% of the days monitored. The total distance moved by this animal was 0.68 km in 8 days. This animal was found dead on 12 September 1992.

Results - Site OR 163 W

Four turtles were tracked at this location between July 1993 and March 1994. Because movements were recorded in a slightly different fashion than at other sites, comparison is difficult since no exact movement data was included with the report furnished by the USFWS. A copy of the material furnished is included as an appendix in this section.

Results - West Eugene Sites

A total of 23 turtles were captured and equipped with transmitters in the west Eugene area by consultants working for the Oregon Department of Transportation (CH2M Hill, 1994; Fishman Environmental Services, 1994). These parties tracked the movements of these animals for approximately two months from June to late August 1993. In late September a member of this project took over tracking and followed the animals until late December to determine overwintering habits and habitats (see section on overwintering). Material in the final report furnished by Fishman Environmental Services (Fishman, 1994) does not allow determination of distances moved by individual turtles since no scale was included on maps in the report. However, it is apparent from the examination of these maps that the turtles engaged in extensive movements within the watercourses in the area. Calculation of movements in the CH2M Hill study was made by direct measurement off of maps in the report with calipers. Distances were calculated as minimum straight-line distances and are subject to some measurement error. Maximum and mean distances moved should therefore be expected to vary from figures presented in the CH2M Hill report (CH2M Hill, 1994).

Turtle # 001 was a male tracked from 14 June to 02 September 1993. The average distances moved per day was 12.8 m, and the greatest distance moved per sampling period was 171 m between 09 July and 14 July. The average distance moved per movement was 58 m. Movement was observed on 80% of the occasions monitored. The total distance moved by this animal was 870 m in 80 days.

Turtle # 002 was a male tracked from 16 June to 02 September 1993. The average distance moved per day was 22.6 m, and the greatest distance moved per sampling period was 177 m between 05 and 07 July. The average distance moved per movement was 105.7 m. Movement was observed on 92.4% of the occasions monitored. The total distance moved by this animal was 1269 m in 78 days.

Turtle # 003 was a male tracked from 16 June to 16 August 1993. The average distance moved per day was 54.3 m and the greatest distance moved per sampling period was 807 m between 08 and 12 July. The average distance moved per movement was 220.8 m. Movement was observed on 78.9% of the occasions monitored. The total distance moved by this animal was 3.31 km in 61 days.

Turtle # 004 was a non-gravid female tracked from 14 June to 15 August 1993. The average distance moved per day was 13.1 m and the greatest distance moved per sampling period was 194 m between 02 and 11 August. The average distance moved per movement was 87 m. Movement was observed on 100% of the occasions monitored. The total distance moved by this animal was 785 m in 60 days.

Turtle # 005 was a gravid female tracked from 16 June to 02 September 1993. The average distance moved per day was 8.9 m, and the greatest distance moved per sampling period was 134 m between 20 and 27 June and again between 06 July and 02 August. The average distance moved per movement was 55 m. Movement was observed on 84.7% of the occasions monitored. The total distance moved by this animal was 697 m in 78 days.

Turtle # 006 was a gravid female tracked from 21 June to 13 August 1993. The average distance moved per day was 21.9 m, and the greatest distance moved per sampling period was 752 m between 30 June and 05 July. The average distance moved per movement was 129.2 m.

Movement was observed on 75% of the occasions monitored. The total distance moved by this animal was 1163 m in 53 days. One false nesting movement was noted on or about 12 July.

Turtle # 007 was a male tracked from 20 June to 02 September 1993. The average distance moved per day was 22.0 m, and the greatest distance moved per sampling period was 154 m between 23 and 25 June. The average distance moved per movement was 71.2 m. Movement was observed on 86.6% of the occasions monitored. The total distance moved by this animal was 926 m in 42 days.

Turtle # 008 was a male tracked from 21 June to 13 August 1993. The average distance moved per day was 39.8 m, and the greatest distance moved per sampling period was 3 10 m between 06 Aug and 10 August. The average distance moved per movement was 169 m. Movement was observed on 100% of the occasions monitored. The total distance moved by this animal was 2337 m in 53 days.

Turtle # 009 was a male tracked from 12 July to 02 September 1993. The average distance moved per day was 20.2 m, and the greatest distance moved per sampling period was 295 m between 06 and 10 August. The average distance moved per movement was 147.2 m. Movement was observed on 63.6% of the occasions monitored. The total distance moved by this animal was 1031 m in 51 days.

Turtle # 010 was a male tracked from 24 July to 15 August 1993. The average distance moved per day was 3 1 .0 m, and the greatest distance moved per sampling period was 301 m between 24 and 29 July. The average distance moved per movement was 114.1 m. Movement was observed on 85.7% of the occasions monitored. The total distance moved by this animal was 683 m in 22 days.

Discussion

As is obvious from the results above, there is tremendous variability in movement within and among the sexes and within and among habitats. There are several caveats that should be noted as a part of any discussion of movements. First, there is obviously some degree of measurement error in the data discussed above. As previously noted, locations determined by telemetry were plotted on maps divided into ten by ten meter quadrats. While in some cases the exact location within this quadrat could be determined (such as at Site OR 050 U), in other cases the location is an approximation. As such, an animal determined to have moved from one quadrat to another could have moved as little as two meters or as much as eighteen meters. Without a radically different data collection technique, this level of measurement error must be accepted. In relation to other studies, this level of accuracy is on the "high" end, intermediate between the five meters quadrats used by Brewster and Brewster (1992) for juvenile *Clemmys insculpta* and the 500 m intervals used by MacCullough and Secoy (1983) in a study of a riverine population of *Chrysemys picta belli.*

Second, the summary estimates of movements are generally conservative. Calculated distances between sampling points are minimum straight-line distances. Obviously, in many cases turtles do not move in a straight line between areas, as numerous field observations indicate. As such, the actual distance moved is generally considerably greater than the "calculated" distance moved.

Third, only adults were tracked in this study. While adults comprise the majority of a population in most instances, movements of juvenile turtles of almost all species remain little studied and poorly understood. For example, Brewster and Brewster (1992) have shown that juvenile wood turtles *(Clemmys insculpta)* may make movements of up to 500 m, although the average movements are considerably smaller. Determination of the movements of juvenile western pond turtles will form a critical part of any overall management effort for this species.

Fourth, the collective sample size on this project, although greater than on any other species of freshwater turtle studied to date, in most cases represents only a small and select fraction (in most cases) of the turtles present in these areas. Furthermore, the time frame (summer) in which these studies were conducted as discussed above represents only a fraction - perhaps as little as 20% or as much as 50% - of the turtles normal activity period. While studies continue on movements outside this season, extrapolation from these results should be cautious, as some data indicate that spring and fall movements differ significantly from summer movements.

Fifth, the problem of "lost" signals may well be significant. On several occasions during this study, signals were lost from an animal from one day to several weeks after release, or for extended periods of time during the course of normal monitoring. There are at least two possible explanations for this phenomenon. First, that the animal is in fact still in the general area but that the signal is "blocked" by the presence of rocks or other material. This has been observed at sites CA 014 K and OR 017 U. However, in most cases at most sites this is unlikely, based upon the nature of the terrain. The second explanation is that the animal has moved out of the normal reception range of the receiver - approximately 200-300 m under normal circumstances. Based upon field observations and other information, this is the most likely explanation. Data from several sites indicate that daily movements in excess of 400 m are not uncommon, and it is likely that animals may move significantly further than this. The result of this is again that calculated movements may be very conservative, and may well under-represent actual movements.

Sixth, and perhaps most important, is that the results of this study were derived from only two seasons research - effectively slightly less than two years. For an organism such as the western pond turtle with a complex life history and long-life span (40+ years), considerably more information needs to be collected to form an adequate empirical data base from which to derive and develop sound short- and long-term management practices. Irretrievable commitments of resources and effort based upon one years data run a very high - indeed an unacceptable - risk of being inadequate or possibly even counterproductive. As is apparent from many other aspects of this species life history, it is highly "plastic" in many respects. This plasticity, as represented in part by the variance in life history parameters, will be the primary driving force in designing adequate management and mitigation efforts for western pond turtles.

<u>Movements within riverine habitats</u> - Three sites - CA 010 K, CA 014 K and OR 017 U - are classified as riverine, upper perennial systems, as per the USFWS Classification system (USFWS, 1979). One site (OR 163 W) is classified as riverine, lower perennial. Previous work in riverine systems (Bury, 1972; Rathbun et al., 1992) have indicated that turtles may move extensively within these areas. For example, Bury (1972) found that animals at a stream site in northern California may move as far as 1550 m in one summer. In short-term movements (O-94 days), males appeared to move further distances than females or juveniles, but there is no apparent correlation between the distance moved and the time involved, regardless of size or sex. Data from long-term movements (> 1 year), however, indicated that males typically move 2-2.5 times as far as females and 2 times as far as juveniles. Rathbun et al. (1992) note that two of four gravid females at a stream site in central California made upstream movements of approximately 1

and 2 km to move out to nesting areas. In one case, one female moved approximately 1.5 km upstream in a three-day period. Observations from a stream site in southern California (B. Goodman, pers. comm.) indicate that females may move over 1 km upstream to move out to a nesting area.

Our data indicate that on the average, males move further and more frequently than females. At Site CA 014 K (Fig. 2), the two males transmittered moved an average of 128 and 188 m/day respectively, and movements were noted on all but four and six of the days monitored, respectively. Movements of five gravid females averaged only 21.27 m/day. At site OR 017 U, females in 1992 averaged 29.97 m/day, while the non-gravid female averaged 27.8 m/day and the two males averaged 5 1.1 m/day. For site CA 0 10 K the movements were tracked on a weekly basis, but gravid females averaged 12.96 m/day, while non-gravid females averaged 16.5 m/day and males averaged 22.15 m/day. Given that these movement figures include movement(s) upstream and/or downstream to nesting areas for the gravid females, the "average" daily movements would be considerably lower for this group if it were possible to "factor out" this situation. While the extent of the movements are interesting, the apparent pattern in the nature of the movements may yield some insight into the daily and seasonal activities of the animal. Based upon observations and data from both sites CA 014 K and OR 017 U, some similarities and differences emerge. At site CA 014 K, gravid females seem to remain in a given pool, engaging in only short upstream or downstream movements in the period immediately (< 1 week) prior to oviposition. In moving to the oviposition site, the animal may move anywhere from a few dozen to several hundred meters within the watercourse in a single day or over a period of a few days - turtle # 1870 moved 536 m downstream sometime between 02 July and 07 July (Fig. 3). Turtle # 7621 moved 301 m downstream on 30 June, and then moved out to an oviposition site. Similar patterns were displayed by other animals. At site OR 017 U, the pattern is perhaps similar. Turtle #'s 7216 and 7217 were captured in the same pool approximately 250 m downstream from the nesting area at this site, and moved to the pool adjacent to the nesting area between 30 May and 06 June 1992. In 1993, all gravid turtles were captured in refugia in the immediate vicinity of the pool adjacent to the nesting area. Movements prior to nesting were very limited - often only a few meters in the course of a day. The general pattern seems to be that females may remain in a "home" pool, in which they spend the majority of their time, and engage in short-duration, long-distance movements to the pool adjacent to the nesting area. The animal may remain in this pool for a period of several days to over a week, and then move out to nest. Alternately, she may move out to nest almost immediately upon reaching the pool adjacent to the nesting area. This apparent "clustering" of gravid females in a given pool seems to be a general pattern and has also been noted at other sites in the same drainage as Site OR 017 U. Interestingly, all nesting areas surveyed in this system in 1992 and 1993 were adjacent to large, generally deep pools. Movements of gravid females in the pre-oviposition period seem to be generally small-scale and often centered near a basking or refuge site adjacent to the nesting area. Interestingly, a similar pattern was noted at a series of pond sites in Washington in 1990 (Holland, 1991b). Post-ovipositional movements are more extensive, and the animal may or may not return to the "home" pool within a short period of time. Movements of both males and non-gravid females in the same time period are more extensive and frequent. Males apparently engage in short-distance movements both upstream and downstream from a give pool site on a frequent basis. Turtle # 7219 made numerous movements of less than 100 m between late June and early August 1992 at Site OR 017 U (Figure 4). These movements centered around the same pool inhabited by the gravid females # 7216 and # 7217, who exhibited much less frequent and extensive movements (Fig. 5 , Fig. 6). The non-gravid female (# 3 105) made a series of movements intermediate in both frequency and distance between the male and gravid females (Fig. 7). In 1993, turtle # 7217 was again gravid and exhibited a similar movement pattern (Fig. 8). Turtle # 3 105 was again not gravid, and again made movements (Fig. 9) that were slightly more extensive than # 7217, but that did not approach the movements made by males (Fig. 10).

Movements at site CA 010 K are somewhat more difficult to interpret, given the sampling protocol (see above), but reflect the same general pattern. Male # 335B displayed extensive movements throughout the monitoring period in both 1992 (Fig. 11) and 1993 (Fig. 12). Female # 215 displayed movements in 1992 that are slightly more extensive than gravid females in other areas, but not significantly so (Fig. 13). In 1993, the movements of this animal decreased significantly (Fig. 14), and appear to resemble more closely the movements noted at site OR 017 U. Movements of turtle # 868, a non-gravid female in 1992, were also somewhat atypical, with very little to no movement exhibited during the monitoring period (Fig. 15). The differences in mean daily movements between sites (14.94 m/day for CA 010 K in 1992 as opposed to 27.23 m/day for OR 017 U) is likely the result of the sampling protocol rather than any real difference in movement patterns. This is supported by the results of a comparison of mean daily movements between males at the two sites (22.4 m/day for CA 010 K, 51.1 m/day for OR 017 U).

Reduction of movement data from site OR 163 W was not possible as this data was not provided by the USFWS, but some information collected is relevant to a larger question - that of "lost" signals and the possibility of very long-distance movements by turtles. It is likely, based both upon data from site OR 163 W and observations at a number of other sites, that a significant percentage of each population - usually males - may engage in very long-distance movements within a riverine system. Observations from Site OR 017 U in 1992 indicated that one animal had moved over 1 km downstream within 1 week after release, and the signal was lost shortly after that time. The immediate loss of signal from both males after the release at site CA 014 K indicates that they likely moved out of the study area immediately. Intensive and extensive efforts to locate these animals within the 3.5 km stretch of the stream in the study area were not successful. A critical question then becomes - How far do these animals move? In late August 1992, a large male was captured, fitted with a transmitter and released at Site OR 163 W. Within 3 weeks, the signal was lost. Extensive searches upstream and downstream for a distance of over 2 km failed to produce any trace of a signal. It was not until over a month later that the signal was re-acquired - approximately 5 km (straight-line) distance upstream from the original point of release. Moving through the watercourse, the distance approached 7 km. This animal returned to near the original site of capture in spring 1993, and exhibited the same pattern in the fall of 1993, moving away from the original capture site within 4 days of the date he moved in 1992. This animal has returned to the general area where he over-wintered in 1992-1993.

<u>Movements within lacustrine/palustrine habitats</u> - Four sites - OR 002 U, OR 050 U, OR 039 W, and OR 001 C - qualify as approximately "natural" lake/pond habitats and will be discussed separately from reservoir habitats. There are no published studies of western pond turtle movements in these types of systems. The results from this portion of the project are interesting in several respects. First, both the average daily movements and extent of movements within these systems does not appear to vary significantly among the sexes. At site OR 002 U in 1992, daily movements of gravid females averaged 185.5 m, while non-gravid females moved an

average of 188.7 m/day. Males, interestingly, moved only slightly more, averaging 194.5 m/day (Fig. 16). In 1993, only non-gravid females were tracked, and the moved an average of 109 m/day, while males moved only 110.1 m/day (Fig. 17). Similar results are present for Site OR 050 U, the "created" pond in the Umpqua drainage. Gravid females at this site averaged 42.2 m/day, while non-gravid females averaged 45.5 m/day and males averaged only 36.9 m/day (Fig. 18). At site OR 039 W, only gravid females were tracked, who averaged 40.8 m/day (Fig. 19). At site OR 001 C, the gravid female moved an average of 68.9 m/day, while non-gravid females averaged 96.88 m/day, and males moved 91.6 m/day (Fig. 20).

A second major point is that the *pattern* of movement does not appear to vary significantly among the sexes in these habitats. Turtle # 7247, a gravid female, moved frequently and extensively within the lake habitat at Site OR 002 U from the initiation of tracking in early June to the termination of tracking in early August (Fig. 21). Turtle # 7202, a male tracked during the same time period, showed little apparent difference from # 7247 (Fig. 22). Similar results are shown in the movements of # 7246, another gravid female (Fig. 23), although her movements are slightly more periodic. Turtle # 5524, a non-gravid female, shows slightly less extensive and more periodic movements (Fig. 24). Interestingly, the movements of animals # 7246 and # 7247 in 1993 show a significant difference, as might be expected from the average daily movements in 1993. Movements tend to be more cyclic, although their extent is not significantly different from 1992. The movements of turtle # 9909, a male tracked for the first time in 1993, show a similar pattern both in timing and extent (Fig. 25). Movements at site OR 050 U also show this pattern - extensive movements within the watercourse on almost all days monitored. Turtle # 7235 and # 7241 both display movements (Fig. 26 and Fig. 27) that are very similar to that displayed by non-gravid female # 7234 (Fig. 28) and gravid female # 7232 (Fig. 29). Movements of gravid females at site OR 039 W are also very similar across animals - compare the movements of turtles # 7501 (Fig. 30) 4851 (Fig. 31), 4855 (Fig. 32) and 4854 (Fig. 33). Movements of turtles at Site OR 001 C follows a generally similar pattern as well, with turtle # 7405, a gravid female, moving an average of 68.9 m/day (Fig. 34). While this figure is lower than for the other classes, this may well be an artifact of the small sample size (1). Movements of turtle # 4906, a male, follow the same general pattern of # 7405 (Fig. 35) the movements of a non-gravid female (# 4913) are much more extensive and frequent (Fig. 36).

A third point is that the daily movements of the turtles in these systems cover the majority of the habitat in small-medium size ponds. Tracking and visual observation data from both small pond sites (OR 050 U and OR 039 W) and the medium-sized pond site (OR 001 C) indicate that the turtles move freely among almost all portions of the pond in the course of the day. Observations from Site OR 001 C may indicate that the turtles "track" the appearance of sunlight on the emergent vegetation basking sites, moving from the west side of the pond in the morning to the east side of the pond in the late afternoon. The orientation of the ponds at Site OR 050 U does not require such movements, but turtles move freely within the entire area of the pond on a daily basis. Similar results were noted from Site OR 039 W. It is apparent from the tracking and visual survey data that turtles in small and moderate-sized ponds effectively utilize the *entire* pond area in the course of a day, and do so with regularity. Anecdotal observations of repeated use of a particular basking site do not invalidate this claim, as turtles may utilize one basking site repeatedly during the course of the day and still move over a relatively large area. The calculated (and therefore linear) average daily movements of almost all animals within the smaller pond sites averages 80-100% of the greatest linear dimension of the pond. In the medium-sized pond, the average is approximately 60% of the greatest linear dimension but 200 % of the average width. For site OR 002 U, the results are slightly different. Although movements in this system averaged 197 m/day for all animals, the greatest linear dimension of the system is slightly over 150 m. Movements of most animals within this lake were essentially centered on the western side of the lake. This may represent a response to frequent human disturbance on the eastern edge, or may reflect the presence of more basking and refuge sites on the western side.

Movements within large-scale artificial lacustrine habitats - The two reservoir sites, OR 082 W and OR 097 W, present an interesting contrast, Movements tracked at site OR 082 W indicate that the animals move extensively within the habitat on a daily basis, and average distance moved for all animals approximates 77 m/day (Fig. 37). In this case, males moved further on the average (87.7 m/day) than did gravid females (63.5 m/day) or the non-gravid female (61 m/day). Long-distance movements are considerably greater than at any other site, possibly because of the nature and extent of the habitat. Three of the seven animals tracked at this site made long-distance movements (>400 m), and the maximum distance moved was 867 m. At site OR 097 W, however movements averaged only 29 m/day (Fig. 38). In this area, the two males averaged only 8 m/day, the single non-gravid female 4 m/day, and the gravid females averaged 40.2 m/day. The difference in movements among the sexes at this site is likely related to the need to move a considerable distance to reach or return from a suitable oviposition site for the females, while the males and the non-gravid female were essentially sedentary. This contention is supported by the movements of three gravid females, who made 370, 600 and 380 meter movements, respectively. The difference in average movements between the two sites may well be tied to the nature of the habitat. The study area at Site OR 097 W consists of a series of small ponds along a river channel, somewhat isolated from the main body of the reservoir. The study area at Site Or 082 W, in contract, consists of a series of small "bays" or "arms" of the reservoir with little or no isolation from the body of the reservoir proper. Disturbance is likely to be more frequent at the latter site, and fluctuating water levels and their potential effect on the availability of prey, basking and refuge sites may also influence the nature and extent of movement.

Movements within disturbed wetland habitats - Much of the west Eugene area consists of a complex mixture of urban, industrial and degraded wetland habitats. Based upon the summer movements recorded by the ODOT consultants, it is obvious that extensive use of the area by western pond turtles occurs. Turtles were regularly found to have moved distances of several hundred meters over the course of a few days, with at least one turtle (# 003) moving over 800 m in a four day period. Examination of plotted movement data from the CH2M Hill report for the Golden Gardens population indicates that these turtles regularly move extensively throughout the majority of the borrow pit. Other data indicate that animals regularly move through heavily altered watercourses (i.e. roadside ditches, channelized watercourses), often over distances of several hundred meters, The extent of overland movements in these areas remains poorly understood, but it is obvious that at least this does occur on a fairly regular basis. The observation of two road-killed animals in the course of the project (June-August 1993) indicates that this may be a significant source of mortality to the population in this area.

Males in this area moved an average of 28.95 m/day, while the single non-gravid female moved 13.1 m/day and the two gravid females moved an average of 15.4 m/day. Although the habitat is arguably not in some ways similar, the logical comparison for this area is Site OR 002

U, a lacustrine site in the central Cascades. For the available data, the comparison indicates that turtles move far more extensively within Site OR 002 U than at the West Eugene Sites. Males at Site OR 002 U moved an average of 194.5 m/day in 1992, approximately 7 times as far as turtles at the west Eugene site. The disparity for gravid females is even greater, with animals at Site OR 002 U moving approximately 12 times as far on a daily basis. However, these results should be interpreted with caution because of the disparities in data collection methodology between the two sites (every two hours on a daily basis for site OR 002 U, one/day on an intermittent basis at the west Eugene sites). Movement data on representative turtles at the west Eugene site are presented in Figs. 39-43, and summarized in Fig. 44.

General Management Considerations regarding movement

There are several key points concerning movement that should be considered in formulating any overall management or mitigation strategy. Although some have been mentioned elsewhere, they bear repeating, and are briefly discussed below.

1. At present, there is not adequate data to formulate a detailed management and mitigation plan. As is shown by the very limited results from site OR 002 U, significant year-to year variation in the extent and pattern of movement may occur within a given site. Because of both practical and ecological constraints, it will require several years to develop an adequate data base to determine the variance inherent in these systems, and to integrate this information with other data to produce an accurate representation of the population dynamics of this species. Failure to adequately consider the variance in such as system runs a very high risk of fatally compromising the effectiveness of any short- or long-term management effort.

2. It is apparent that, based upon the existing information, management and protection efforts confined to a single portion of a watercourse, particularly the small-medium sized ponds, run a risk of producing impacts to the population in the system as a whole. Review of the movements of individuals turtles plotted at the west Eugene sites (CH2M Hill, 1994) and examination of the extent of movements at Sites OR 002 U, OR 050 U, OR 039 W and the COE reservoir sites indicate that extensive, long-range movements typically occur throughout the watercourse. As such, it may be difficult if not impossible to develop "multiple-use" strategies involving concurrent fishing, recreational, industrial and other activities at these sites without impacting western pond turtle populations. As we do not currently understand how to or even whether or not these activities can be "mitigated" to insignificance, the preferred strategy in these situations should be avoidance of impacts.

3. The data presented and discussed above cover only a portion of the year - specifically summer. Data concerning overwintering habitat use are presented elsewhere in this report. A general overview of the findings to date is appropriate. First, movements both in the spring and fall may well be more extensive, but perhaps not as frequent, as summer movements. Observations from some sites indicate that movement generally reaches a low ebb in late August, and then increases in September. However, at the west Eugene sites, extensive movements have been noted to occur throughout the summer, Second, individual movements may be far more extensive than reported above - several reports exist of movements approaching 1 km in a relatively short time period (1

week or less). Third, nocturnal movements are frequent, particularly in lake and pond habitats. In fact, much of the apparent decrease in late summer daily movements may be misleading, as extensive movements can and do occur at night.

4. Over-wintering behavior is now known to be far more variable than previously thought, although it remains poorly understood. Animals in some stream and river habitats apparently leave the water as early as September and move into upland habitats for periods of up to 10 months. In other cases, particularly in small ponds, the majority of the animals appear to overwinter in the watercourse (such as at site OR 002 U), usually in undercut areas along the bank. However, in some of these cases the surrounding terrestrial habitat has been altered - often by the removal of vegetation surrounding the watercourse (as at Sites OR 039 W, OR 050 U and the west Eugene sites). Thus, it is unclear whether or not this is a "natural" behavior, a forced response to the loss or alteration of terrestrial over-wintering sites, or a combination of both. In riverine habitats, turtles are known to overwinter in areas up to 500 m from the watercourse. Furthermore, extensive movement within the terrestrial habitat may occur during the winter, with some animals changing microsites several times others apparently remaining in the same location. As such, some activities such as late season timber harvest, road building, unseasonal fires, and recreational use may well impact populations of turtles at some distance from the watercourse.

5. Terrestrial movements that are not tied to over-wintering or reproductive behavior are also known to be more variable and extensive than previously thought, with animals as small as 80 mm having been observed in extensive terrestrial movements. Some animals may leave the water to move into terrestrial habitats during the summer, remaining in upland sites for one day to several weeks.

6. Movement among aquatic habitats is also now known to be far more extensive than previously thought, even in disturbed and degraded habitats such as the west Eugene wetlands area. Documentation of overland movement between watercourses has been noted at sites OR 001 C, OR 039 W, OR 002 U, OR 050 U and is likely to occur at all other sites. In some cases, turtles may follow existing microdrainage patterns in these movements. In other instances, it is obvious that turtles have engaged in overland movements that do not follow existing watercourses. As such, it is likely that protection and management efforts for this species confined to watercourses or "buffer" zones surrounding them may be inadequate to protect existing dispersal pathways and may also affect both short-term population dynamics and long-term gene flow. As such, protection of surrounding terrestrial habitats (for nesting, over-wintering and dispersal purposes) is of paramount importance to any protection and management effort.

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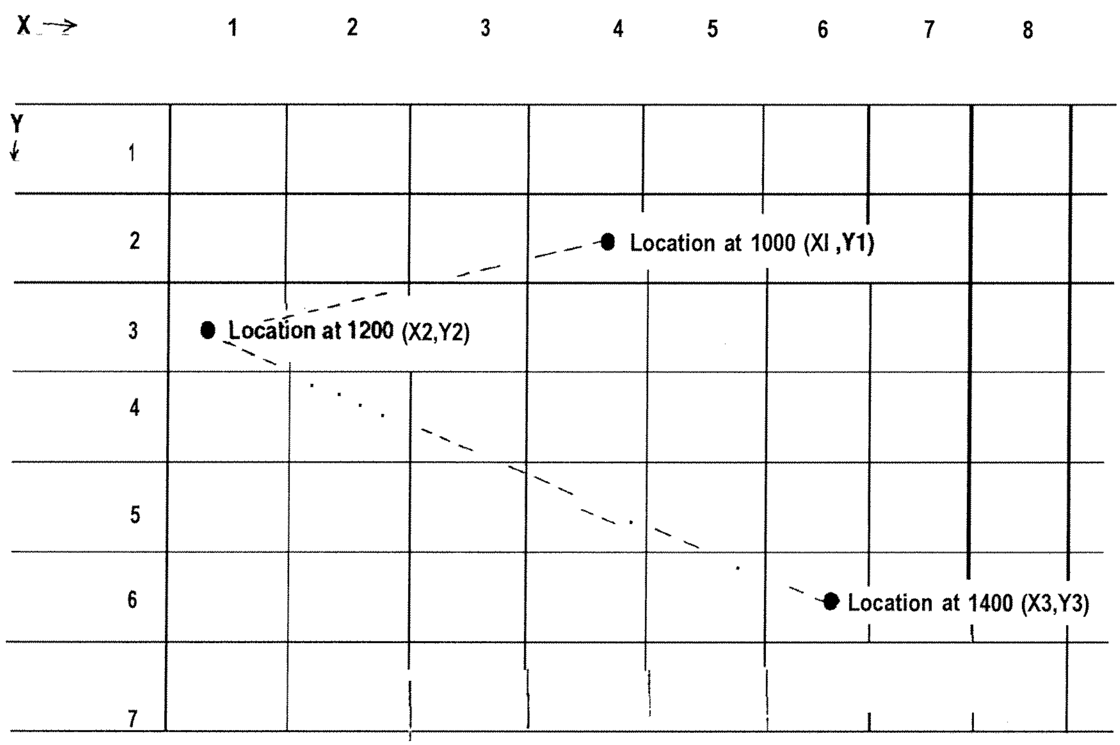

Distance moved 1000 -1200 = square root of ((abs(X1-X2)*10 • (abs(X1-X2)* 10) • (abs(Y1-Y2)*10) • (abs(Y1-Y2)*10))

Distance moved 1200 -1400 = square root of ((abs(X2-X3)*10 • (abs(X2-X3)* 10) • (abs(Y2-Y3)*10) * (abs (Y2-Y3)*10))

Figure 1: Method of calculating distance moved by turtles in a 10 x 10 m quadrat system. All calculated distances are the minimum straight line between any two points.

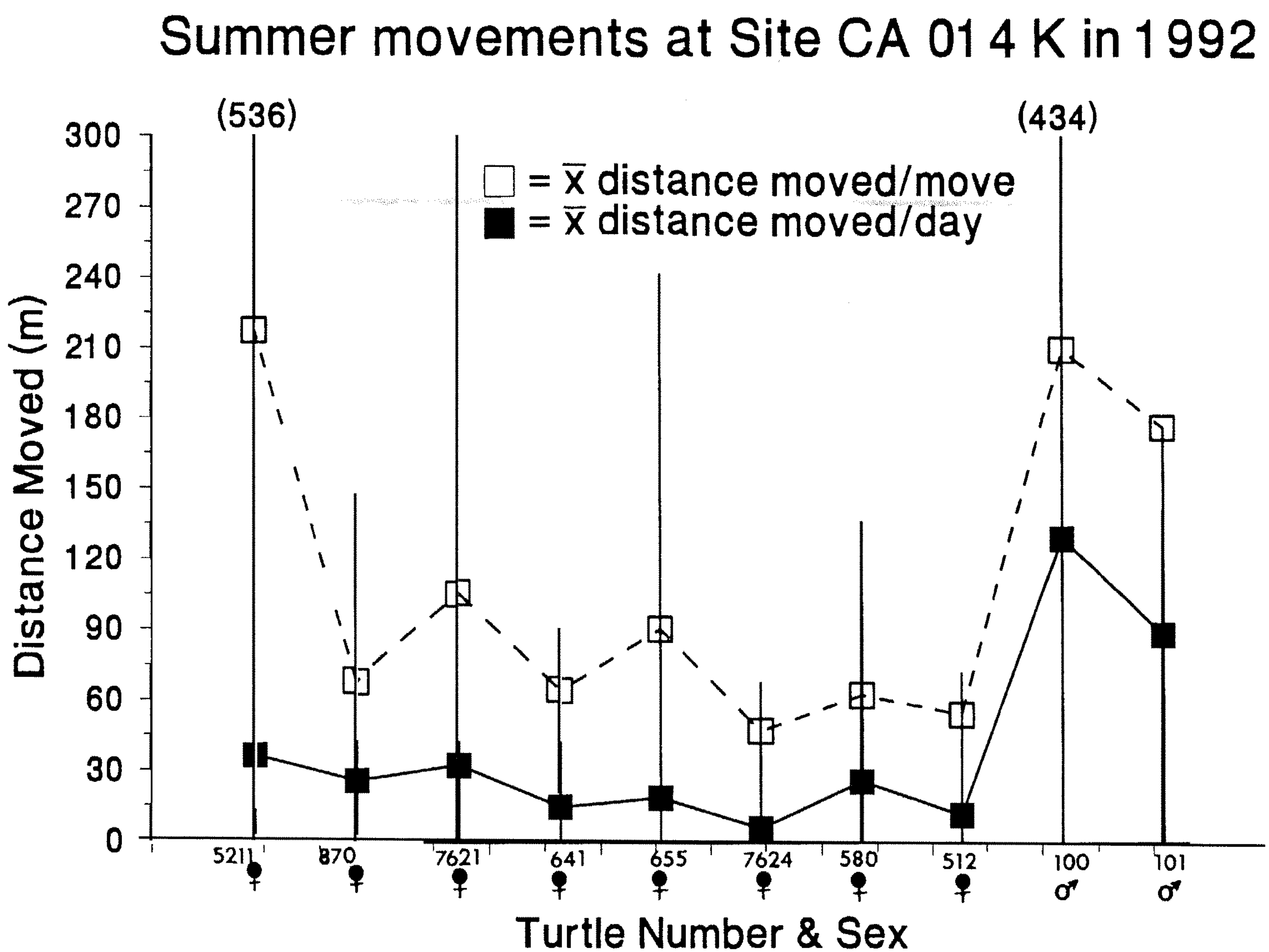

Figure 2: Summary of movement data from Site CA 014 K for summer 1992. Solid circles represent gravid females.

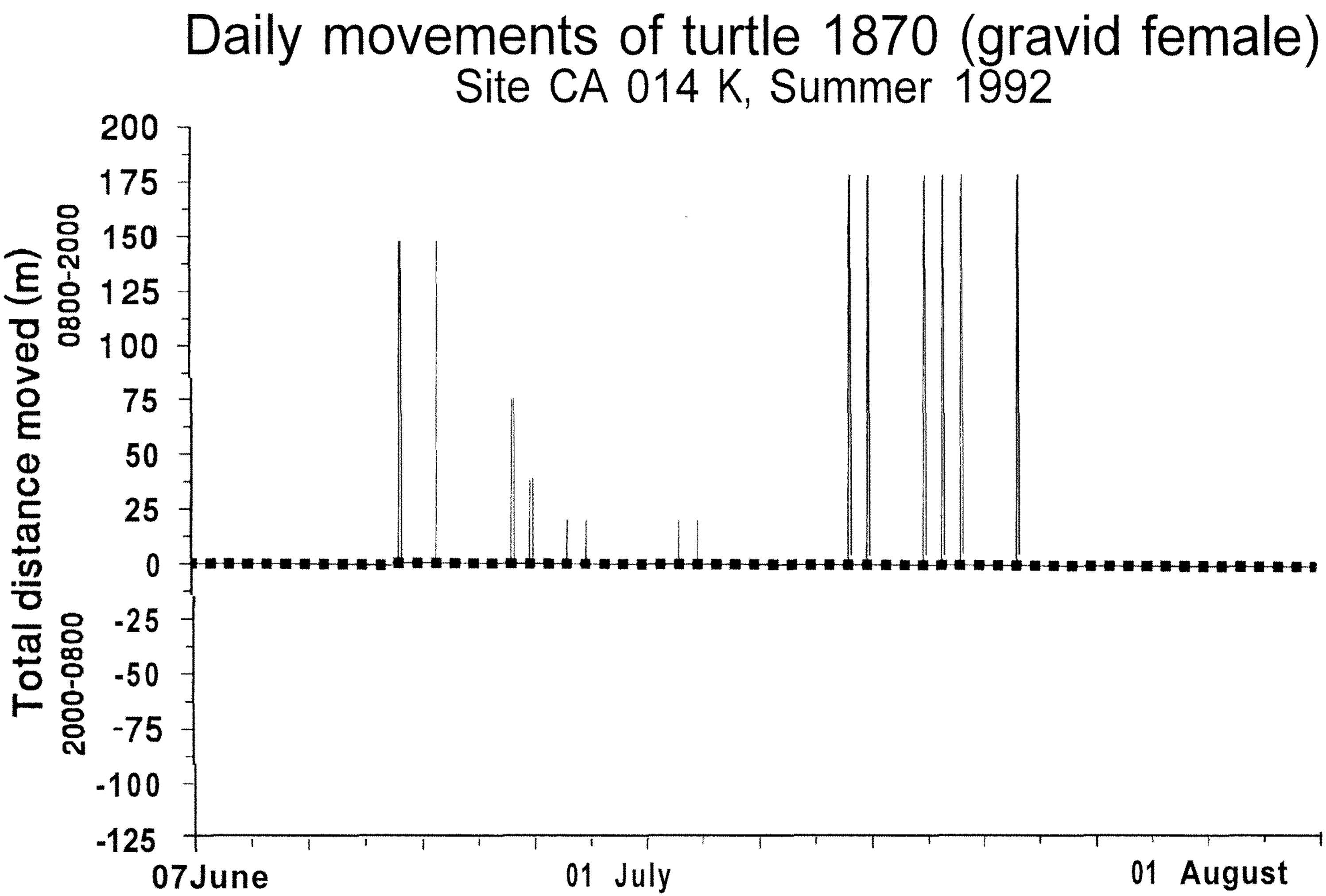

Figure 3: Summer movements of turtle # 1870 at Site CA 014 K in 1992.

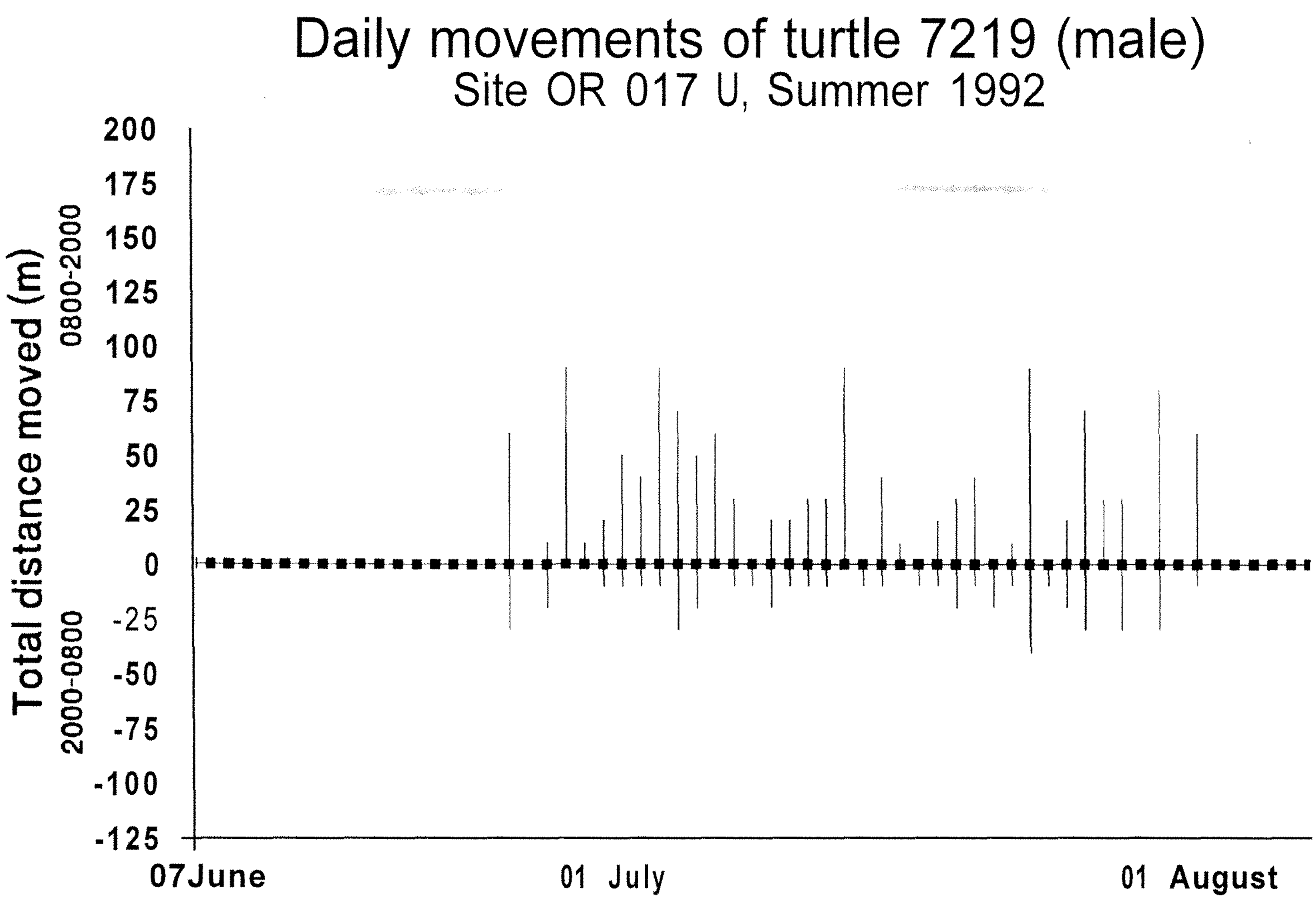

Figure 4: Summer movements of turtle # 7219.

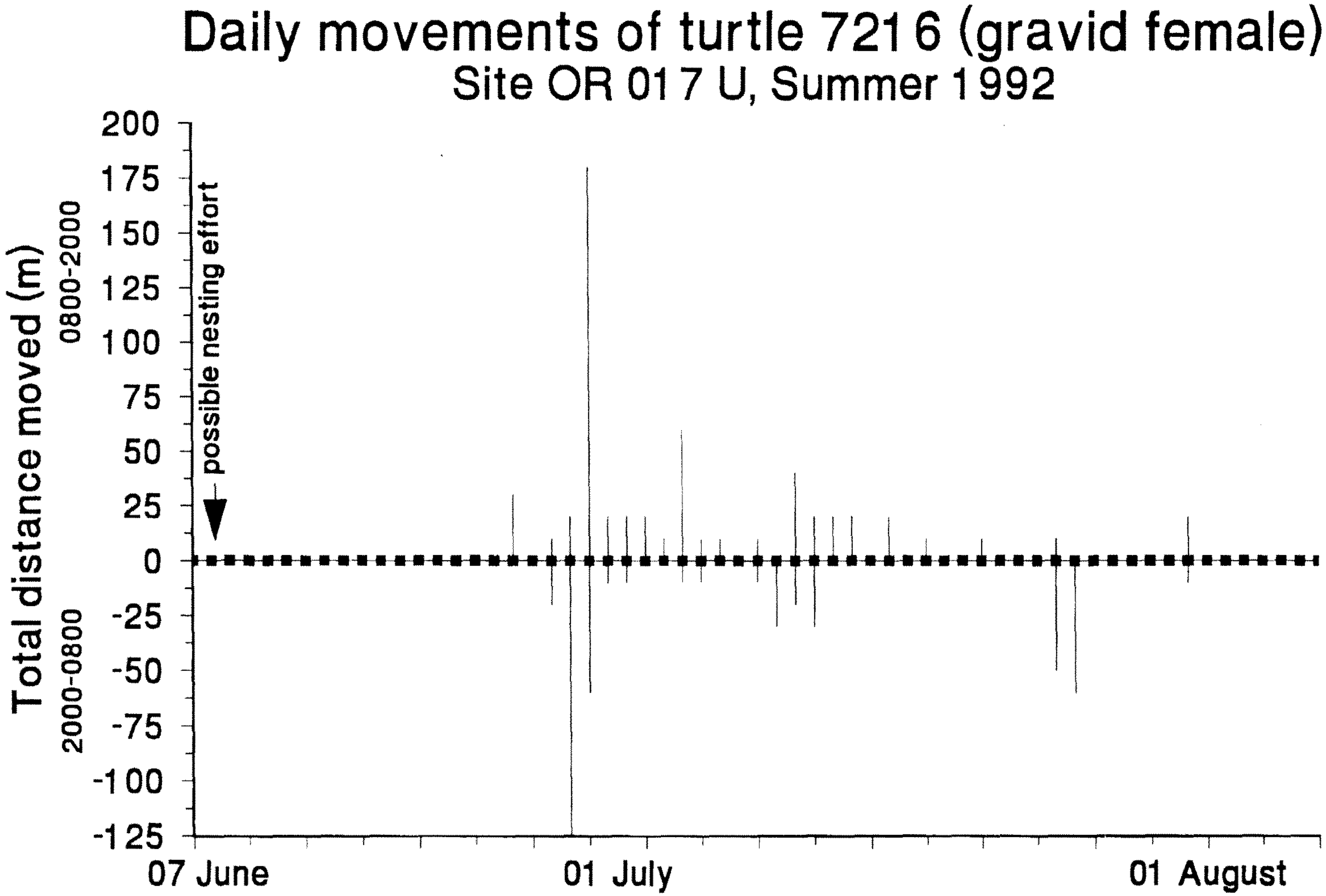

Figure 5: Summer movements of turtle # 7216.

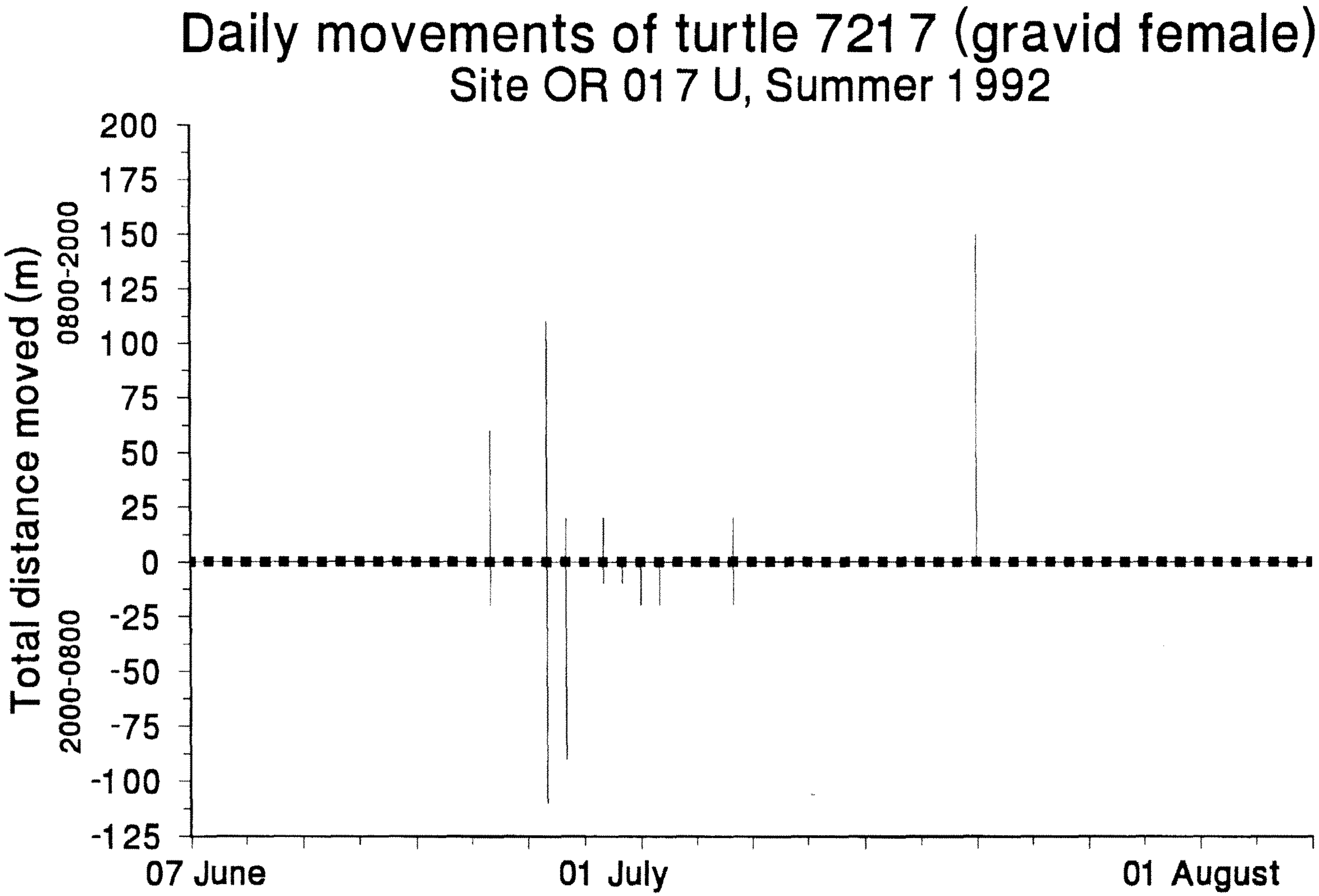

Figure 6: Summer movements of turtle # 7217.

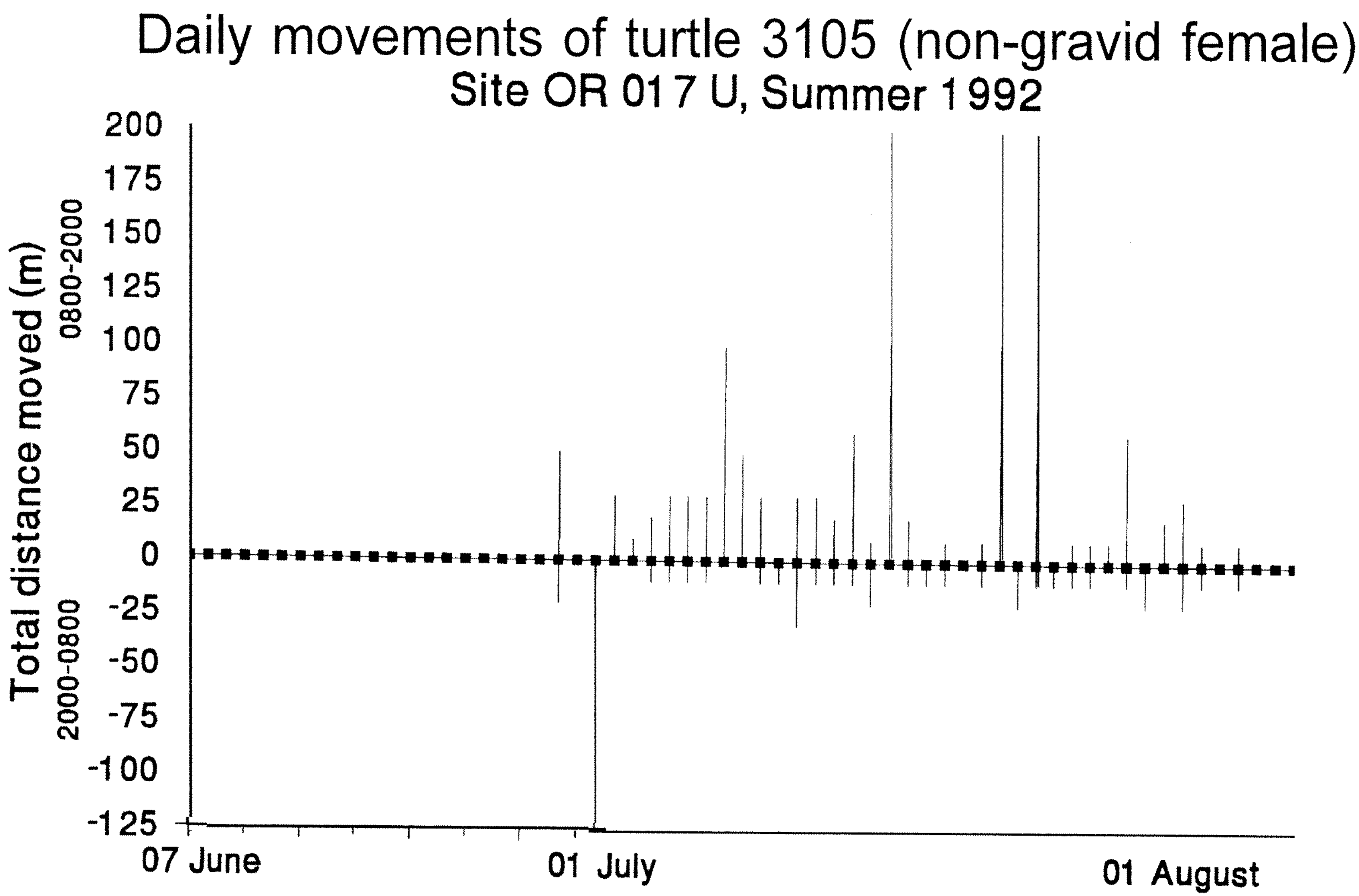

Figure 7: Summer movements of turtle # 3105.

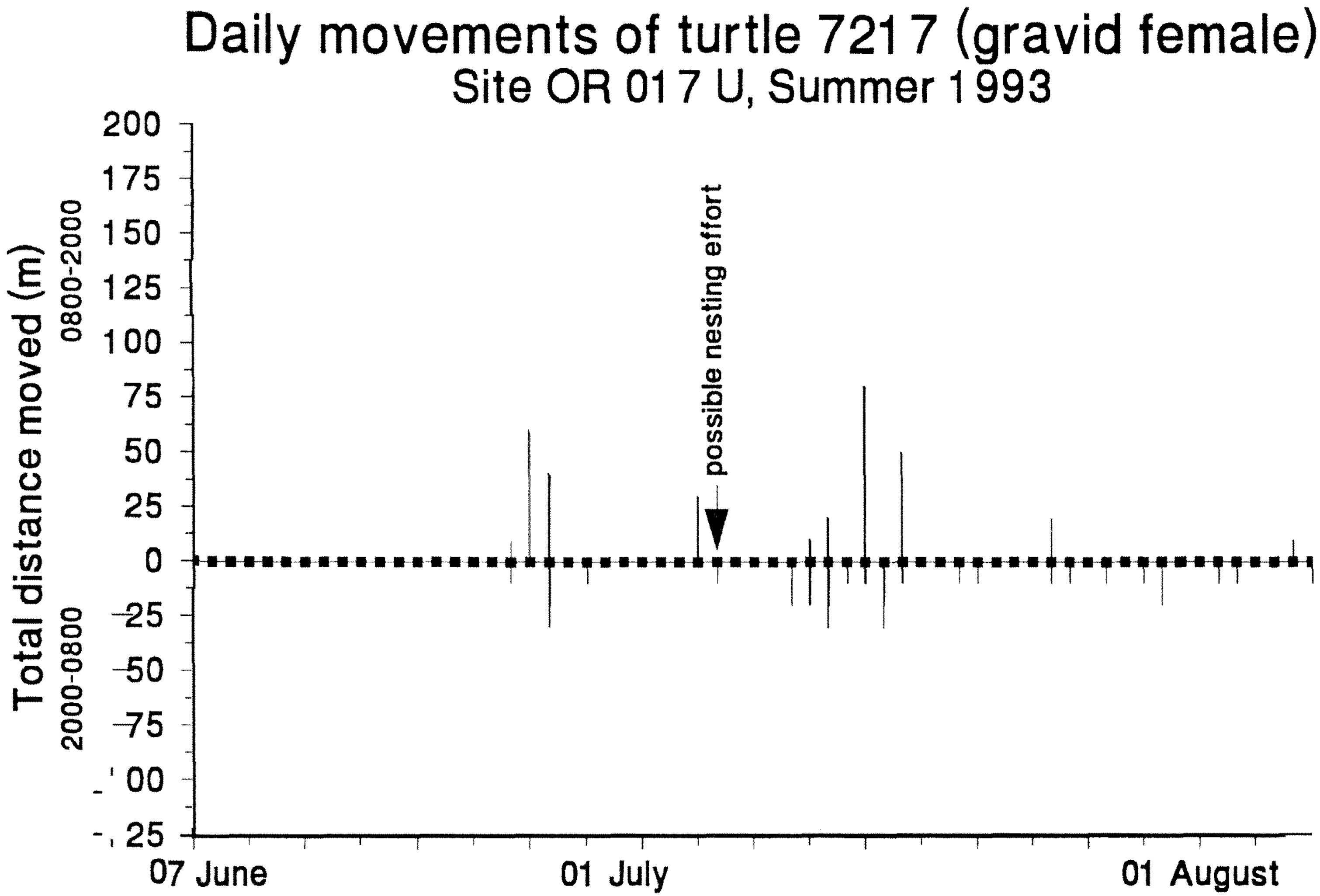

Figure 8: Summer movements of turtle # 7217.

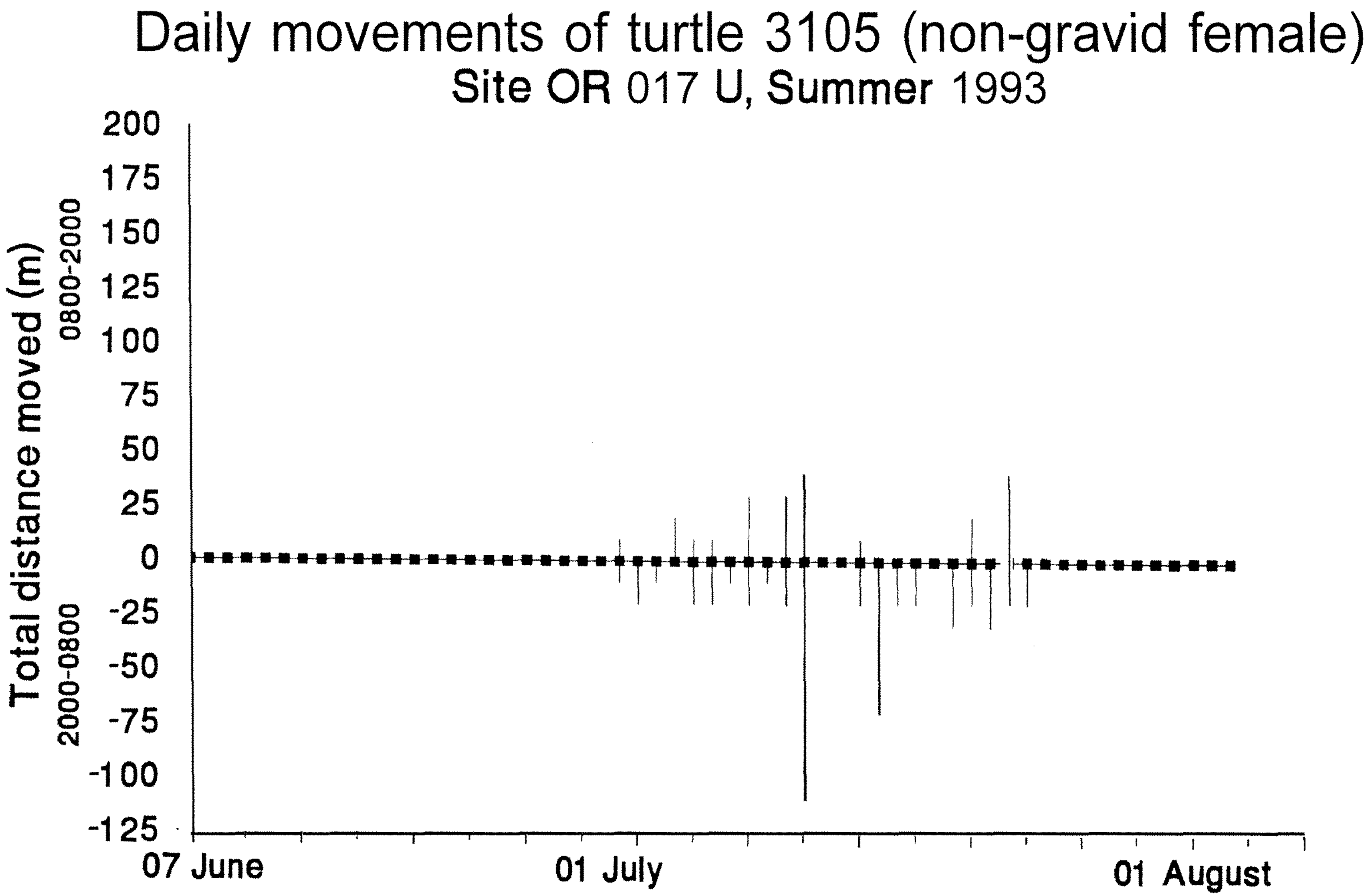

Figure 9: Summer movements of turtle # 3105.

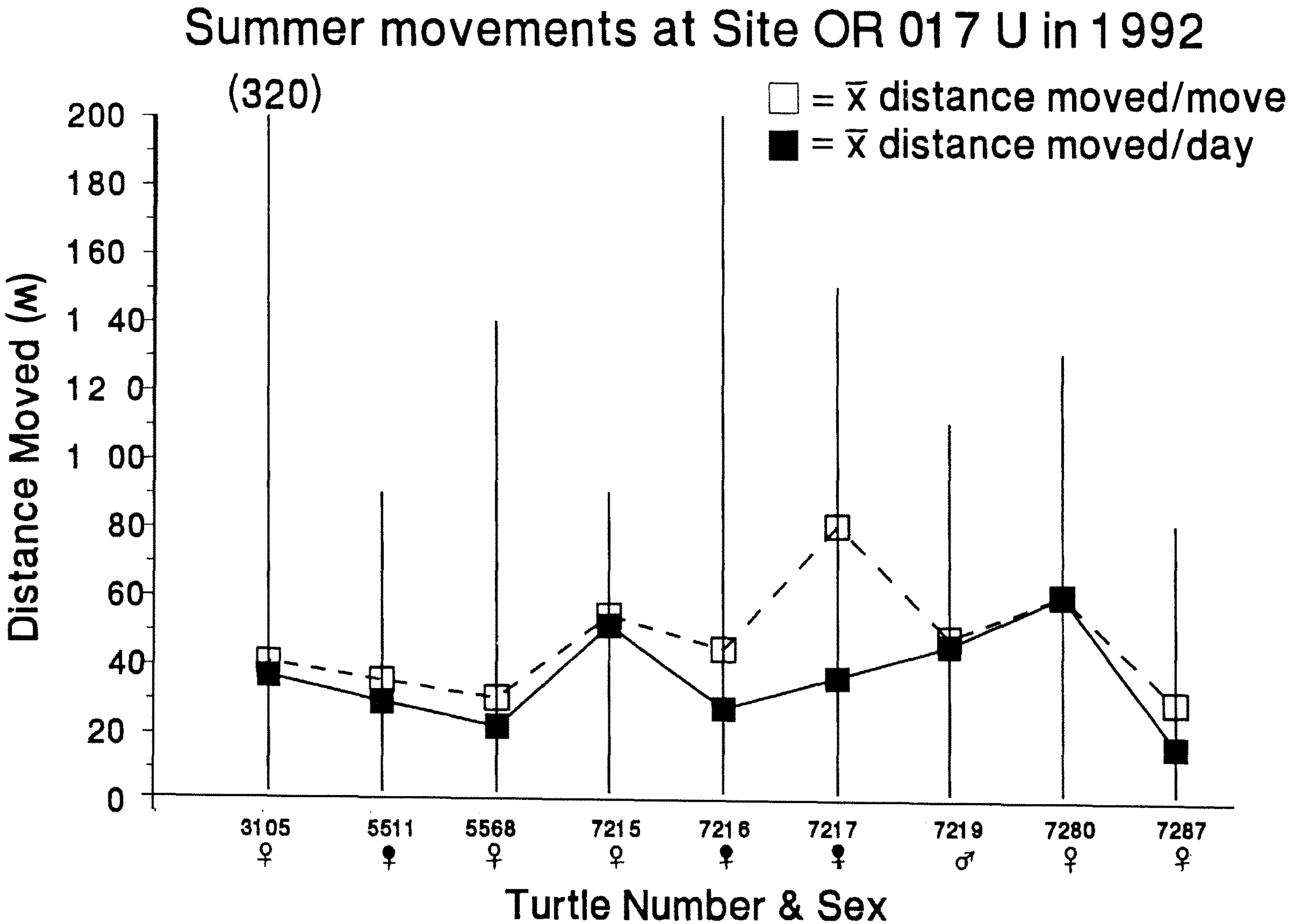

Figure 10: Summary of movement data from Site OR 017 U for summer 1992. Solid circles represent gravid females.

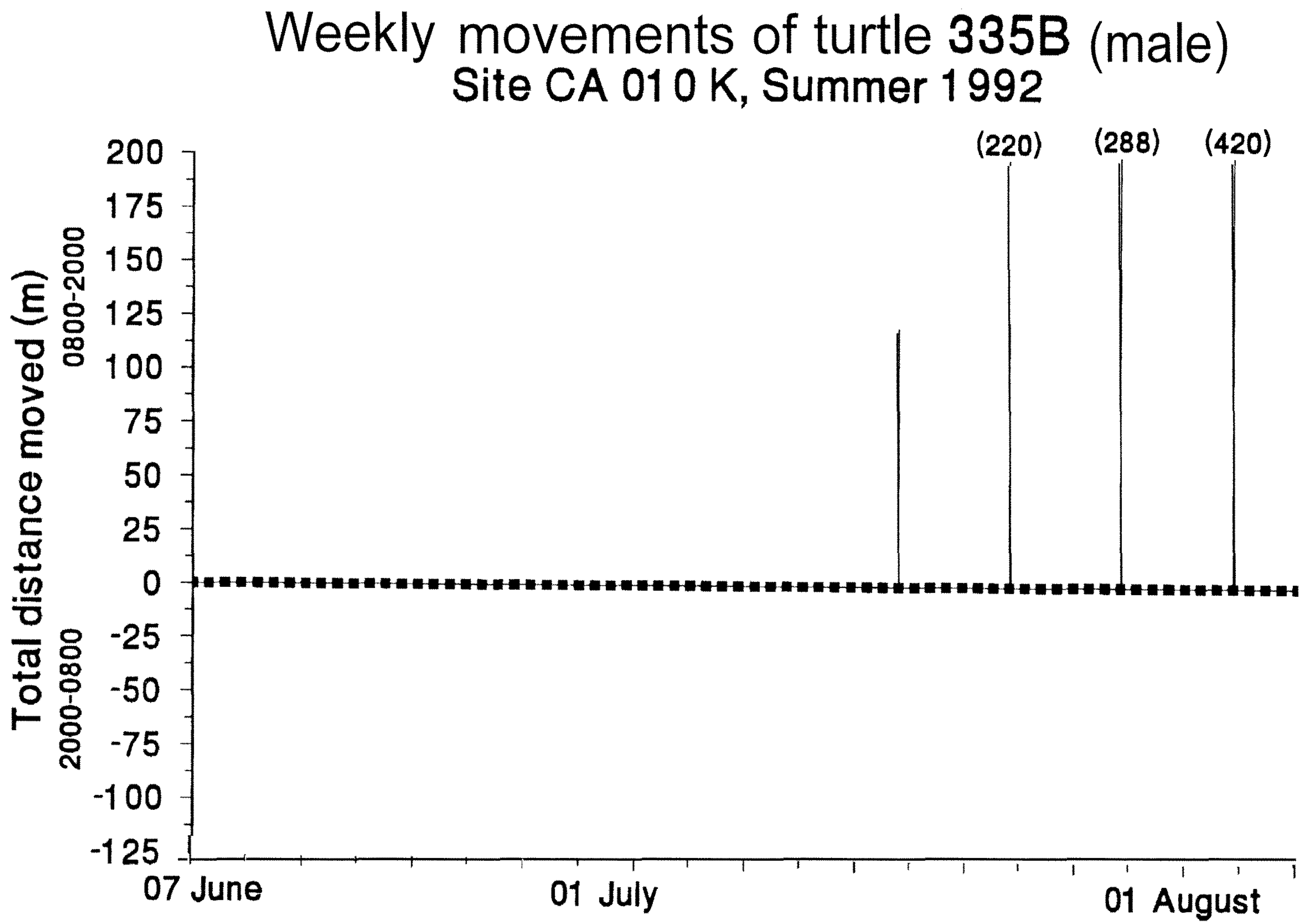

Figure 11: Summer movements of turtle # 335B.

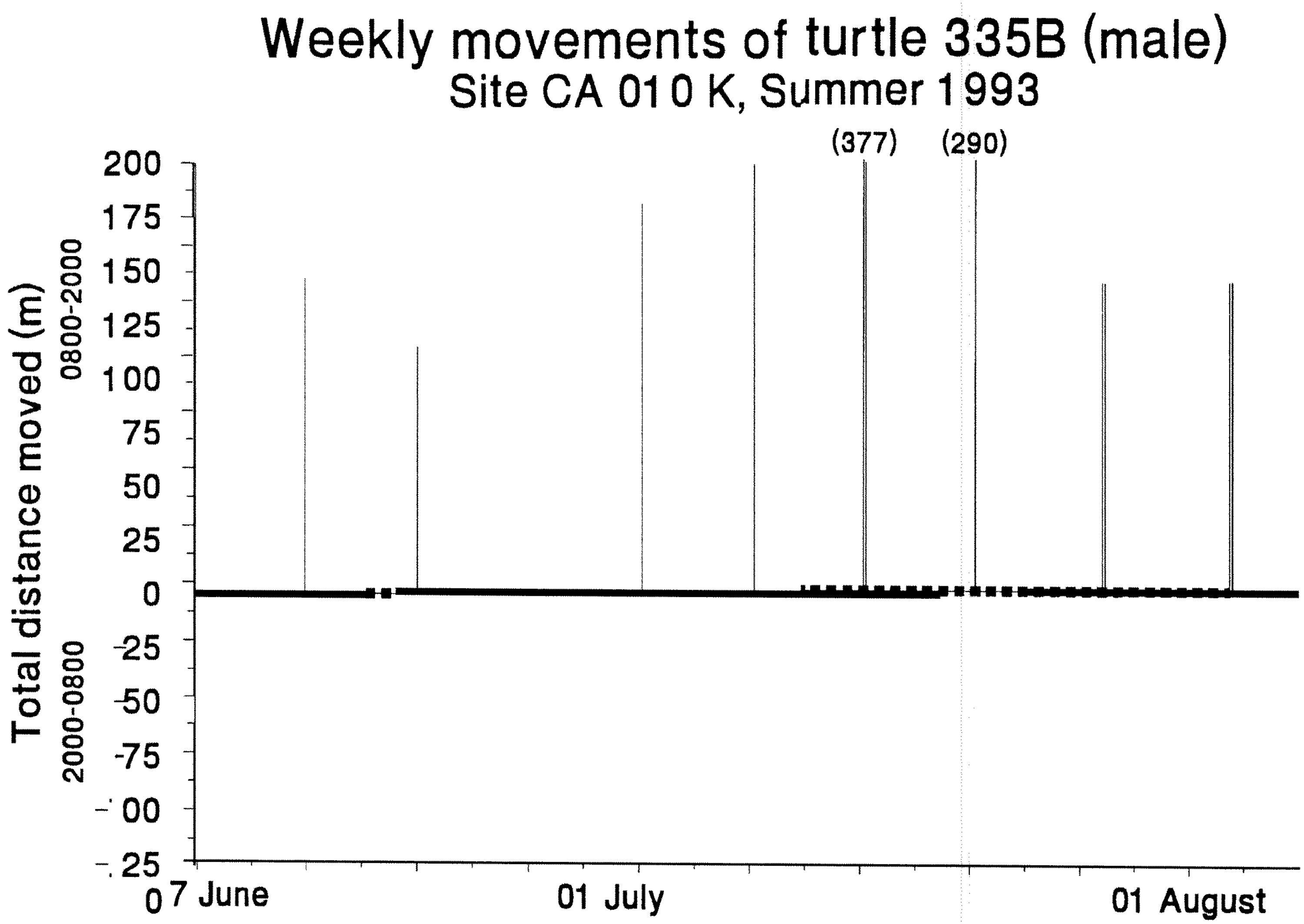

Figure 12: Summer movements of turtle # 335B.

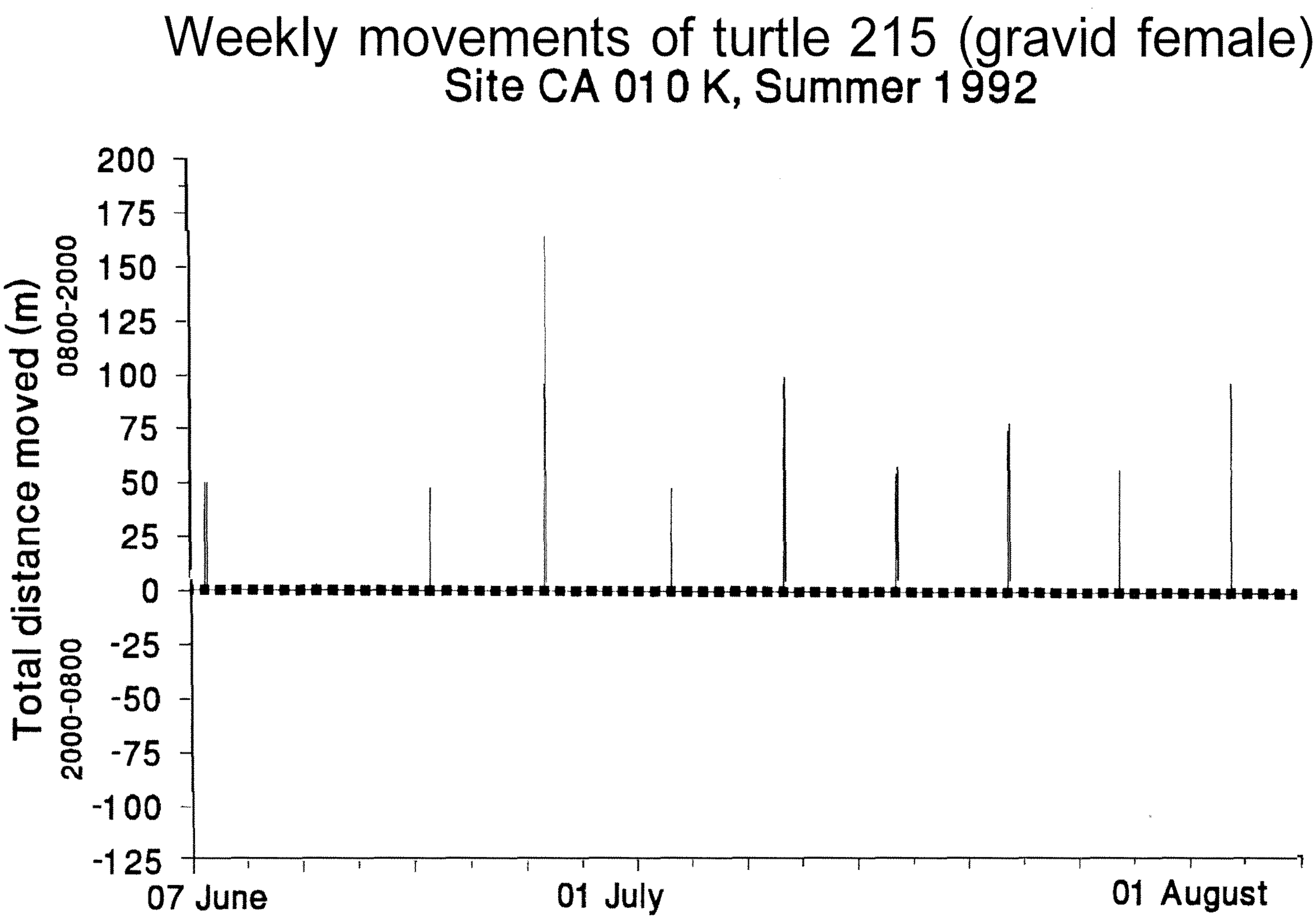

Figure 13: Summer movements of turtle # 215.

Weekly movements of turtle 215 (gravid female)
Site CA 010 K, Summer 1993

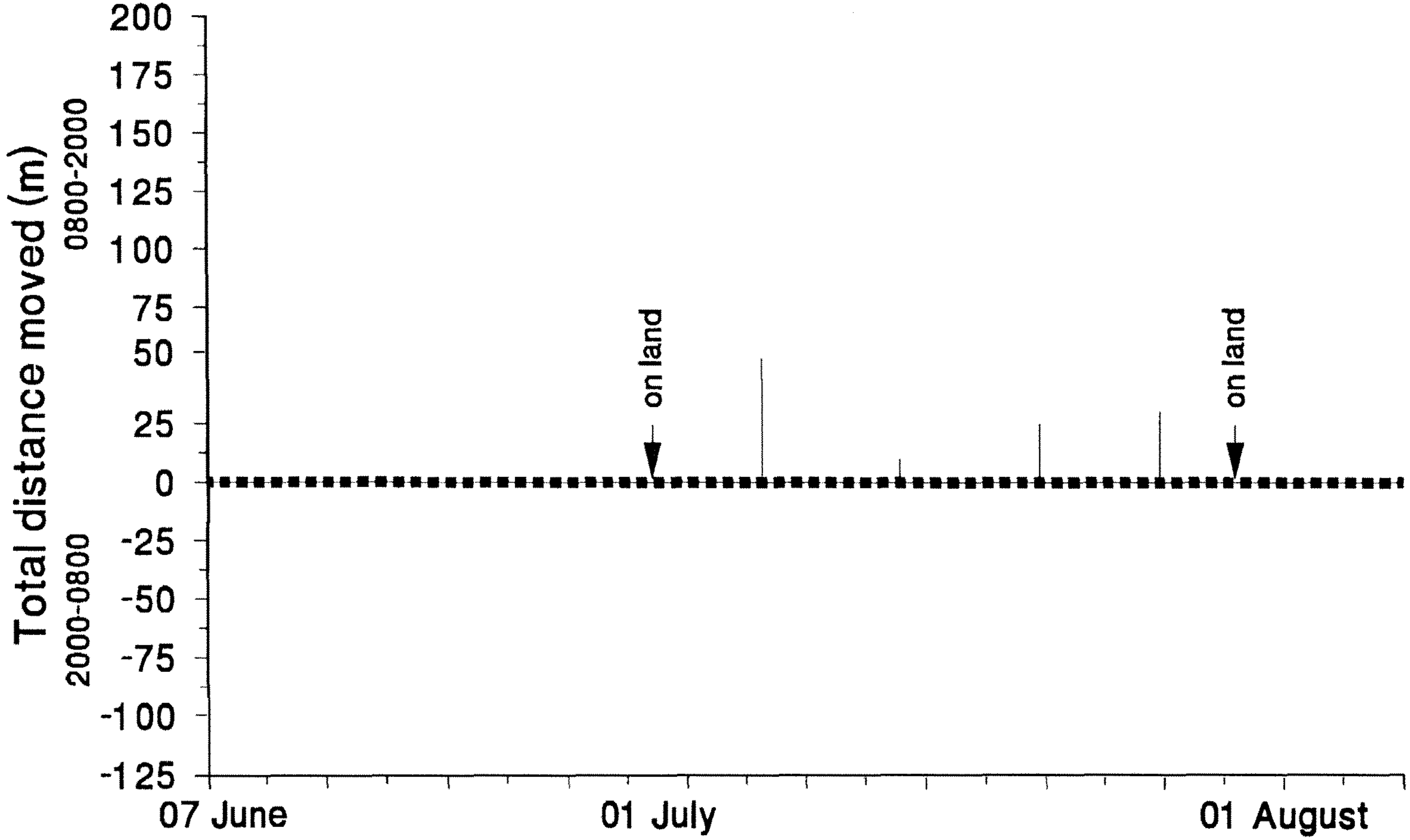

Figure 14: Summer movements of turtle # 215.

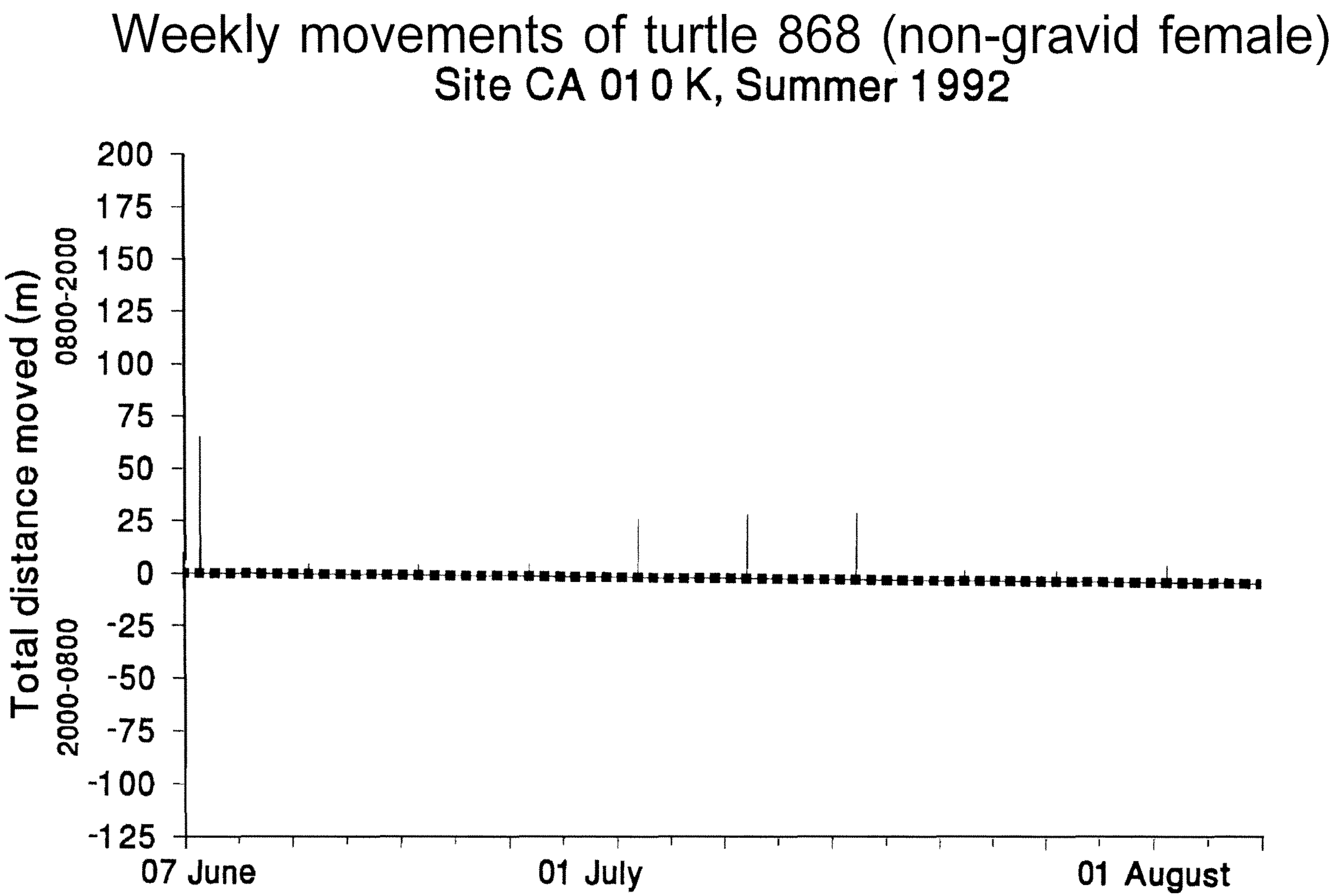

Figure 15: Summer movements of turtle # 868.

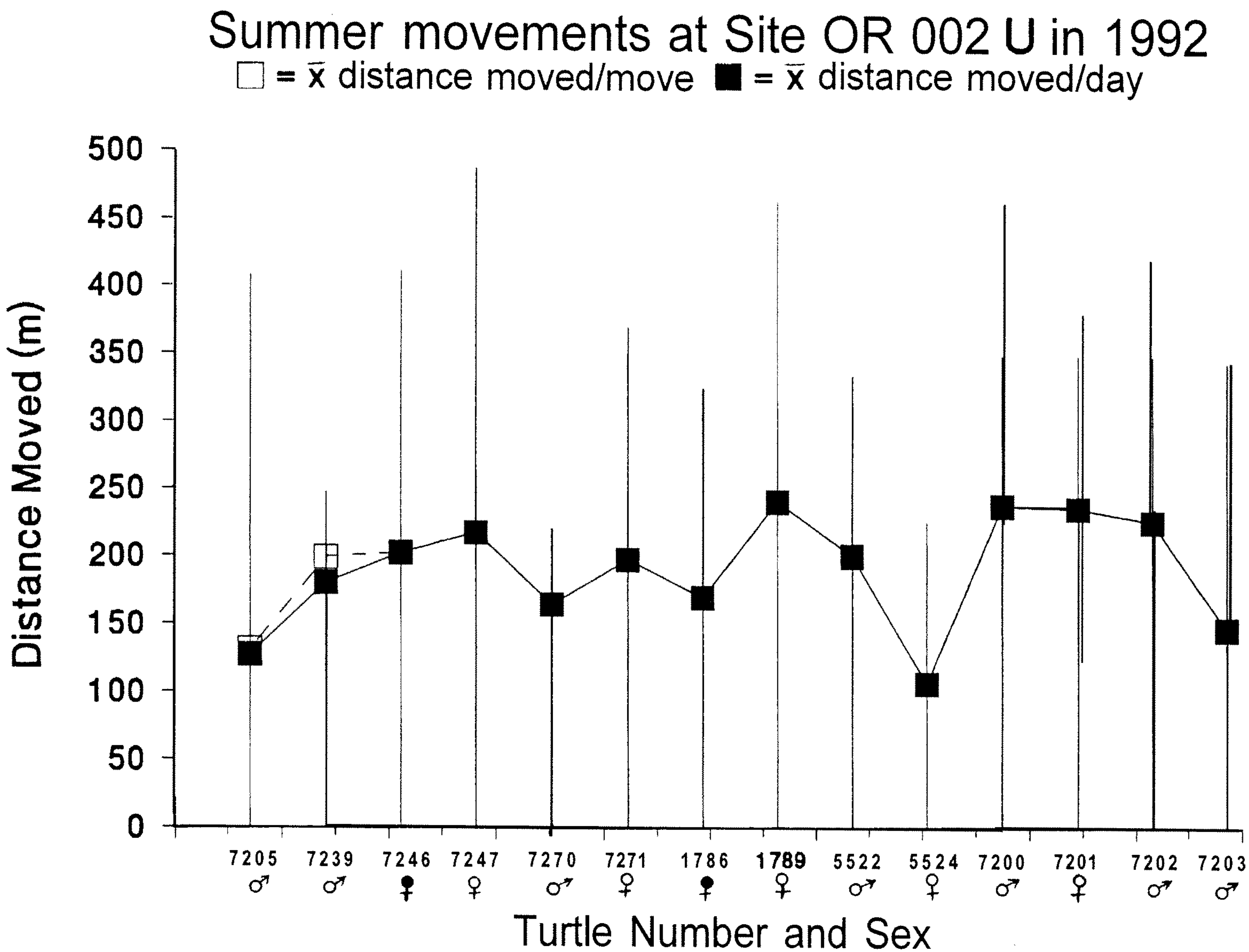

Figure 16: Summary of movement data from Site OR 002 U for summer 1992. Solid circles represent gravid females.

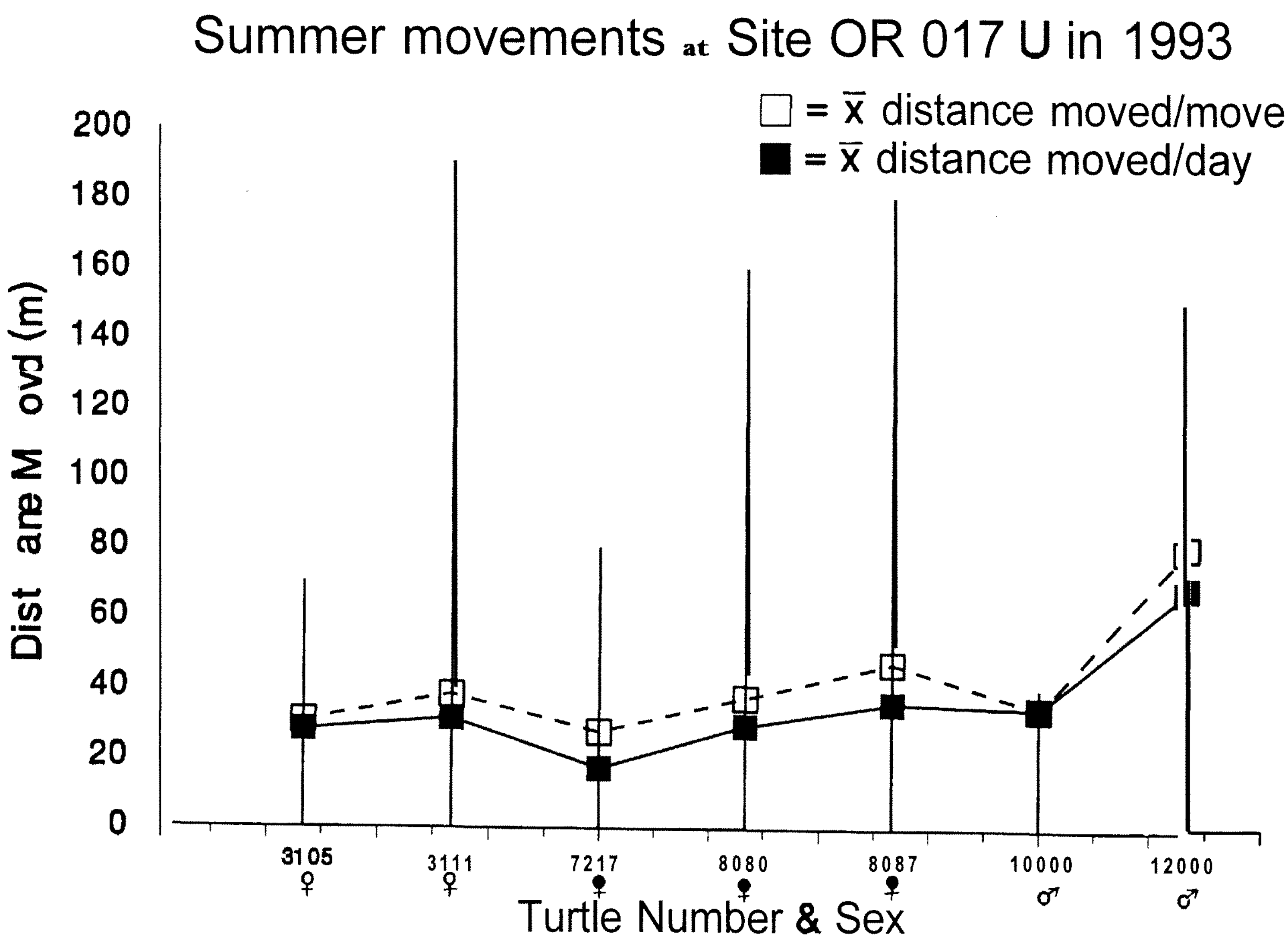

Figure 17: Summary of movement data from Site OR 002 U for summer 1993. Solid circles represent gravid females.

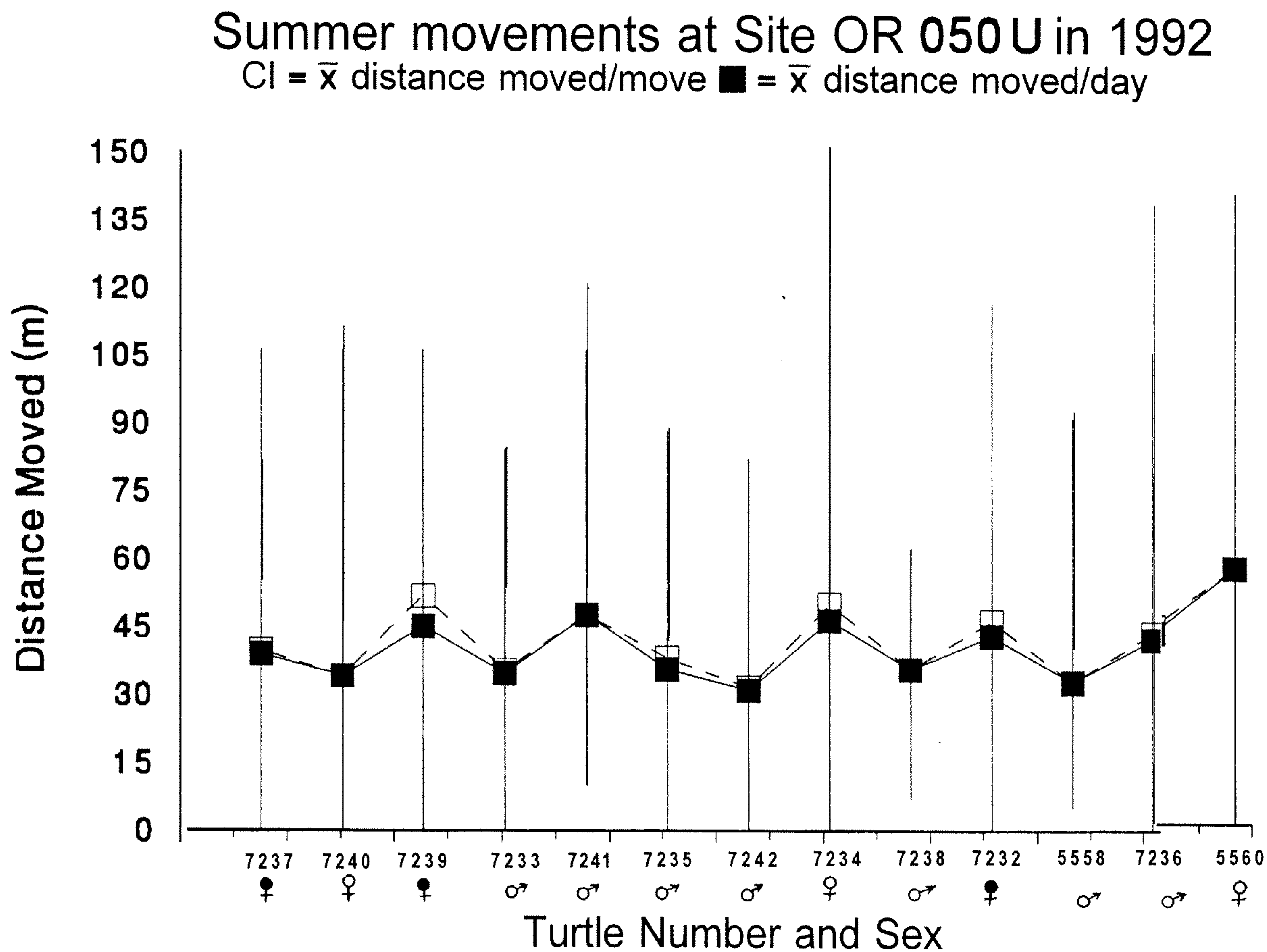

Figure 18: Summary of movement data from Site OR 050 U for summer 1992. Solid circles represent gravid females.

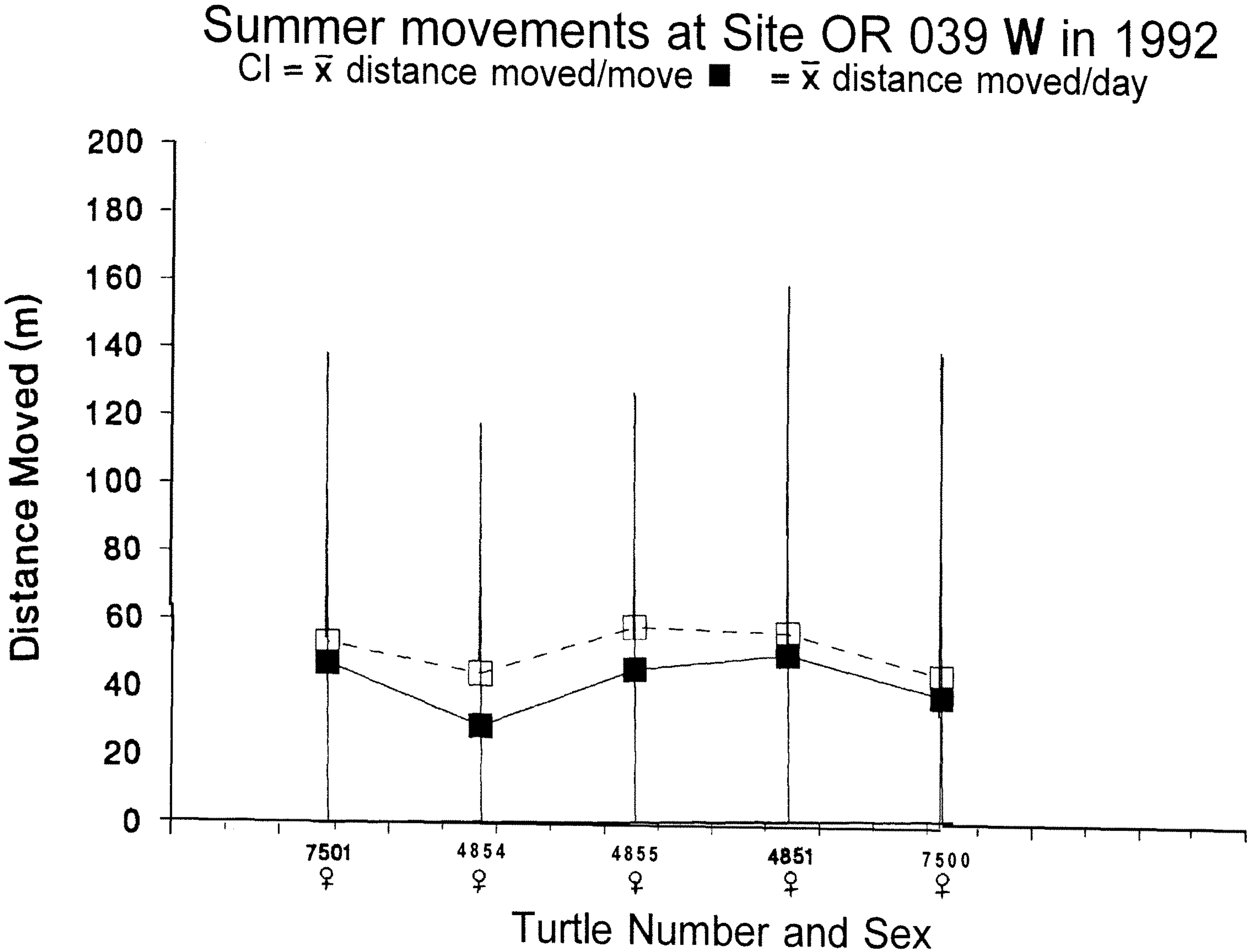

Figure 19: Summary of movement data from Site OR 039 W for summer 1992. Solid circles represent gravid females.

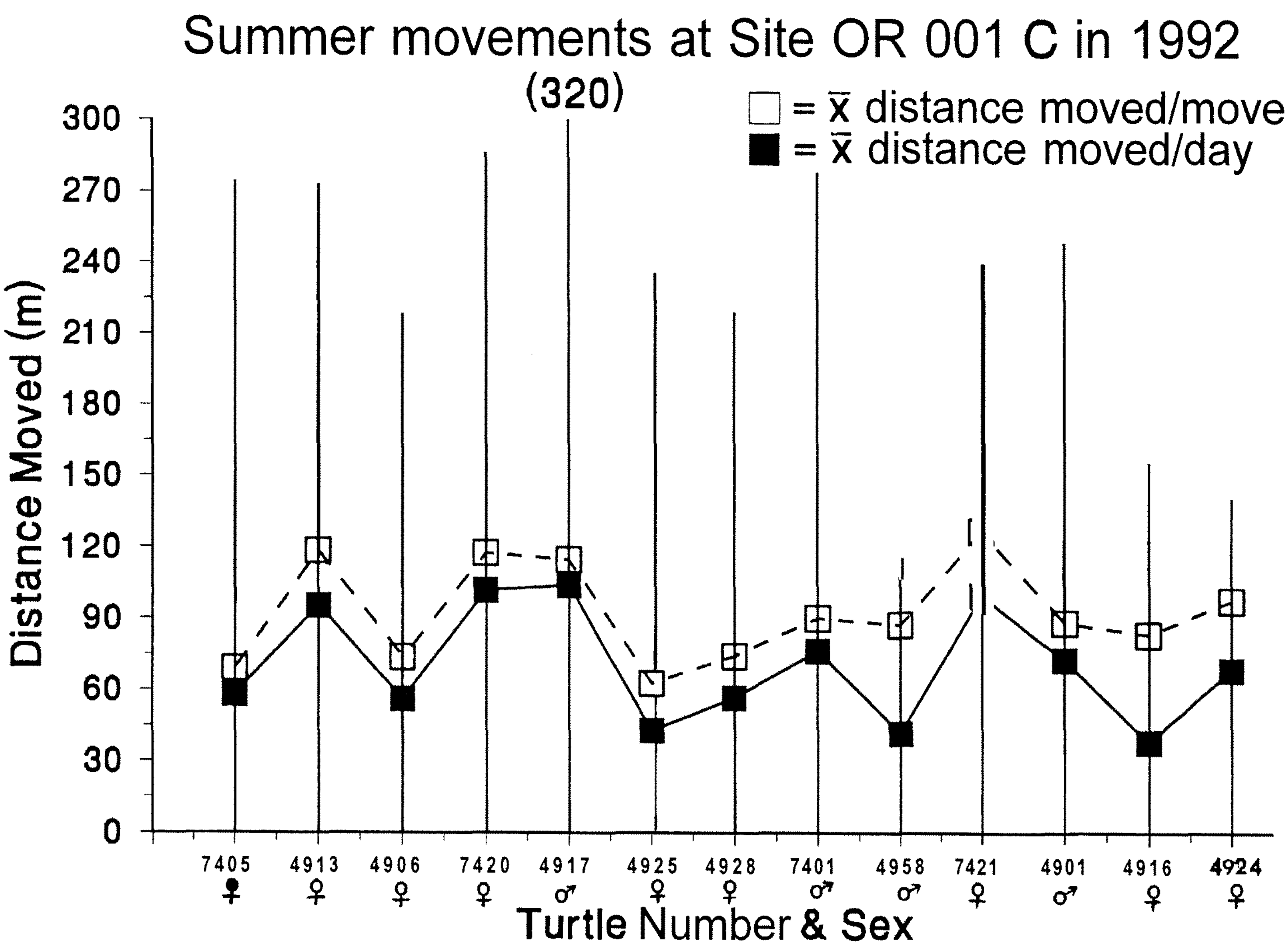

Figure 20: Summary of movement data from Site OR 001 C for summer 1992. Solid circles represent gravid females.

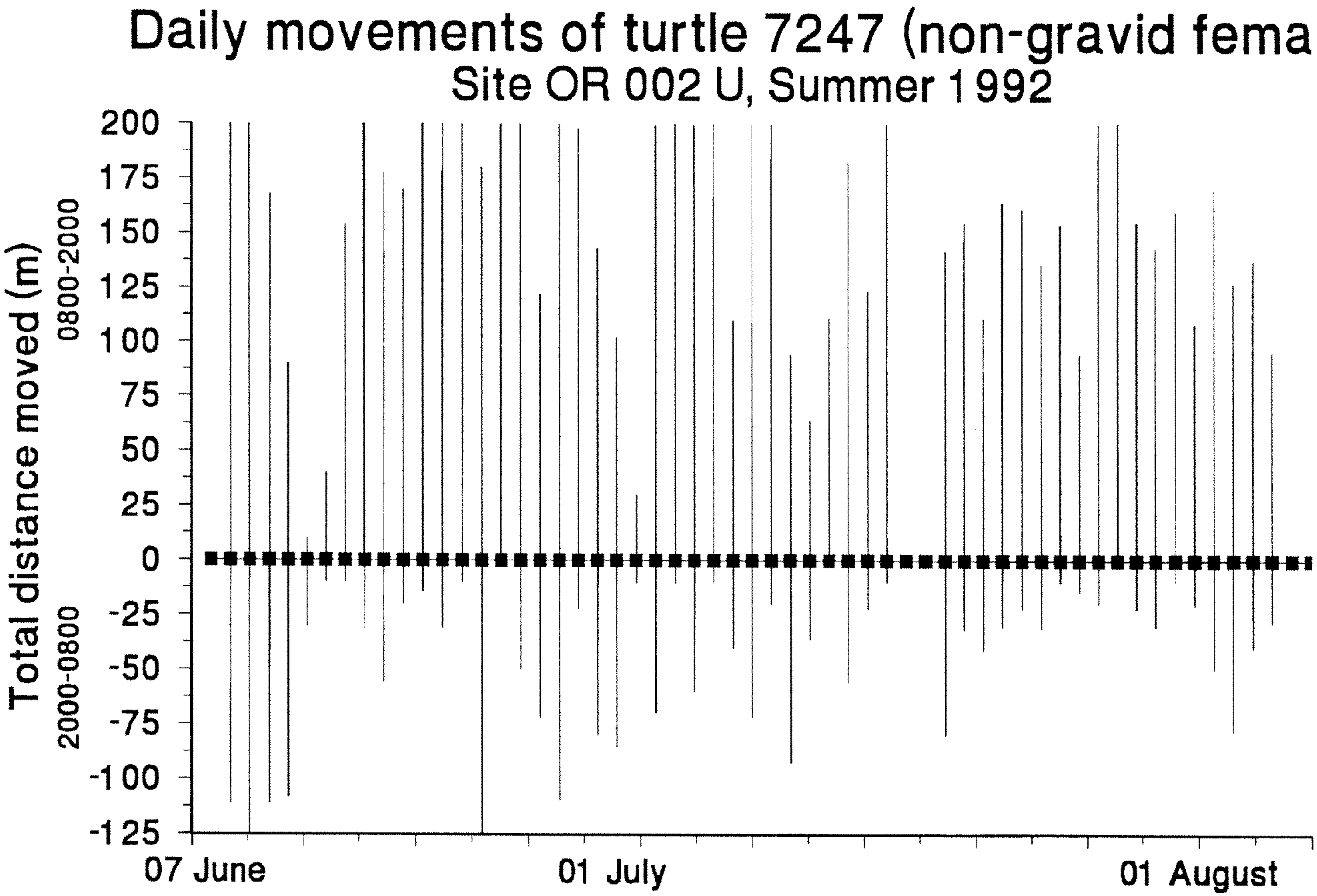

Figure 21: Summer movements of turtle # 7247.

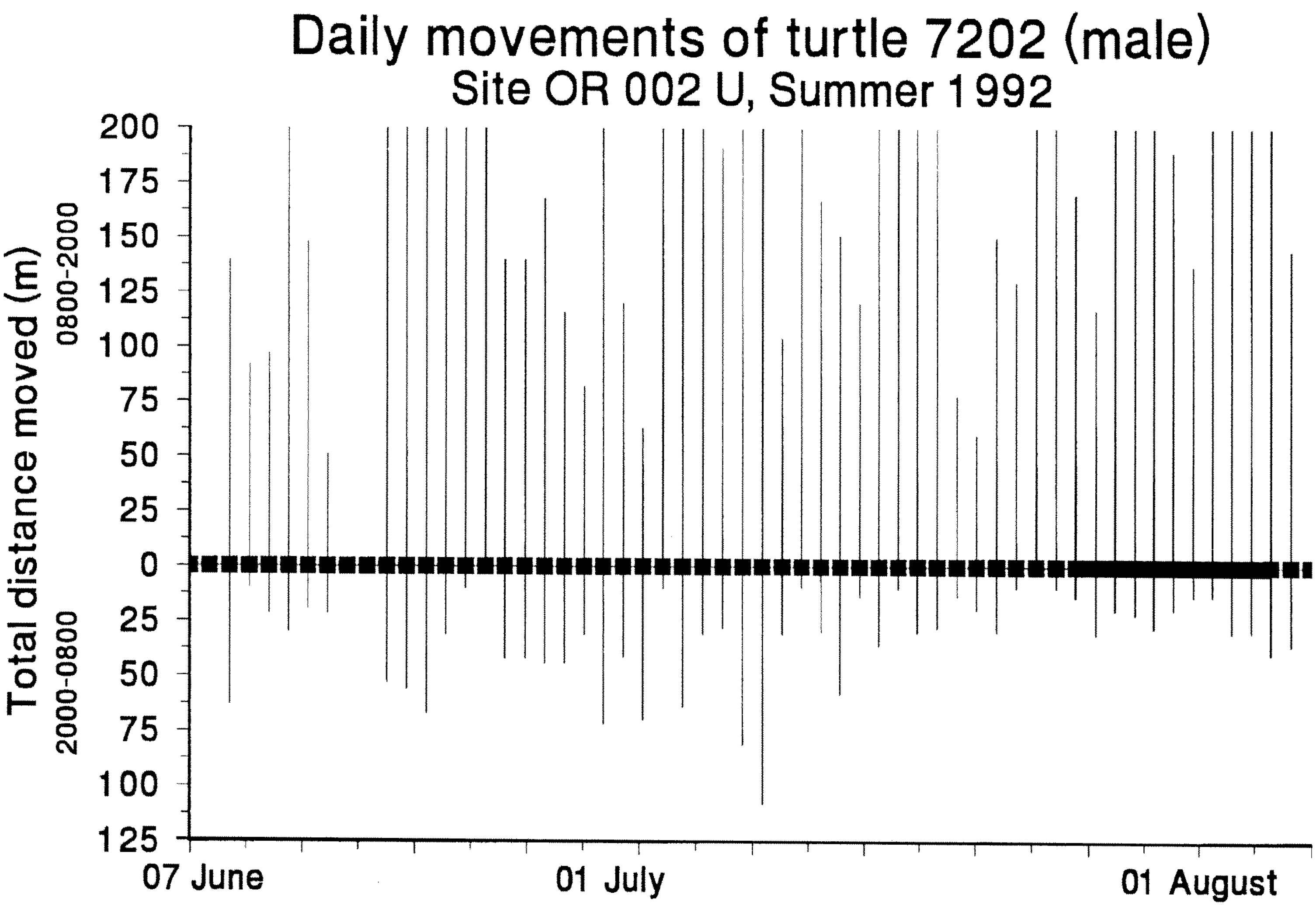

Figure 22: Summer movements of turtle # 7202

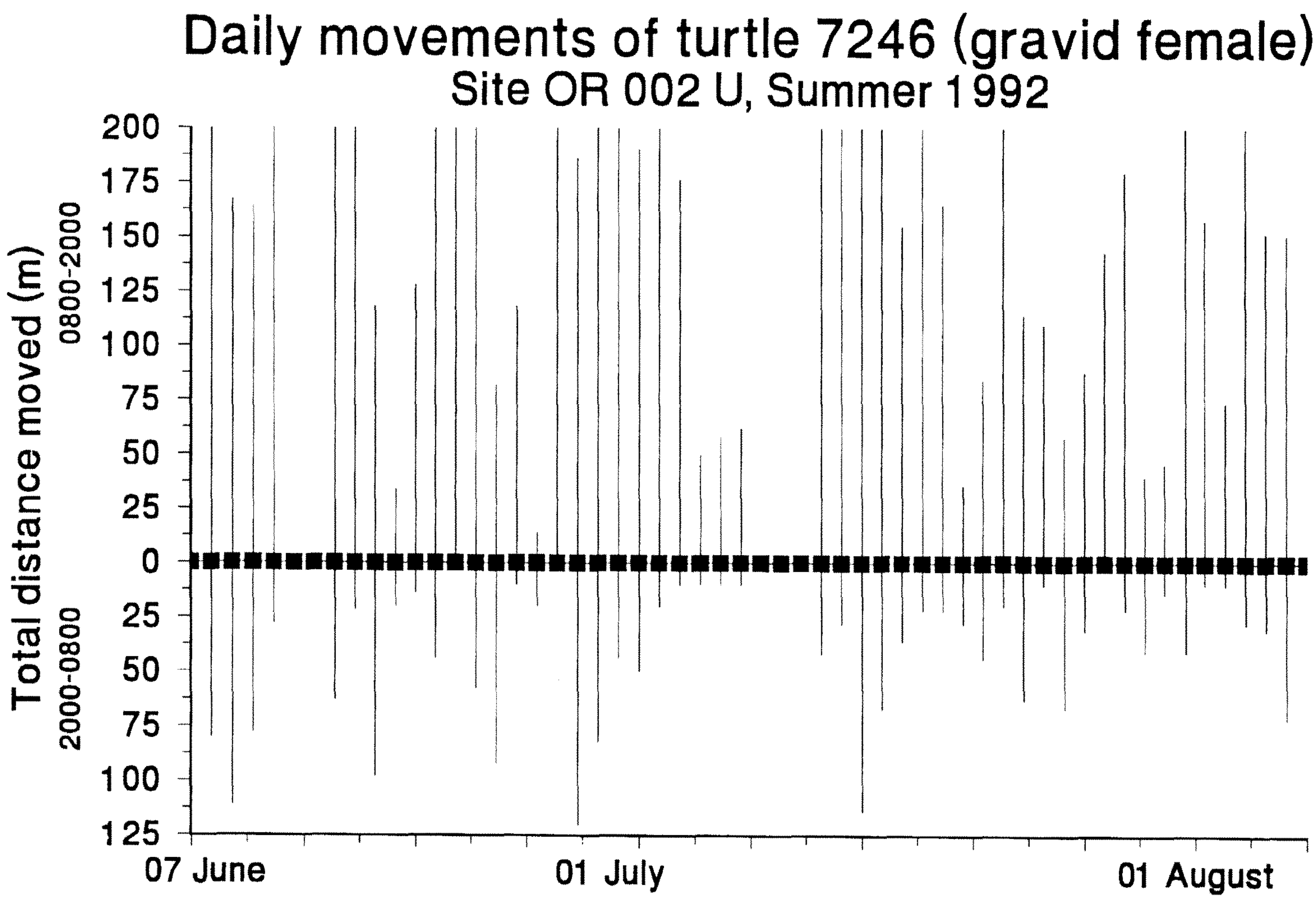

Figure 23: Summer movements of turtle # 7246.

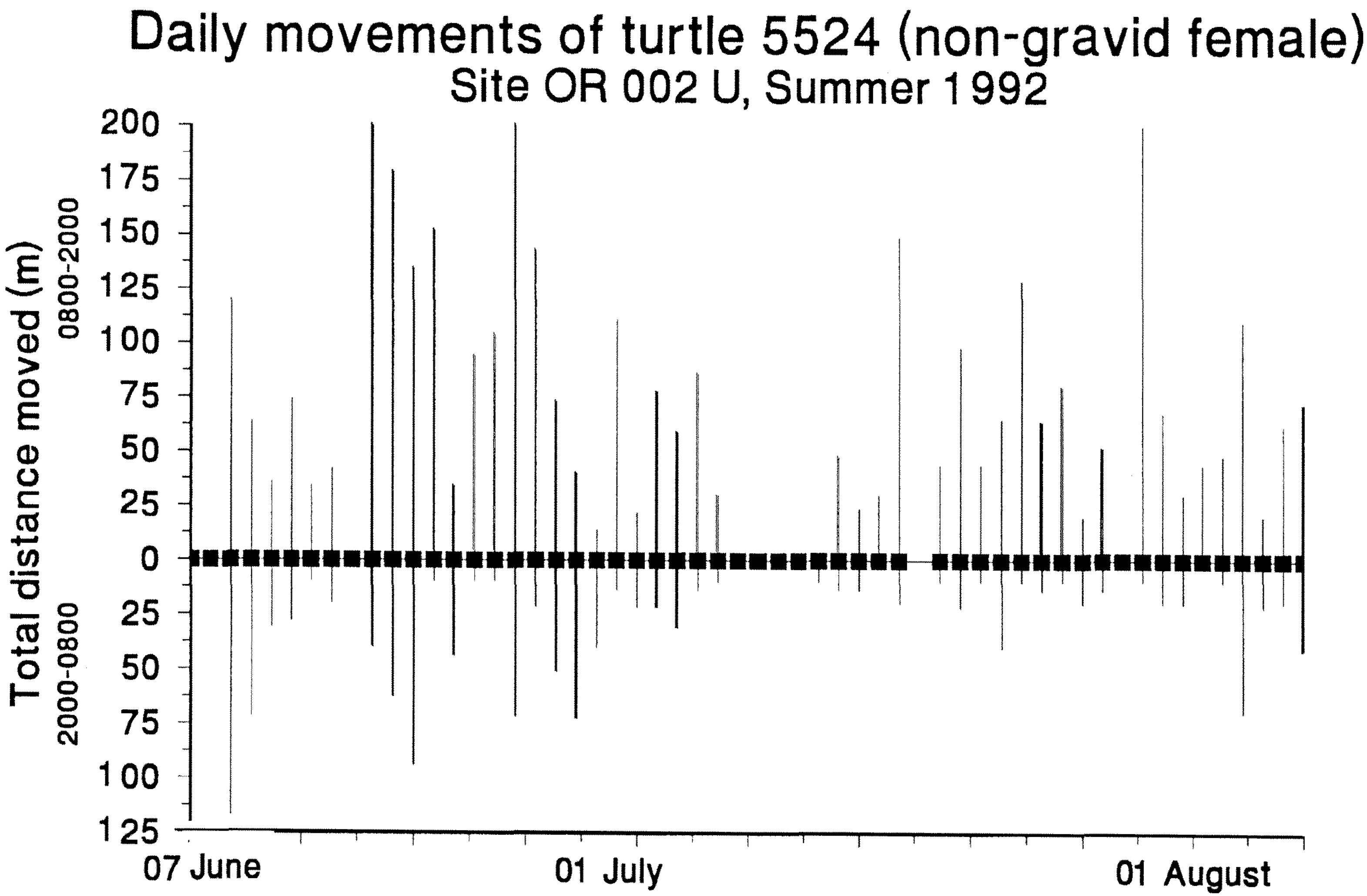

Figure 24: Summer movements of turtle # 5524.

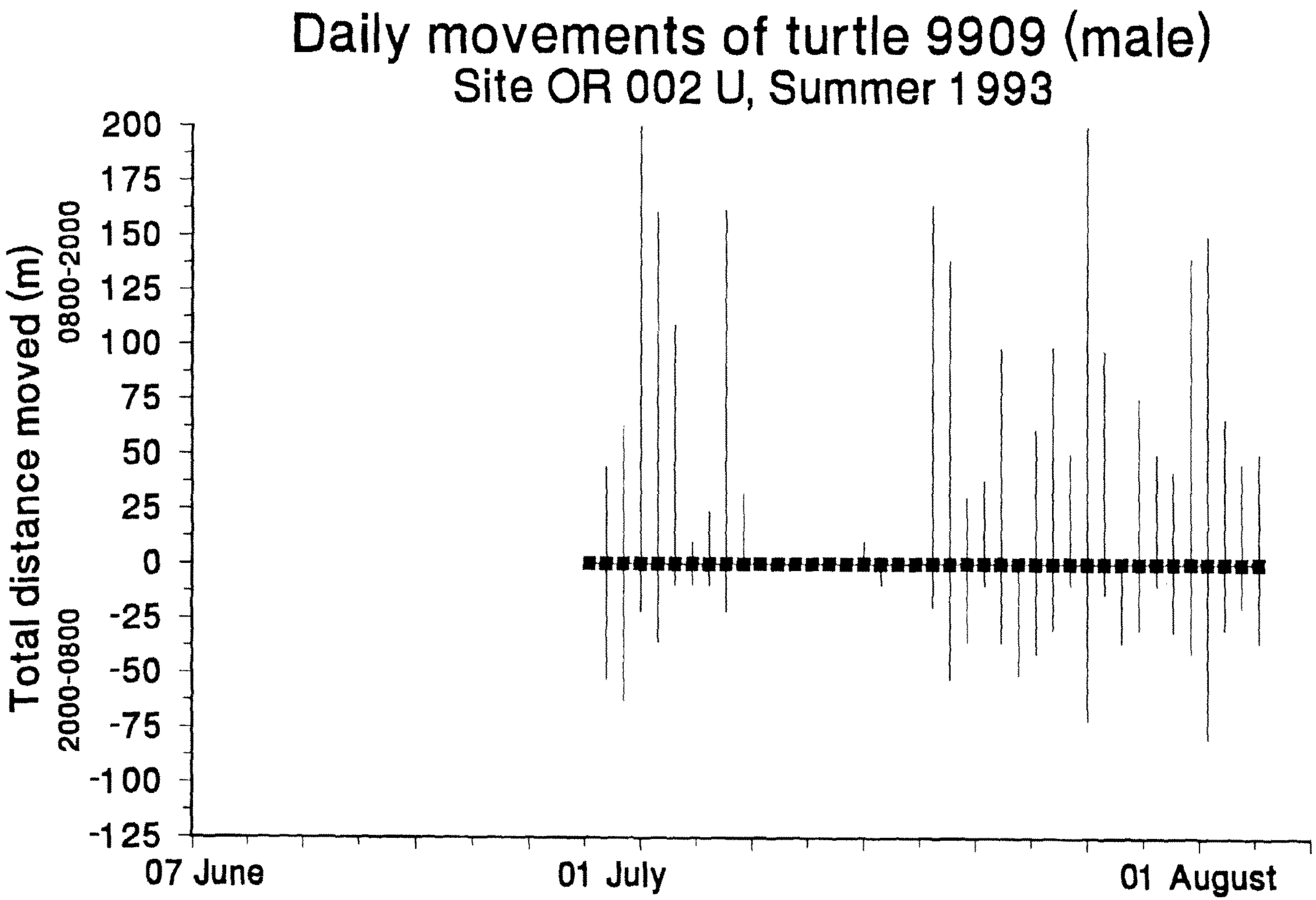

Figure 25: Summer movements of turtle # 9909.

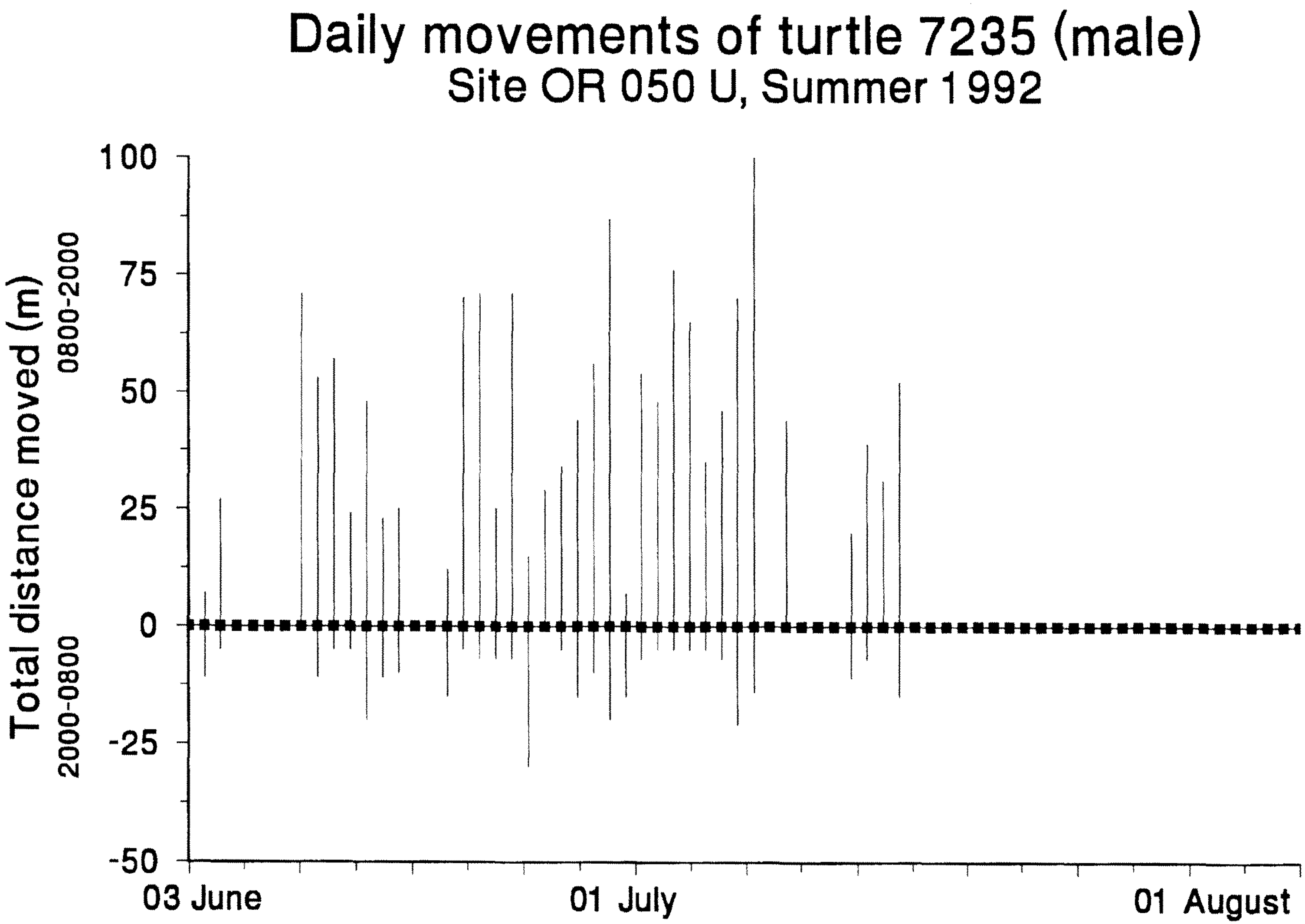

Figure 26: Summer movements of turtle # 7235.

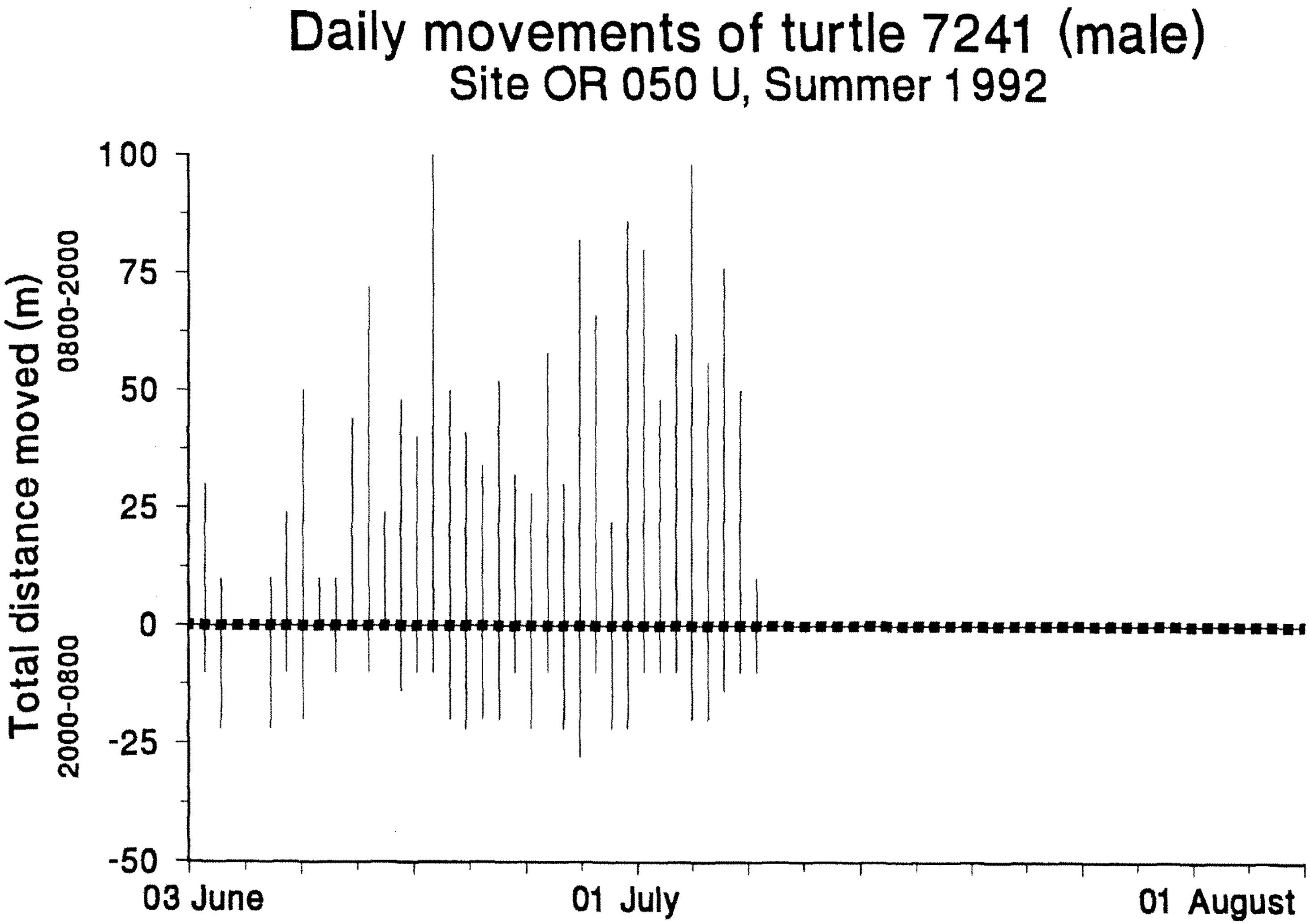

Figure 27: Summer movements of turtle # 7241.

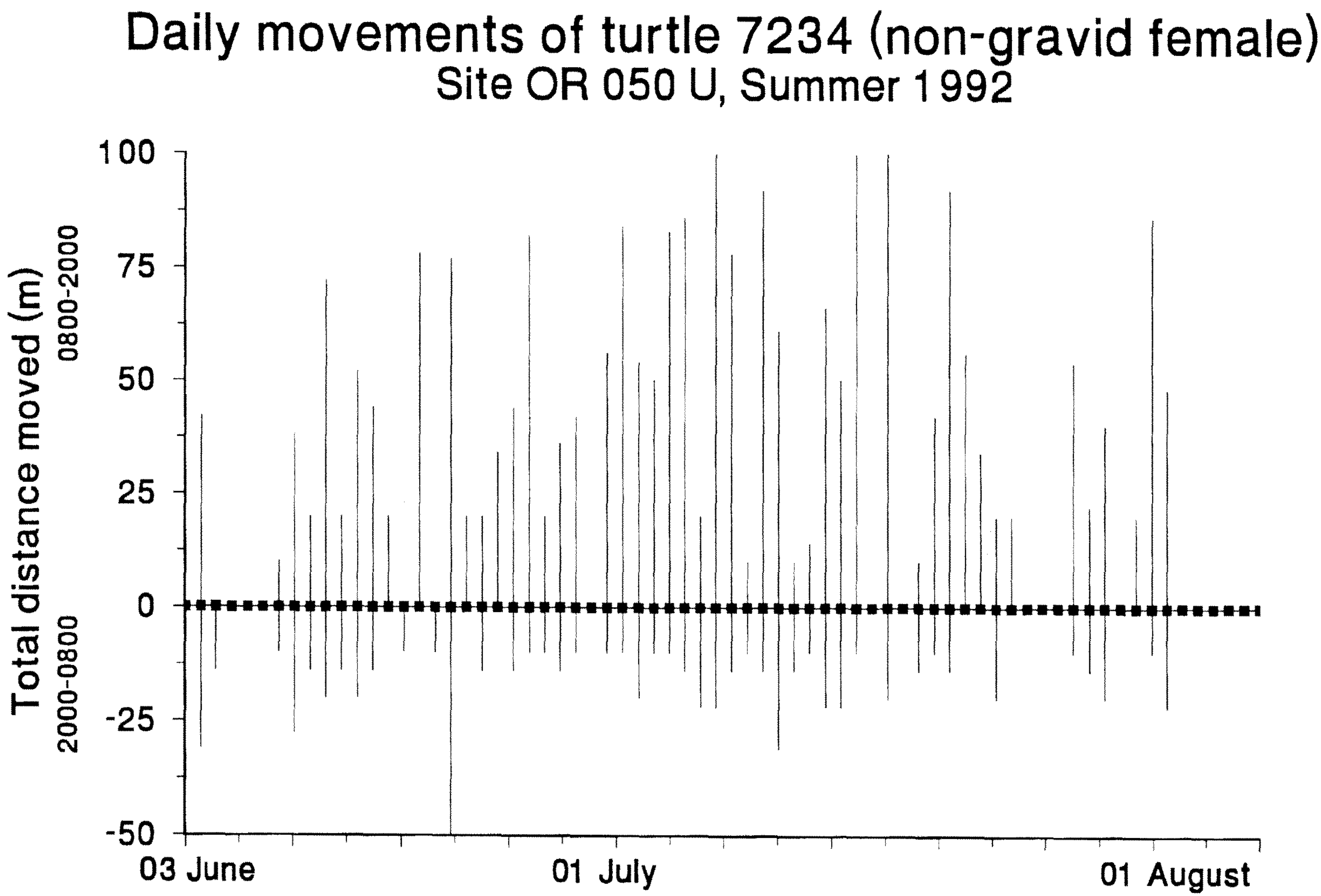

Figure 28: Summer movements of turtle # 7234.

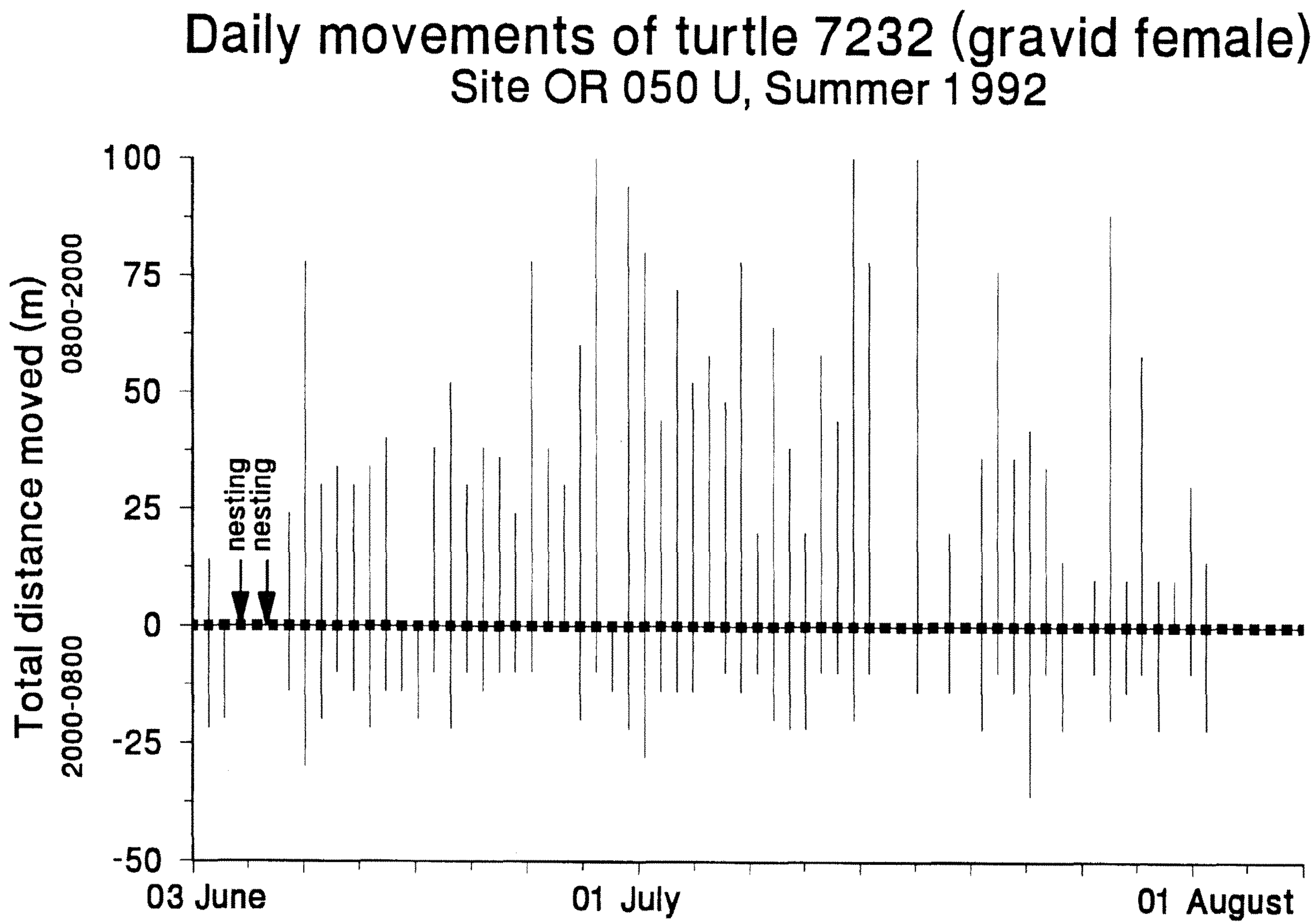

Figure 29: Summer movements of turtle # 7232.

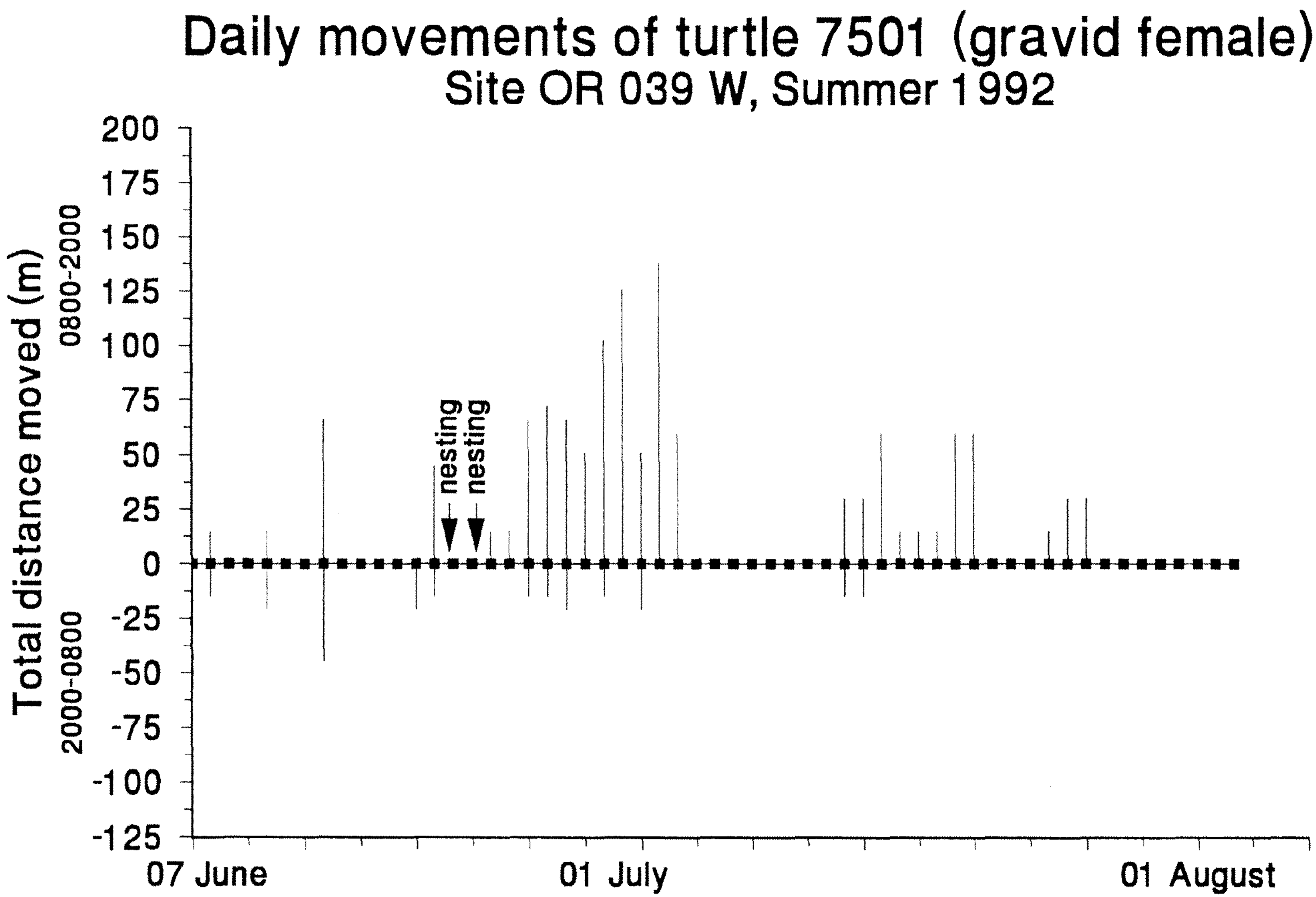

Figure 30: Summer movements of turtle # 7501.

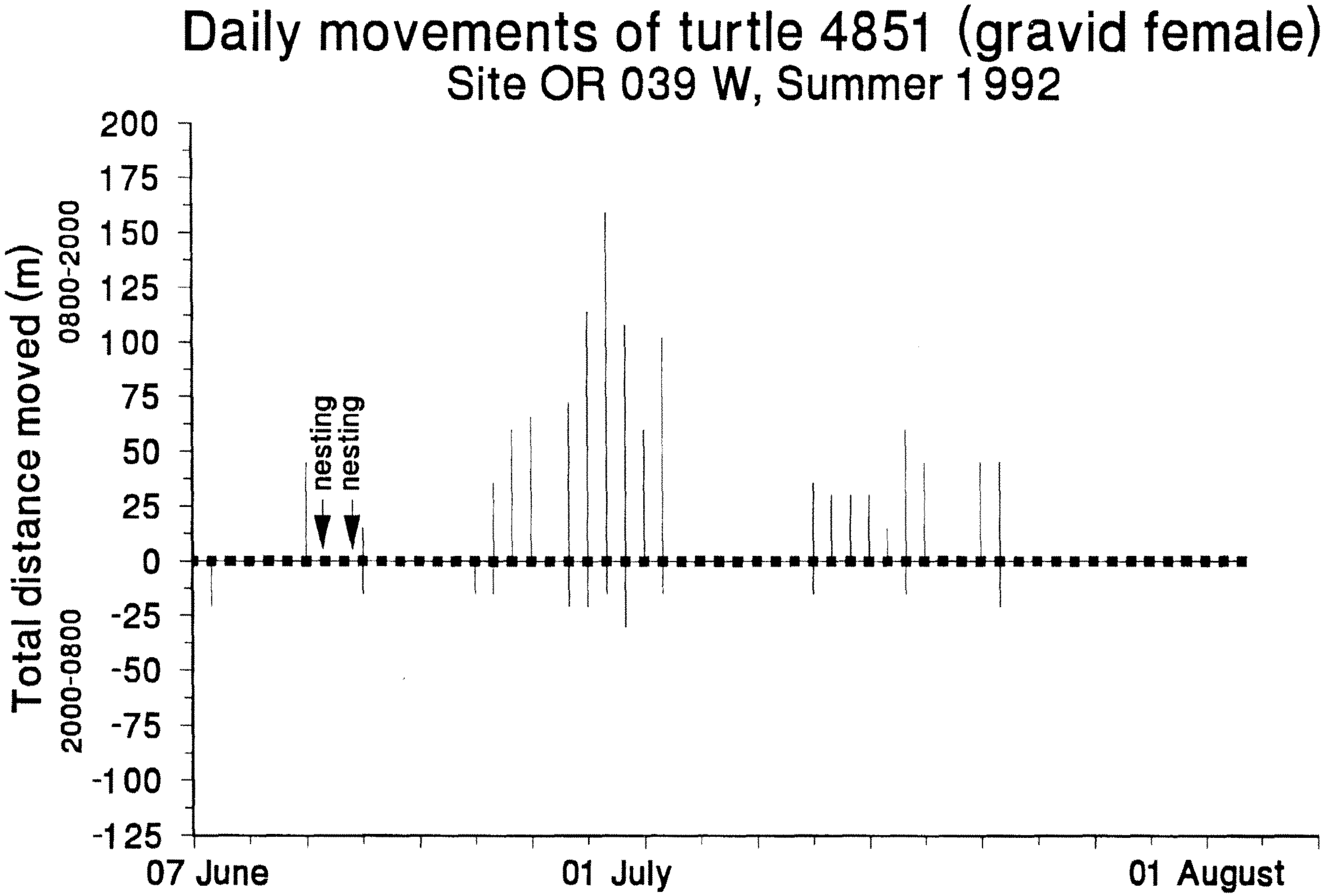

Figure 31: Summer movements of turtle # 4851.

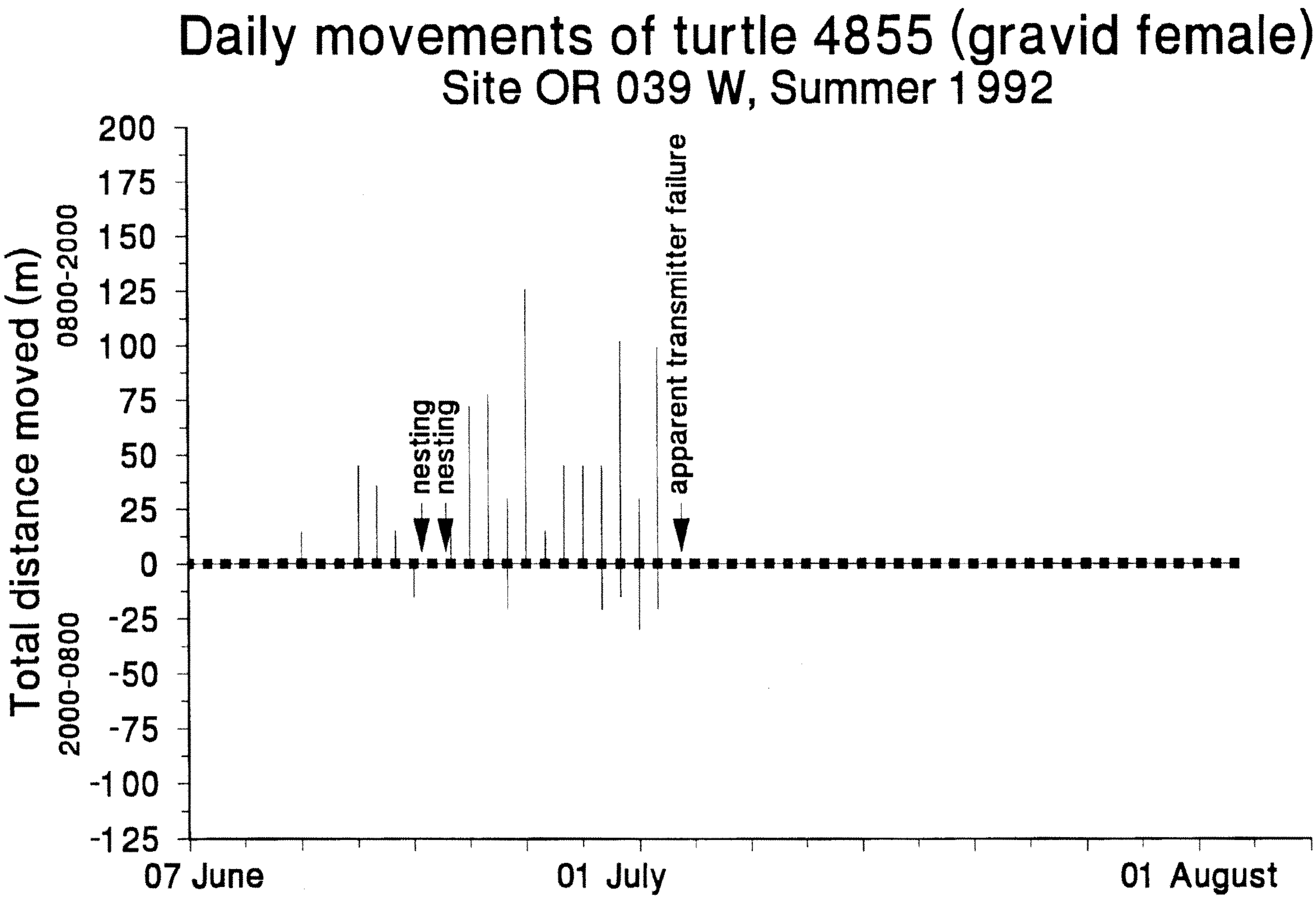

Figure 32: Summer movements of turtle # 4855.

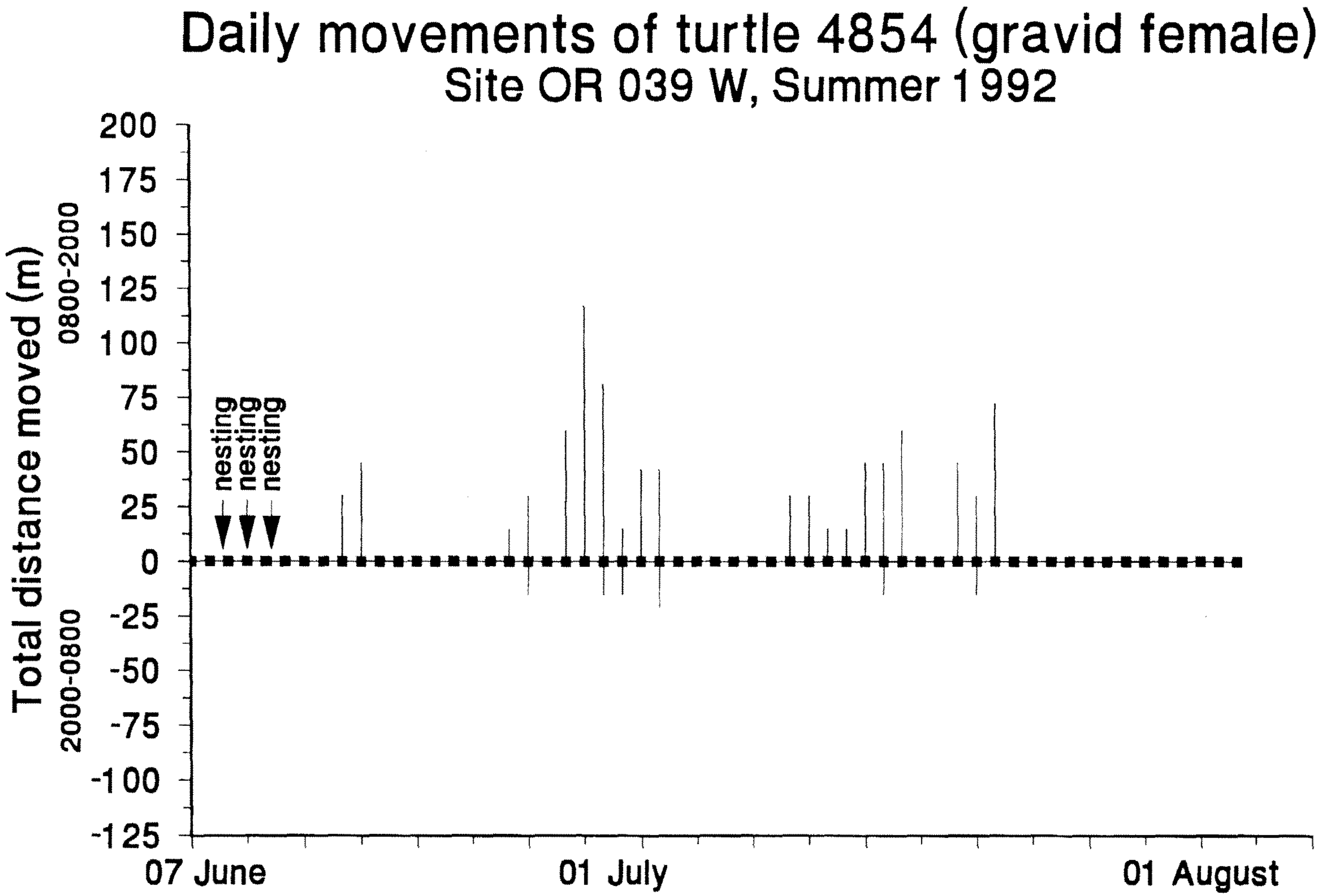

Figure 33: Summer movements of turtle # 4854.

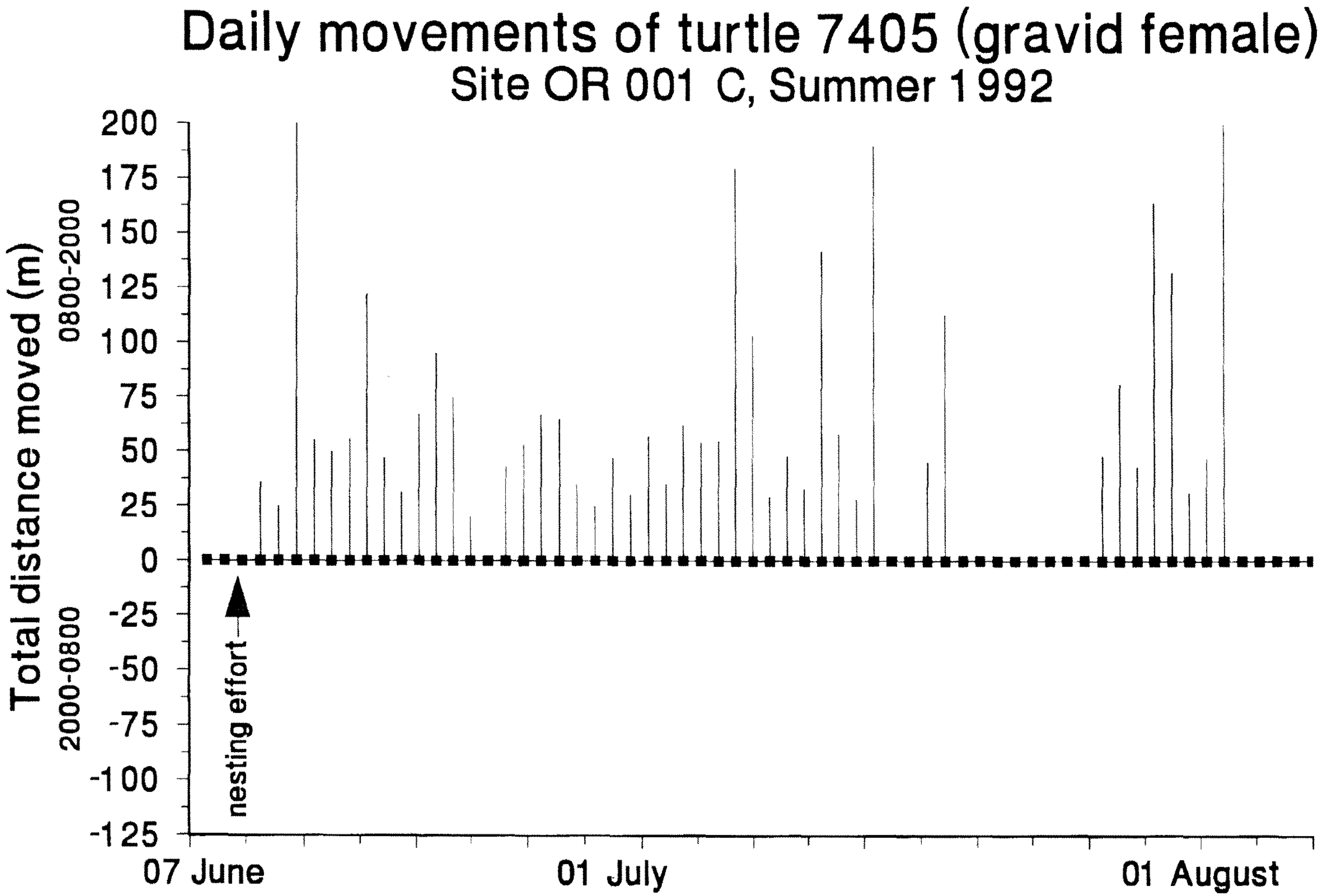

Figure 34: Summer movements of turtle # 7405.

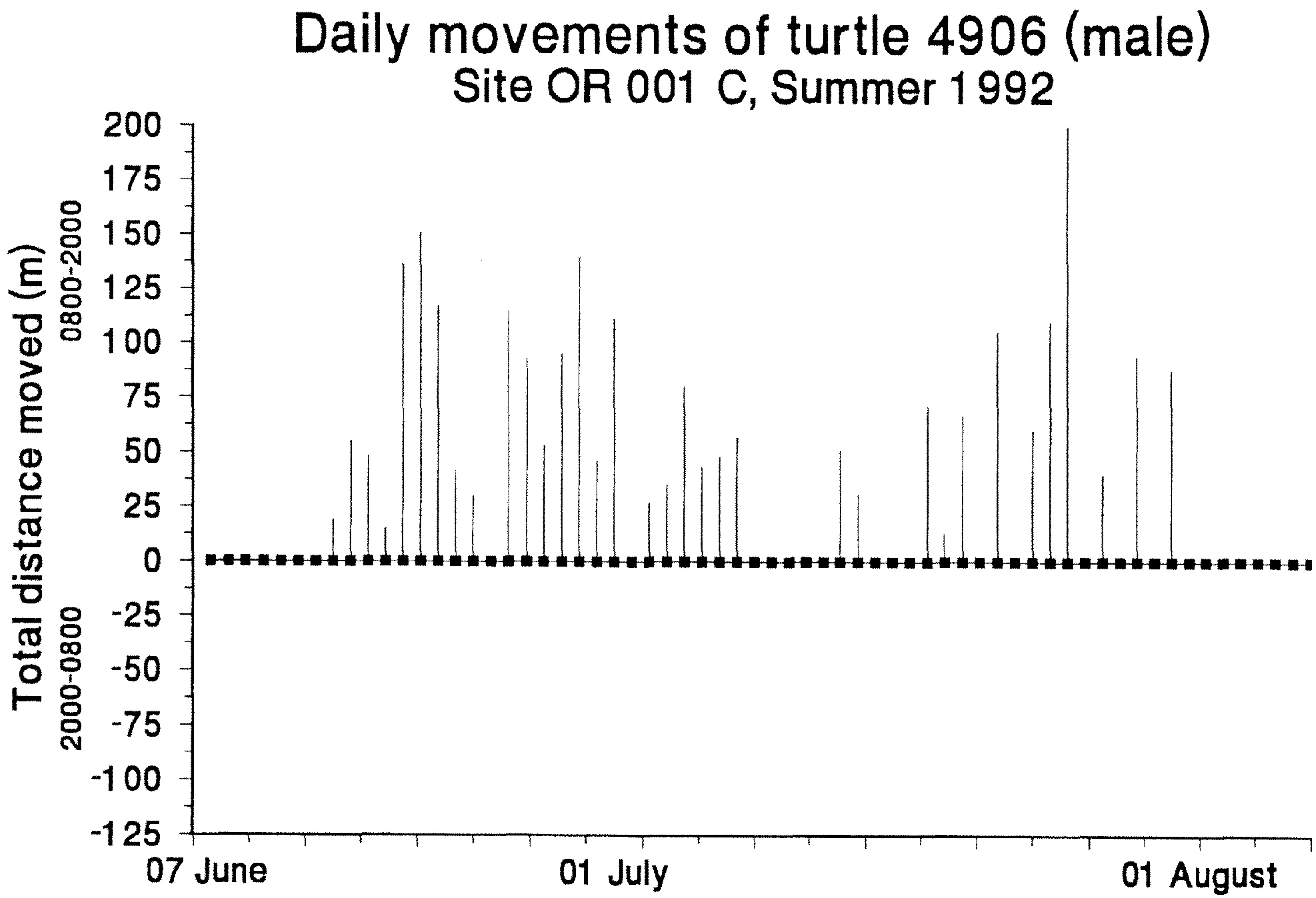

Figure 35: Summer movements of turtle # 4906.

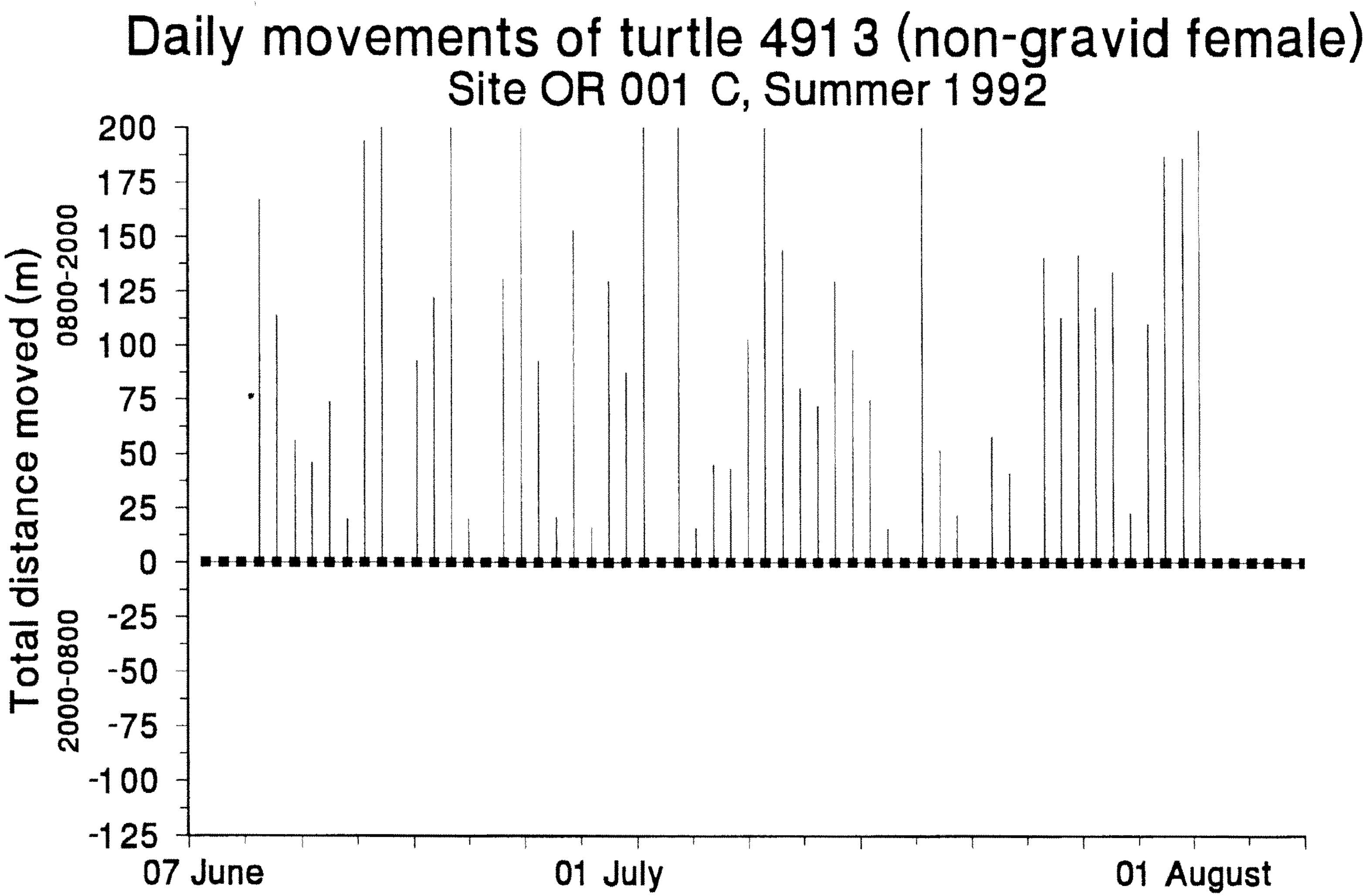

Figure 36: Summer movements of turtle # 4913.

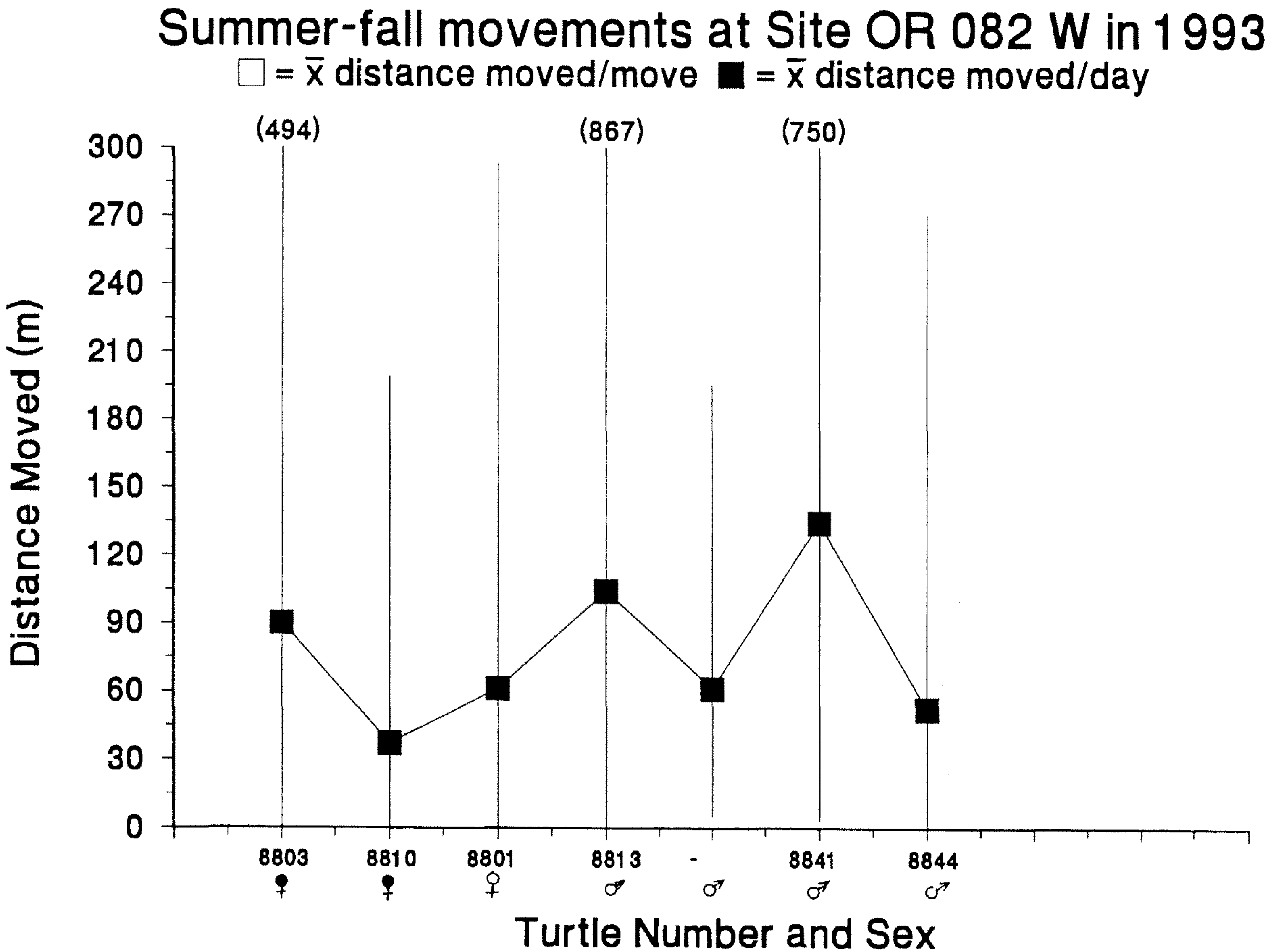

Figure 37: Summary of movement data from Site OR 082 W for summer 1993. Solid circles represent gravid females.

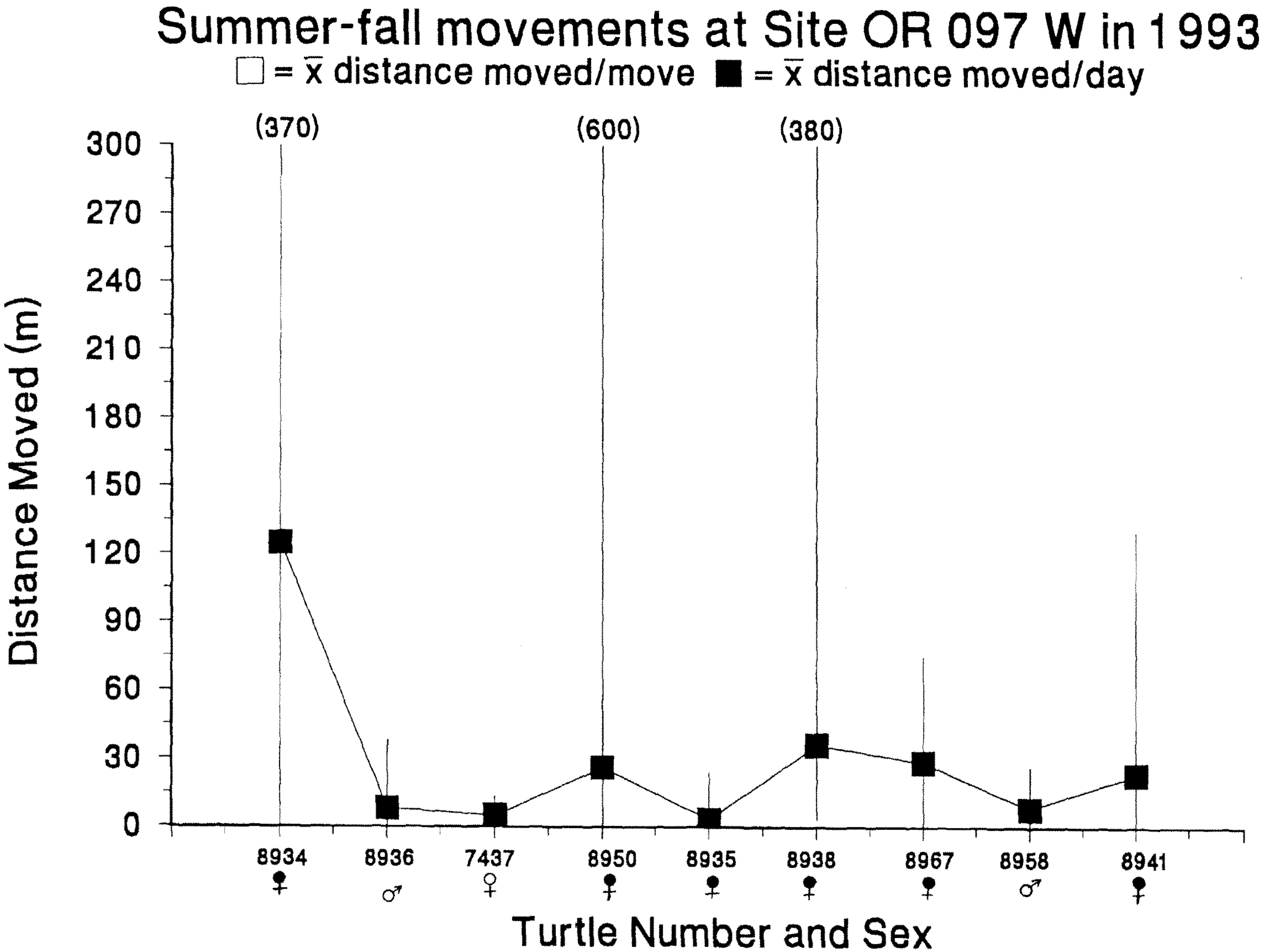

Figure 38: Summary of movement data from Site OR 097 W for summer 1993. Solid circles represent gravid females.

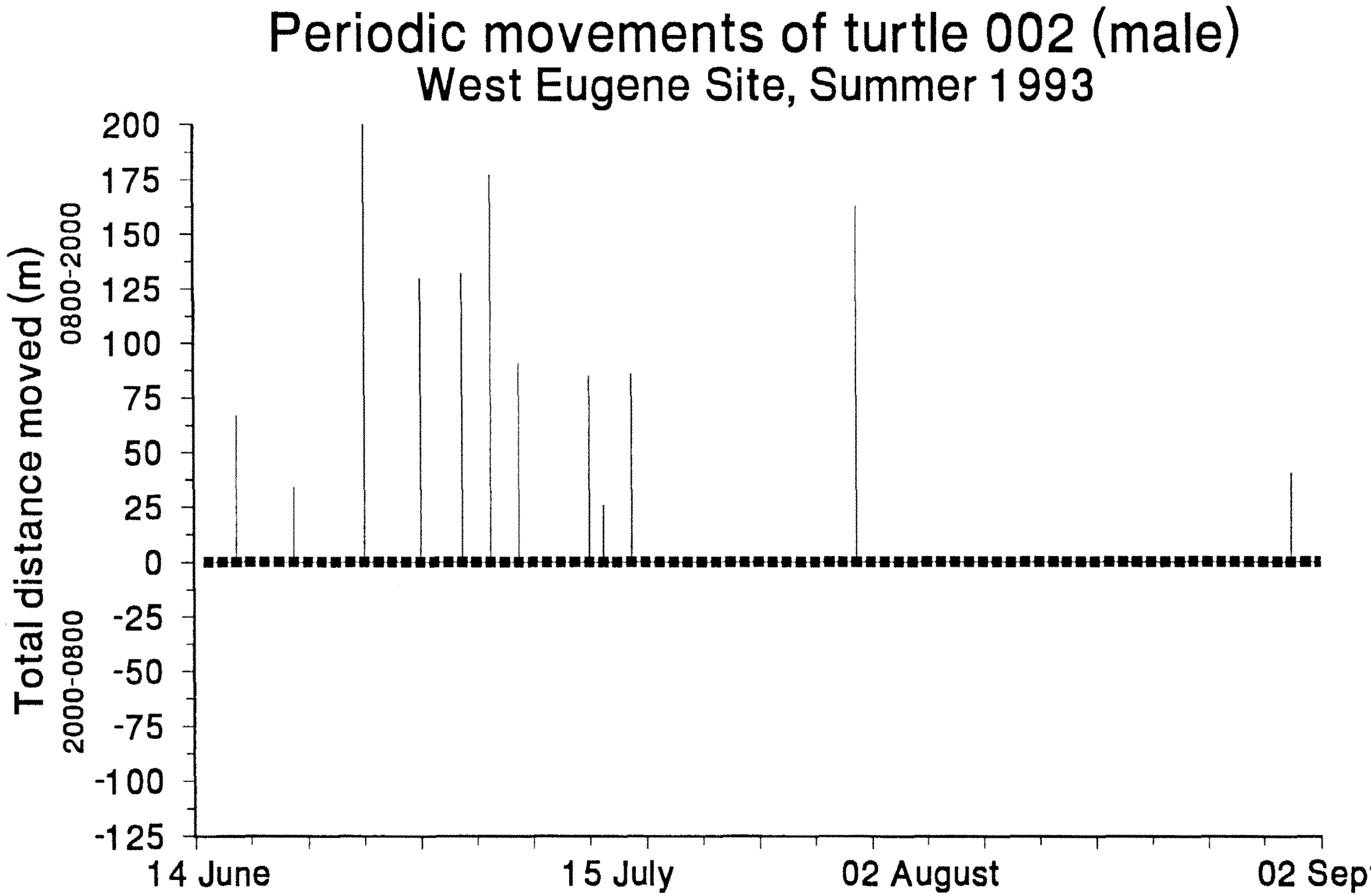

Figure 39: Summer movements for turtle # 002.

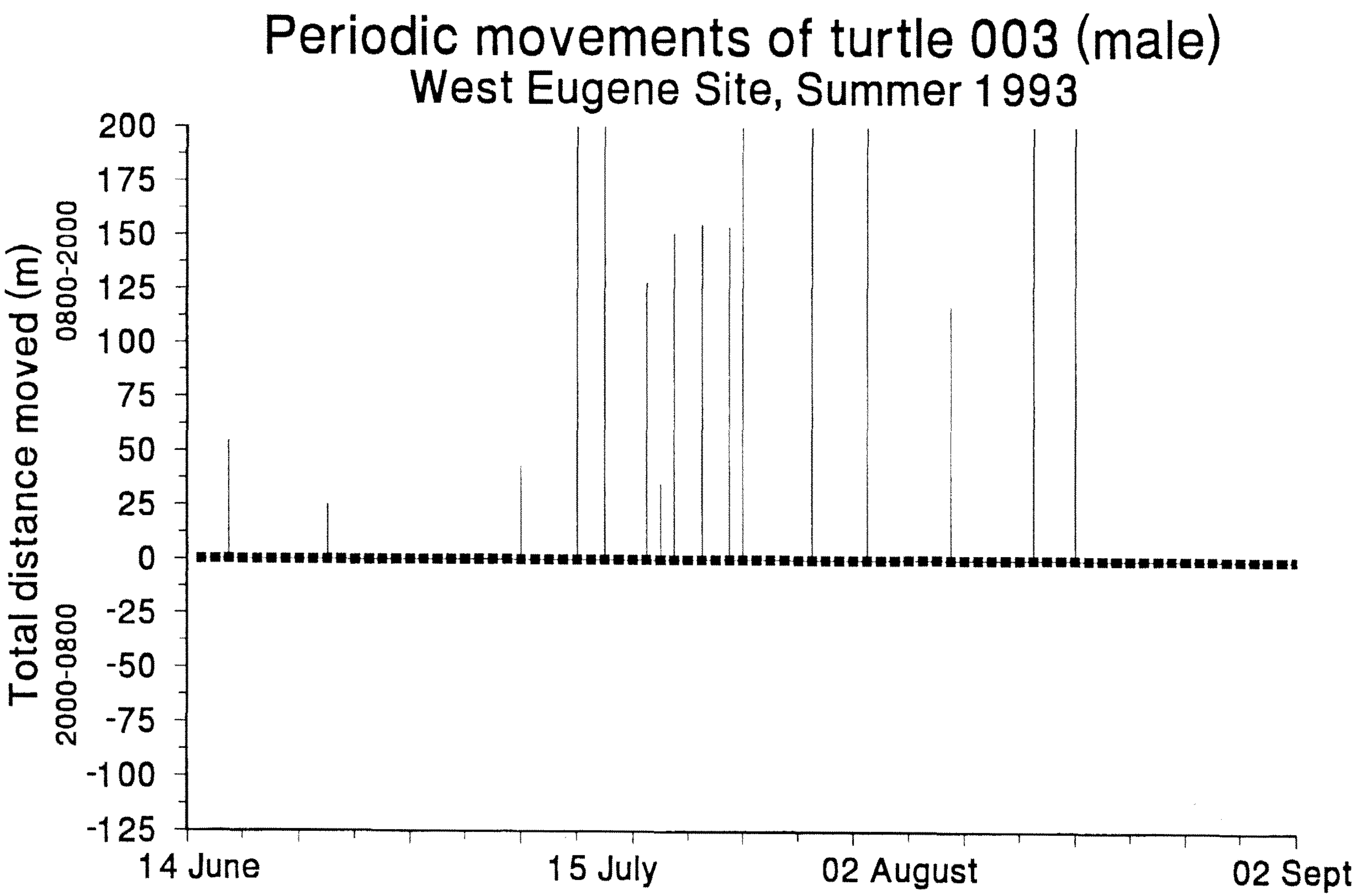

Figure 40: Summer movements for turtle # 003.

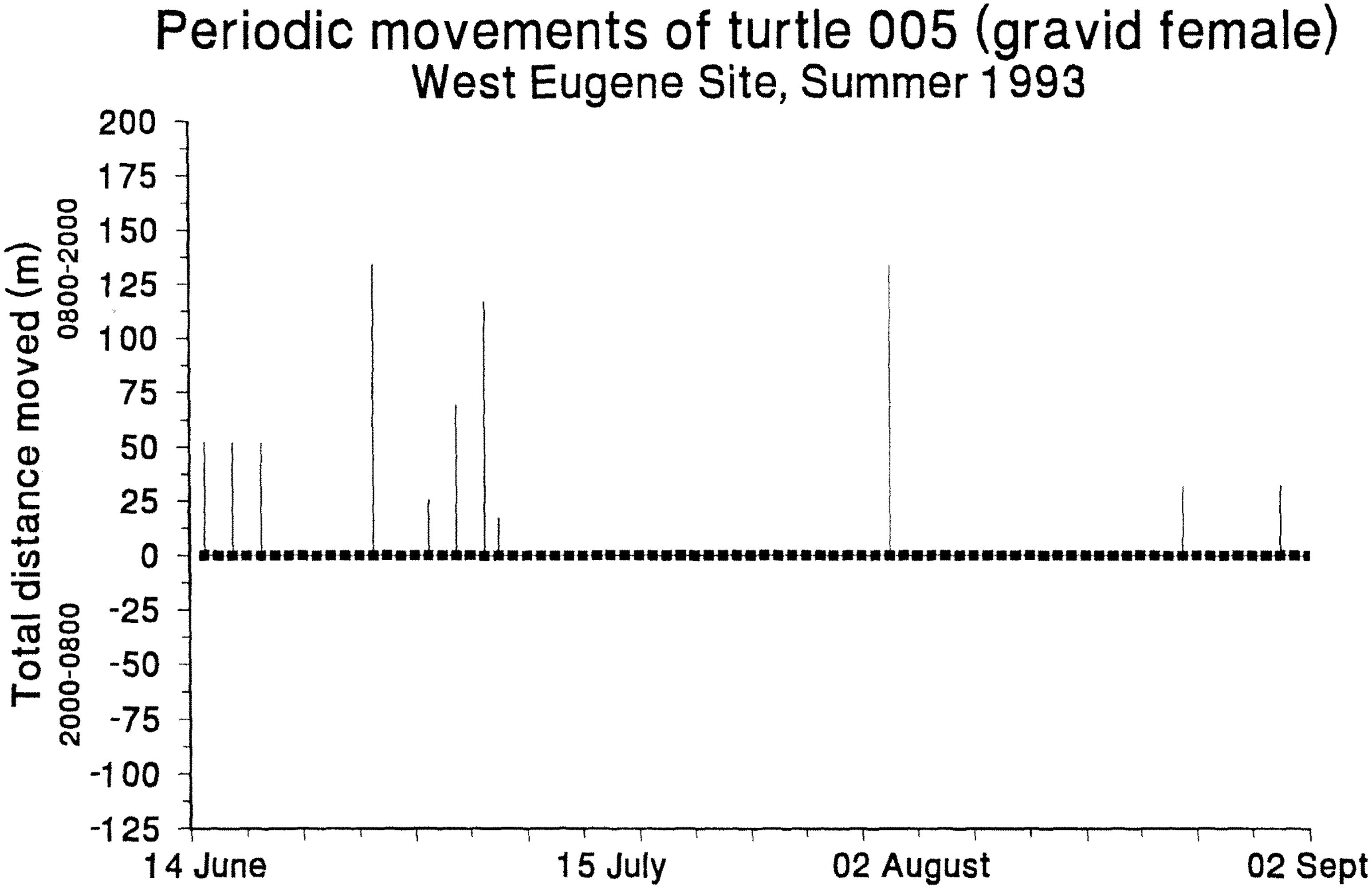

Figure 41: Summer movements for turtle # 005.

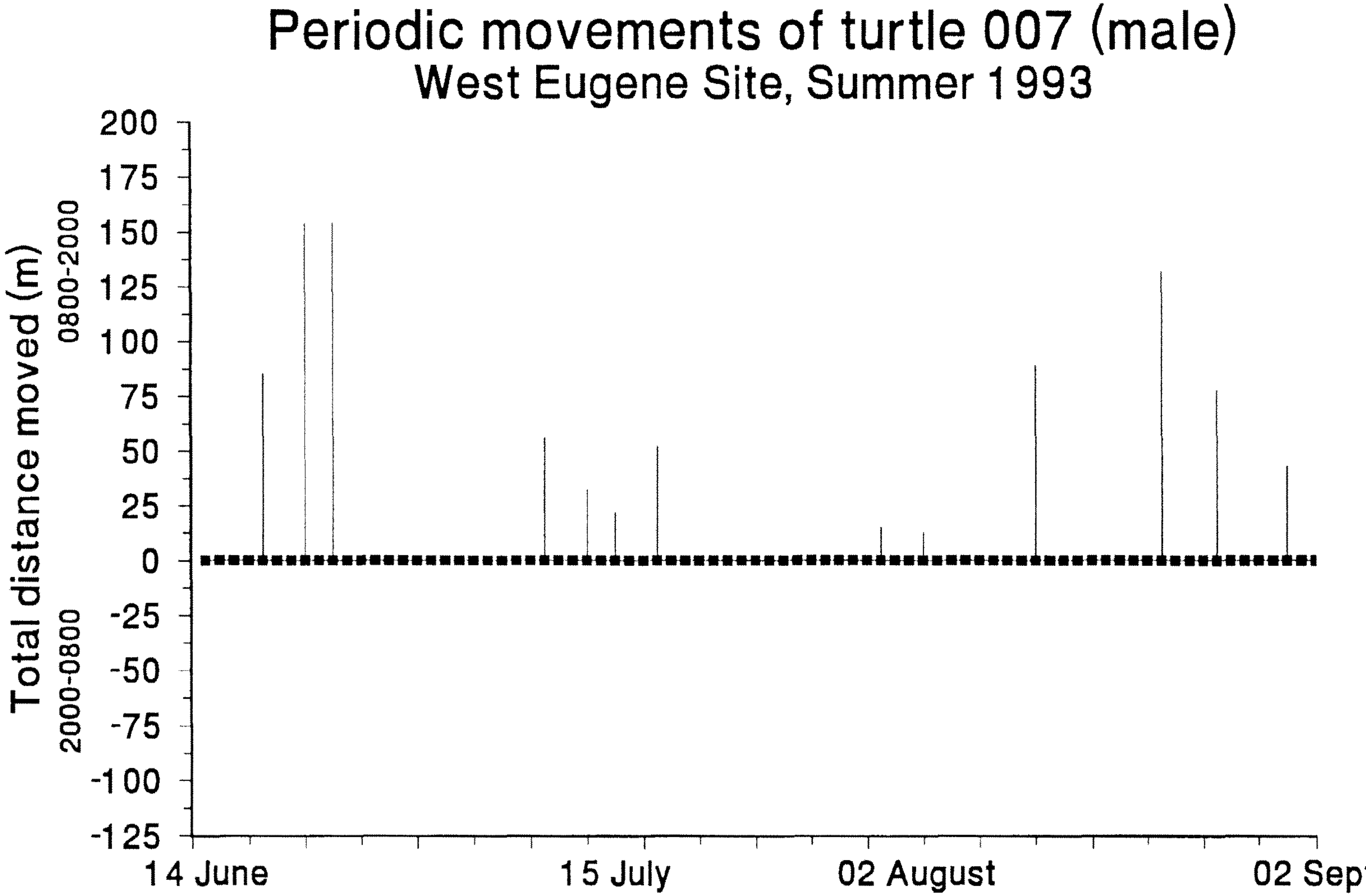

Figure 42: Summer movements for turtle # 007.

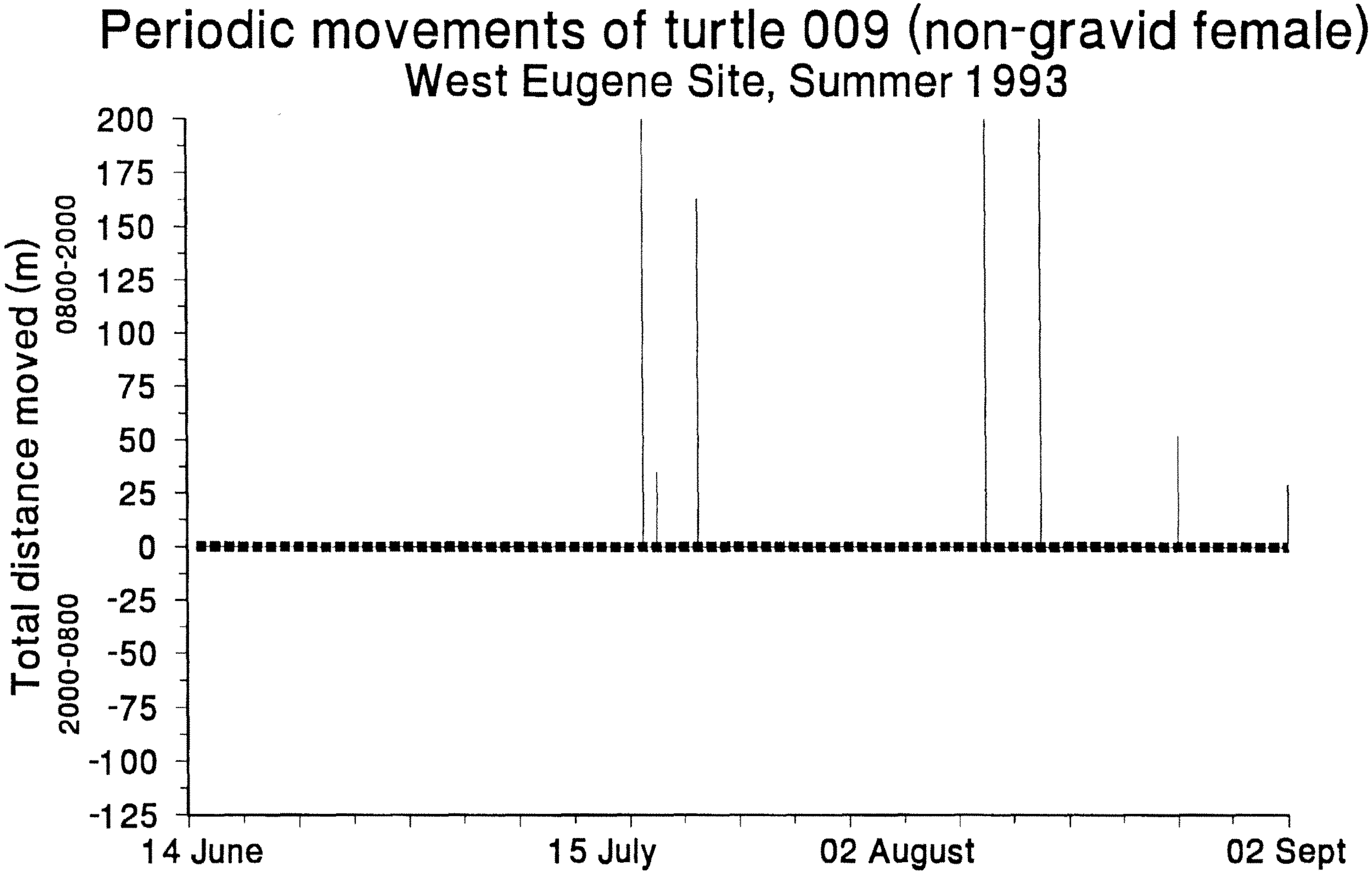

Figure 43: Summer movements for turtle # 010.

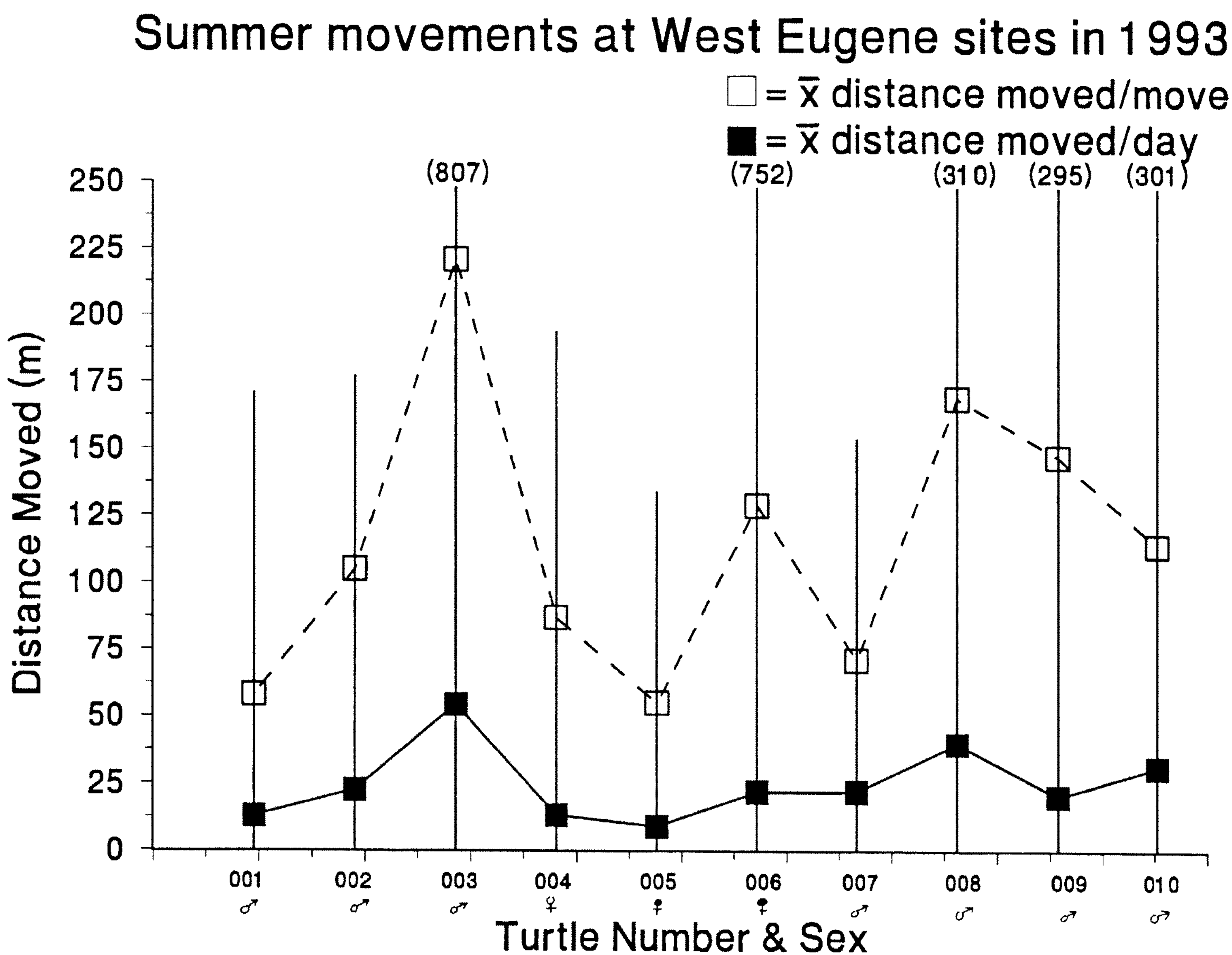

Figure 44: Summary of summer movements by telemetered turtles in the west Eugene wetlands study.

CHAPTER 8

Overwintering in the Western Pond Turtle

Overwintering in the Western Pond Turtle

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Introduction

Anecdotal evidence has existed for some time that western pond turtles engage in over-wintering behavior in some areas (see Holland, 1985, 1991). However, at this point relatively little is known about the specifics of this behavior. Turtles were monitored on an sporadic basis throughout the winter of 1992 at several sites, and consistently at four sites during the winter of 1993-1994. As with many other aspects of the species ecology, there appears to be a significant amount of plasticity in regard to over-wintering habits among and possibly within habitats. The discussion below is structured on a site-by site basis.

Results - Riverine Stream Habitats

Site CA 014 K

Turtles were monitored at this site on an intermittent basis throughout the winter of 1992-93. By late October, all turtles with transmitters (seven) that were still functioning or were still within receiver range had left the stream and moved into upland habitats. All sites were either west or southwest-facing, and ranged in elevation from less than 3 m above the stream level at that time to over 60 m in elevation above the stream. The closest animal to the watercourse was approximately 15 m east of the stream, and buried at a depth greater than 20 cm under a moderate-sized shrub. The substrate was composed of a mixture of soil, decomposed granitic rock, small rocks and pebbles, and leaflitter. The turtle was not located and to avoid further disturbance excavation were terminated. The slope at this site was estimated at approximately 15 degrees. Another animal was located approximately 154 m east of the stream on an west-facing slope under a several small oaks. This animal was buried under leaf litter (oak) and no attempt was made at excavation. The slope of the site was estimated at 20 degrees. Another animal was located 112 m east of the stream on a south-facing slope, buried under leaf litter at the base of a small oak. The transmitter was visible and the depth of the duff in which the animal was buried was estimated at 10-12 cm. A fourth animal was located west of the stream (the only animal noted on this side) in an open space 157 m from the stream bank. This animal was buried in pine duff an estimated 20 cm thick, in the open in a small grove of Jeffrey Pine. The slope at this site was estimated at 5 degrees or less. The last animal located was found on a south-facing slope under the base of a large (20 m) Coulter Pine an estimated 60 m in elevation above the watercourse and 187 m away from the east bank of the stream (Fig. 1) . This animal was buried an estimated 15 cm deep in a mixture of pine and shrub-leaf duff. All animals appeared to be awake and alert when uncovered, and did not exhibit any unusual behaviors.

Site OR 017 U

Six animals were tracked in the river at Site OR 017 U up until 30 September 1993. On 03 November we radio-located only two animals in the terrestrial habitat on the east side of the river immediately adjacent to the nesting area at this site (Fig. 2). Both animals were located in shallow duff under small Oregon oaks from 29-46.5 m from the water. Careful examination of the site revealed a total of 3 other turtles buried in the duff within 46.5 m of the water. Two animals were located within 1 m of each other. All animals appeared to be awake and alert when discovered. In all cases the degree of exposure ranged from 50-80% (% of shell uncovered). When the next survey was conducted (14 November) all animals had moved further into the forest. An account of each animal follows.

Turtle # 3 105 was a non-gravid female initially found approximately 28.7 m from the riverbank in duff under some small oaks. By 14 November she had moved an additional 75 m into the forest and was 20-30 m higher in elevation than previously. This animal remained in the same overwintering site until at least 29 December. On 06 January the signal was lost from this animal and was not relocated prior to the termination of monitoring. Repeated surveys subsequent to this for distances of up to 250 m in all directions from the last known overwintering site failed to produce a signal.

Turtle # 5860 was a male initially found approximately 30 m from the watercourse in duff under some small Oregon oaks. This animal was equipped with a transmitter and released on 05 November. On 14 November this animal was located approximately 115 m from the watercourse. This animal mad a slight move (3 m) toward the riverbank between 28 November and 06 December. No changes were noted until 20 January 1994, when the animal was discovered only 47 m from the watercourse. Between 20 January and 28 January the animal moved again, and was discovered 102 m from the watercourse on the latter date. Between 28 January and 02 February, the animal moved an additional 4 m further away from the watercourse. No movement was noted between 02 February and 26 February. When the animal was located on 06 March, it was 42 m from the watercourse. No further movement was noted between 06 March and 19 April. No signal was received from this (and several other animals) on this date, indicating that the turtle may have moved out of range.

Turtle # 11500 was a male initially found approximately 41.5 m from the riverbank. This animal was equipped with a transmitter and released on 05 November. By 14 November the animal had moved to approximately 140 m from the watercourse. No movements were noted on this animal until between 06 March and 14 March, when it was discovered approximately 45 m from the watercourse. On 25 April this animal was located in a small pool near within 3 m of the river.

Turtle # 7214 was a male initially found approximately 46.5 m from the watercourse. This animal was equipped with a transmitter and released on 05 November. This animal was relocated approximately 75 m from the watercourse on 14 November. The animal made a small movement (3 m) further away from the watercourse between 28 November and 06 December. A movement to within 65 m of the watercourse occurred between 06 December and 15 December. No further movements were noted until 05 April, when the animal was discovered approximately 40 m from the watercourse. When the area was surveyed on 25 April 1994, the signal from this transmitter was not detected, indicating that the turtle may have moved out of range.

Turtle # 300 was a male initially found 46.5 m from the watercourse (within 1 m of # 7214). This animal was equipped with a transmitter and released on 05 November. This animal was relocated approximately 55 m from the watercourse on 14 November. On 28

November, the animal was located 80 m from the watercourse. On 06 December, the animal had moved back toward the watercourse, and was now only 5 1 m away from the riverbank. The signal was lost from this animal on 22 March 1994, and not re acquired in subsequent surveys.

Turtle frequency # 1.665 was a male initially found on 05 November 100 m from the watercourse. By 06 December the animal had moved to a point 110 m from the watercourse. No further movements were noted until 29 March, when the animal was located 30 m from the watercourse. By 05 April the animal had moved to within 15 m of the watercourse, and was still in this location on 25 April.

Turtle # 3 111 was a non-gravid female initially found on 05 November 100 m from the watercourse. Between 28 November and 06 December the animal moved a further 52 m away from the watercourse. No further movements were noted until 25 April, when the animal was located 10 m from the watercourse.

Turtle # 8080 was a gravid female tracked beginning in mid 1992. This animal was first located on 06 December approximately 260 m from the watercourse. This animal was found predated on 13 January approximately 100 m downhill from the overwintering site. No movements were noted prior to that time.

Turtle # 8087 was another gravid female first tracked in 1992. This animal was also first located on 06 December 220 m away from the watercourse. This animal was unusual in that it was located in an overwintering site approximately 0.3 km E/NE of the other turtles monitored in this study. This animal was located in late October 1992 approximately 226 m from the watercourse in a old-growth area. This animal was observed basking in the open in this area on two occasions prior to 28 June 1993, when she was recaptured approximately 4 m from the watercourse. This animal apparently left the water sometime after 30 September and moved into the same general area she occupied in 1992/93. No movements were noted until 06 March 1994, when the animal was noted to have moved downslope approximately 5 m. Another movement of < 1 m was noted on 14 March. This animal was located in the same site on the termination of readings on 25 April 1994.

Results - Pond/Lake Habitats

Site OR 001 C

Turtles were monitored at this site throughout the summer of 1992. Due to a funding shortfall, only one attempt was made to locate animals at this site during the winter. In November 1992 two animals were located along the edge of the pond, presumably in undercut areas along the banks or in the roots of vegetation. At least two other animals appeared to be in the terrestrial habitat away from the pond, however before these animals could be located the receiver was accidentally dropped in a snow bank and further reception was impossible. As such, the only definitive statements that can be made about overwintering in this area are that at least a portion of the animals appear to over-winter in the watercourse and that apportion appear to overwinter in the terrestrial habitat.

Site OR 039 W

This site is located in the extreme upper end of the middle fork of the Willamette drainage. The study site is a small pond (see site description) located in a clear cut. The pond typically dries by late July or August, and fills again from subsurface flow and fall rains. Turtles monitored at this site during the winter of 1992 (when the site was accessible) were all located around the perimeter of the pond. Monitoring was terminated at this site in early 1993. In late 1993, we began trapping the area in late October to census the population. Surprisingly, two transmitters were found to be active at this point. As the expected battery life on these units is only 12 months and they were attached in June of 1992, this was considered unusual. At this time (18 November) there was already a sheet of ice covering an estimated 95-100% of the pond. The ice was 4-5 cm thick, and the water temperature was 1 degree Celsius. Air temperature was 3 degrees Celsius. One turtle was radio-located in an estimated 30 cm of water (25 cm water, 5 cm ice) under a log (Fig. 3). No attempt was made to remove this animal. Another animal was radio-located in a small side-pool in approximately 30 cm of water (25 cm water, 5 cm of ice). While probing to recover this animal, another turtle was located. In all, approximately 29 turtles (including the transmittered animal) were located in an area of less than 1 square meter. All animals were torpid but displayed some head retraction reflex when lightly touched. This site was surveyed again on 25 November and a further 14 turtles were discovered at this same site (Fig. 4) All animals were torpid but again exhibited some head and limb retraction reflex. The microsite appeared to be typical of much of the pond habitat - bordered by sedges, approximately 25-30 cm deep and with a soft mud bottom. By repeated probing, we determined that turtles were concentrated in the top 20-25 cm of the substrate. Transmitters were attached to three additional animals and these were monitored on an intermittent basis until February of 1994. Telemetry data indicate that the turtles engaged in movement under the ice in this time period, usually moving less than 1 m but on at least two occasions moving up to 10 m away. In one case an animal left the site where it was initially captured, moved to another site an estimated 10 m away, and then returned to the original site.

Site OR 050 U

A total of twelve turtles - two males and ten females - were monitored at this site between 09 September 1993 and 27 April 1994. Two animals - both gravid females - were observed to have moved out of this system in early 1993. One animal was subsequently located in a pump chance an estimated 0.5 km W/NW of the ponds at Site OR 050 U, and remained at that location until relocated to the ponds in June 1994. The other animal moved among several smaller pond and wetland sites over a distance exceeding 1 km over the course of several months. This animal had returned to the ponds by late May 1994 Observations of movements between September and November were usually small-scale (< 10 m) and follow general patterns discussed elsewhere (see movements for Site OR 050 U). Rather than enumerate each turtles movements, a general summary for each pond is provided.

Pond A - only two turtles (#"0" and # 11306) were radio-located at this site. Basking generally occurred at one of two sites in the pond - the northern shore where there was a concentration of logs, or on a log adjacent to the small island in the south side of the pond. By 09 November these two animals had moved into the and overwintering site located immediately south of the island. This site was located in water approximately 44 cm deep, less than 1 m from shore. The substrate in this area is composed of a layer of semi-dissolved organic material approximately 0.8 m deep at this point. It is likely that the turtles were buried to some extent in this material. The turtles remained within 3-4 m of this site until at least 07 April 1994. Visual surveys during this time period indicated that the turtles may been periodically active, particularly on warmer days. No emergent basking was noted at this site, however.

Pond B - Eight turtles - seven females and one male - were monitored at this site. Over 95% of the activity noted in this pond occurred in the northern "half" of the pond despite the presence of seemingly suitable basking and foraging sites on both "halves". By 26 October, most animals appeared to have moved to the over-wintering sites in the pond. There were two locations where the turtles apparently clustered - one in a beaver hole on the north shore. This hole is > 1 m in length and located approximately 25 cm below the waters surface beneath a small clump of willows. The other area where turtles were concentrated was near the outlet of the pond, where is flows into a small stream draining north. The depth of water on the over-wintering sites on these animals ranged from 20-54 cm, and the distance from shore was between 0.5 and 1 .0 m. The substrate at this site is a mixture of soft mud, vegetation and decaying organic material approximately 30-40 cm deep. Activity was noted on several occasions throughout the winter (see below), but turtles began to move out to and occupy "regular" basking sites as early as 03 March.

Other Sites - Two gravid females moved out of Pond B in late May 1993. One animal was located in a pump chance approximately 0.5 km W/NW of Pond B, while the other wandered among a series of wetlands and smaller ponds up to 0.5 km N of Pond B. Both animals overwintered in the aquatic habitat under conditions very similar to those described above. The animal in the pump chance overwintered in a microsite located in 0.48 m of water 0.1 m from the shore. The animal in the wetland area was located in 0.3 1 m of water between 10 m from "shore" (actually a drier area in the wetland).

Site OR 002 U

The movements of turtles at Site OR 002 U are potentially much more significant and interesting than at most other sites. Tracking of animals began at this site in June 1992 and continued until 24 April 1994. The fall-winter movements of animals are discussed on an individual basis below.

Turtle # 7201 was a non-gravid female tracked from 30 September 1993 to 16 October 1993. In that time the animal moved short distances within Site OR 002 U (less than 30 m). The signal was lost on 16 October and was not re acquired prior to the termination of monitoring.

Turtle # 7247 was a nongravid female tracked from 30 September to 30 October 1993. The signal was lost from this animal on 08 November and was not re acquired prior to the termination of monitoring.

Turtle # 7203 was a male tracked from 30 September to 08 November 1993. The signal was lost from this animal on 14 November and was not re acquired prior to the termination of monitoring.

Turtle # 1789 was a non-gravid female tracked from 30 September to 23 October 1993. The signal was lost from this animal on 30 October and was not re acquired prior to the termination of monitoring.

Turtle # 7270 was a non-gravid female tracked from 30 September 1993 to 25 April 1994. This animal engaged in several short-distance movements prior to 14 November, when this animal was located in the same microsite as turtle # 9909 (Fig. 5, Fig. 6) This animal remained in the same microsite until 19 February, when it moved an estimated 5 m further out into the lake. The overwintering site was located on the bottom of the lake in a mud and vegetation substrate approximately 0.5-0.8 m deep and 1.5- 2.0 m from shore. This animal made no further movements until 07 March, when all transmittered animals were observed to have moved into the middle of the lake and resumed small-scale (1 0-20 m) movements.

Turtle # 9909 was a male tracked from 30 September 1993 to 15 March 1994. The signal was lost at this time and was not acquired at the last tracking effort (25 April). This animal apparently made small-scale movements (< 2 m) within the same general area as # 7270, but did not move significantly until 07 March.

Turtle # 7246 was tracked from 30 September 1993 to 25 April 1994. This animal apparently remained in the same general area (< 4 square meters) in the mud at the bottom of a lake approximately 0.5 km west of Site OR 002 U. This site was located under a clump of floating vegetation approximately 3 m from shore in 0.5 m of water. The long-term location of this signal was thought to be a result of a lost transmitter, however repeated probing of the area failed to turn up the turtle and slight movements (usually less than 1 m) were noted over the course of several weeks. This animal was observed to move away from the overwintering site on 07 March.

Turtle frequency # 1.701 was a large female captured at Site OR 002 U on 12 January when it emerged from the general area of the over-wintering site of turtle #s 9909 and 7270 to bask. Air temperature at this time was 6 degrees Celsius and water temperature was 5 degrees Celsius. This animal was tracked from 12 January until 15 March 1994, when it was found dead on the shoreline.

Turtle # 99 10 was a large male captured on 20 January 1994 while basking in the same area where turtle # 1.701 and #s 7270 and 9909 were located. This animal was equipped with a transmitter and release on 22 January. Small scale movements were noted in the general area of the overwintering site (<2-3 m) until 07 March, when the animals moved out into the deeper portions of the lake.

Results - Altered Wetland Habitats

West Eugene Sites - Golden Gardens and Danebo Pond

Turtles were monitored at these sites from 02 September 1993 to 29 December 1993. Approximately 10 turtles were monitored at the Golden Gardens - Danebo Pond and connecting channels complex. An account of each turtle follows.

Turtle # 001 was a male whose last movement was observed in 02 September. This animal moved to the east-facing bank of a drainage ditch immediately adjacent to a major thoroughfare. Small-scale movements (exact extent unknown but less than 25 m) were observed on 56% of monitoring periods between 21 October and 02 December 1993. The animal was in or immediately adjacent to water during this time period. Between 09 December and 29 December no movements were observed. By 09 December the water in the immediate area of the ditch inhabited by the turtle was dry, and the nearest water was > 30 m away. The slope at the microsite was approximately 40 degrees (the ditch bank) and none of the turtle was exposed. The covering vegetation was primarily grass, leaves and weeds.

Turtle # 002 was a male that continued to move extensively within Golden Gardens Pond after 02 September. The average distance moved per movement was 65 m, and the greatest distance moved was 125 m between 11 November and 18 November. No movements were observed after 09 December, and this animal appeared to overwinter in an area immediately adjacent to the bank in less than 2 m of water. The substrate was a mixture of mud, vegetation and cobble. There was no vegetative cover at the microsite, but there were grasses, cattails and blackberries immediately adjacent to the area.

Turtle # 003 was a male that made relatively few movements within Golden Gardens Pond after 17 September. However, these were long-distance movements. The average distance moved per movement was 217 m - greater than the average distance/movement during the summer. The greatest distance moved was 353 m between 11 November and 18 November. No movements were observed after 09 December, and this animal appeared to over-winter in a bank along a small side-channel in less than 0.5 m of water and less than 1 m from shore. The substrate was a mixture of mud and cobble. There was no vegetative cover at the microsite, but there were grasses, cattails and weeds immediately adjacent to the area.

Turtle # 004 was a non-gravid female that moved only once within the Golden Gardens Pond area after 24 September. The single movement noted was 187 m between 15 August and 24 September. This animal apparently over-wintered in an area immediately adjacent to turtles 003 and 010 - a small channel near the A3 channel. As with the other animals, this turtle apparently overwintered in or near the bank in less than 0.5 m of water less than 1 m from shore. There was no vegetative cover at the microsite, but vegetation typical of the area was present along the bank (grasses, blackberries, weeds).

Turtle # 005 was a post-partum female that moved extensively within Golden Gardens Pond and adjacent channels after 02 September. The average distance moved per movement was 90 m, and the greatest distance moved was 265 m between 15 December and 22 December. Movements were observed on 8 1% of monitoring periods between 21

October and 29 December. Based upon movements during monitoring periods in December (4 of 4 instances), it appears that this animal did not use a single overwintering site. This animal was radio-located in open water on the east end of Golden Gardens Pond on 05 January 1994.

Turtle # 006 was a post-partum female on which the signal was lost between 21 October and 02 December. This animal was subsequently located on 09 December in a small channel south of the Golden Gardens east pond. Water depth was estimated at 0.4 m and the microsite was less than 1 m from shore. No movement was observed between 09 December 1993 and 05 January 1994.

Turtle # 007 was a male that made frequent short-distance movements after 02 September. The average distance moved per movement was 59 m, and the greatest distance moved was 79 m between 28 October and 04 November. Movements were observed on 57% of monitoring periods between 17 September and 29 December. This animal, like turtle # 005, also did not apparently use a single over-wintering site. This animal was radio-located in open water on 05 January 1994.

Turtle # 008 was not radio-tracked after 13 August so no data is available on overwintering habits.

Turtle # 009 was a male that made intermittent long range movements after 02 September. The average distance moved per movement was 112 m, and the greatest distance moved was 176 m between 04 November and 18 November. Movements were observed on 58.5% of monitoring periods between 17 September and 29 December. This animal remained at a single site between 02 December and 22 December, but them moved 125 m between 22 December and 29 December. This animal was radio-located in open water on 05 January 1994.

Turtle # 0 10 was a male that made occasional short-distance movements within the watercourse after 26 September. Between 15 August and 26 September the animal moved 407 m. Past that date, the average distance moved per movement was 42.5 m, and the greatest distance moved was 60 m between 02 November and 02 December, and a similar movement between 22 December and 29 December. Movements were observed on only 42.5% of monitoring periods after 26 September. This animal was radio-located in the small channel near the A3 channel on 02 January, in close proximity to turtles # 003 and 004.

West Eugene Sites - Bertelsen Pond and Finn Pond

Turtle # 25 was a post-partum female originally trapped in the Finn Pond area. This animal was radio-located in Finn Pond on 12 occasions between 21 October 1993 and 05 January 1994. The animal did not appear to have moved in this time. The pond is a small (est. 25 m x 15 m) borrow pit along the SP railroad tracks. The substrate is mud, and nutria *(Myocastor coypu)* burrows are abundant in the banks. The banks are estimated to sit at an approximately 25-30 degree angle at the water's edge, the pond is surrounded by a dense growth of blackberry. No emergent vegetation is present in the pond area.

Turtle # 33 was a male originally trapped in Finn Pond. This animal made only two short-distance movements, 10 m between 02 December and 09 December, and 5 m between 09 December and 15 December. No movements were noted on any of the 10 remaining observations between 21 October 1993 and 05 January 1994.

Turtle # 205 was a post-partum female originally trapped in the Bertelsen Pond area. This animal made two movements of 25 m, one between 11 November and 18 November and another between 18 November and 26 November. No movements were noted after this period. The apparent overwintering site was a small pond less than 2 m deep. The animal was located somewhere in this pond on 5 occasions between 09 December 1993 and 05 January 1994. There was no vegetative cover at the site, but blackberries, grasses and weeds dominated the surrounding area.

Turtle # 26 was a post-par-turn female originally trapped in the Bertelsen Pond area. This animal made three movements, one of 25 m between 04 November and 11 November, another of 35 m between 18 November and 26 November, and another of 50 m between 26 November and 02 December. No movements were noted past 02 December, and the animal apparently overwintered in the same small pond as # 205.

Discussion

As with has been the case with most other aspects of this species life history, collection of significant amount of data produces two primary results. First, it re-emphasizes that this is a highly plastic species, displaying not only significant variation in a given behavior among habitats but also among individuals. Second, it also emphasizes that the existing data are incomplete and pose several new questions. However, several generalizations or observations can be made about overwintering behavior.

1) It appears that there may be different over-wintering behaviors utilized at a site on a year-to-year basis. Sporadic tracking of turtles at Site OR 002 U in late 1992 indicated that at least four of the animals radio-located were in the terrestrial habitat in late November. One of these animals was subsequently located in an old-growth area approximately 150 m W/NW of the lake. However, in 1993/1994 the two remaining transmittered animals overwintered in the lake. On at least two occasions in late 1992-early 1993, animals at Site OR 050 U were located in terrestrial habitats up to 20 m from the water in midwinter - in some cases with up to 1.2 m of snow on top of the site. However, all animals monitored in 1993/1994 overwintered in the aquatic habitat. These situations may or may not be anomalous.

2) It is apparent that in general (bearing in mind the observations above) there appears to be a tendency toward use of aquatic sites for overwintering in lacustrine habitats, and of terrestrial sites for flowing-water habitats (such as streams and rivers). Observations from other areas (D. Reese, B. Goodman, pers. comm.) and other data (Rathbun et al. , 1993) also tend to support this idea. However, in some areas (particularly California), animals may remain in stream and riverine habitats for the majority of the year, leaving only when "flushed" out by high water flows during late fall or early winter. Repeated observations of animals leaving stream areas during or immediately after heavy rainfall and an increase in flow in these systems is generally consistent with this idea.

3) Some animals may engage in long-distance movements (> 1 km) prior to moving to an over-wintering site. The sequential loss of 4 transmittered turtles at Site OR 002 U is unlikely to be due to battery or transmitter failure. Repeated grid searches of the surrounding forest and adjacent watercourses up to > 1.5 km in every direction from the lake failed to yield evidence of these animals. Similarly, observations of turtles at the Golden Gardens site indicate that while relatively uncommon, long-distance movements do occur late in the season. Observations from site OR 163 W indicate that one turtle moved a linear distance of almost 5 km to an overwintering site in late 1992. This animal returned to the general area of capture and repeated this movement within 4 days of the time it had left the previous year. Thus, the loss of signal from some of these animals may be because they have moved out of range of the receiver (approximately 300-400 m). The possibility exists that some turtles may have a different "summer" and "winter" range.

4) It is now apparent that activity occurs on a year-round basis for this species. Prior observations (Holland, 1985) noted a decreased level of activity during the winter months along the central California coast. Turtles were still active at water temperatures as low as 9 degrees Celsius. Statements in Holland (199 1) indicate that known year-round activity was restricted to central and southern California. Based upon the results of this study, it is now apparent that turtles may be active (albeit on a reduced level) throughout their range throughout the year. Field notes from Site OR 002 U indicate that turtles may move freely in the lake with water temperatures as low as 5 degrees Celsius (12 January 1994). Turtles may also emerge to bask under these conditions - even when the majority of the watercourse is covered by ice (Fig. 7). Observations at Site OR 050 U seem to indicate that turtles may in fact be thermoregulating *under* the ice - using potential temperature differentials on the dark substrate to marginally increase body temperatures. Repeated observations of turtles moving slowly under the ice, or sitting quietly on the bottom and moving off when disturbed by the observer indicate that the turtles can and do move freely within these habitats even when completely covered by ice. Radio-telemetry data from Site OR 039 W also supports this contention. References in the field notes from Sites OR 002 U and OR 050 U, as well as incidental observations at other sites indicate that it is not unusual for turtles to emerge from aquatic overwintering sites to bask even in January and February. Air temperatures on these occasions have been as low as 6 degrees Celsius.

5) It is now apparent that turtles may overwinter communally in aquatic habitats. The discovery of 43 turtles in an area of less than 1 m^2 at Site OR 039 W, the clustering of several individuals in a beaver burrow at Site OR 050 U, and the location of 4 individuals at one site approximately 2 m^2 at Site OR 002 U lends support to this idea. The reason for this situation is unknown and may be related to microsite quality. Subjectively, however, the microsite at Site OR 039 W appears little different that many other areas in the pond.

6) It is also apparent that when turtles utilize terrestrial habitats for over-wintering purposes, they may move extensive distances into upland areas. For the two riverine/stream sites included in this study, distances ranged from as little as 15 m to as far

as 260 m. Data from site CA 010 K (D. Reese, pers. comm.) indicates that some animals may move up to 500 m overland to an overwintering site.

7) Turtles are obviously thermoregulating during terrestrial habitat use. Repeated observations indicate that turtles may leave the duff layer and move a short distance to a patch of sunlight on the forest floor to bask (Fig. 8). In other sites where sunlight impinges directly upon the overwintering site, turtles have been observed sitting partially covered in the duff with the head extended, presumably to warm this portion of the body without exposing the rest of the body.

8) Some animals overwintering in terrestrial habitats may engage in extensive overland movements during the winter. Turtle # 5860 moved at least 8 times over a distance of approximately 332 m between 14 November 1993 and 25 April 1994 (Fig. 9).

9) Turtles overwintering in terrestrial habitats that are forested typically utilize areas with a duff layer. Measurements of the duff layer at all overwintering sites at OR 017 U indicate that the minimum amount of duff on top of any overwintering turtle was 20 mm, and the maximum depth underneath the turtle was 80 mm. All overwintering sites at Site OR 017 U were under some canopy closure. The average over the entire period was 47 % (n=30). Interesting, the degree average canopy closure varies through the overwintering period and shows a general increase as the season progresses (Fig. 10).

10) The general trend in moving between overwintering sites appears to be an initial move to a site at the "edge" of the forest/riparian area, and then a subsequent move further away from the watercourse. Observations on several animals at site OR 017 U show this general pattern (Fig. 11).

11) Some turtles may exhibit site fidelity on a year to year basis. At least one turtle (#8087) at site OR 017 U tracked during the winter of 1992/1993 returned to within 10-12 m of this location in 1993/1994 Three of the turtles tracked at Site OR 050 U overwintered in the same beaver burrow in 1992/1993 and 1993/1994. In the latter case, this may be due to a limited number of suitable overwintering areas within the pond.

12) Predation in the terrestrial habitat during overwintering may be significant. In this study, at least one animal was lost (#8080) at Site OR 017 U. Observations from southern California in similar situations (B. Goodman, pers. comm.) indicate that several animals may suffer predation in a relatively short period of time (< 2 weeks).

The data collected on overwintering to date re-enforce the general impression of this species as having a "plastic" life history. It also re-emphasizes the need to approach protection and management of the species from an integrated, long-term ecosystem perspective. The majority of known turtle localities throughout the range of the species are in flowing-water habitats. Thus, it seems likely that the majority of the populations of this species engage in terrestrial overwintering behavior during at least some portion of the year. Protection of these overwintering areas is therefore critical to any short or long-term plan for management of the species. It is likely that a variety of activities, including timber harvest and off-season burning for fuels reduction will have an effect on pond turtle populations. It is apparent that in many areas, there is no "safe" period for disturbance of the terrestrial habitat, or that if it exists it is very limited. Females typically leave the watercourse from late May-late July to lay eggs, which are very sensitive to disturbance throughout their incubation period - estimated at an average of 90-110 days. This period (May- early November) covers one aspect of vulnerability. However, as the hatchlings (in most areas) appear to overwinter in the nest and do not emerge until at least March or April, they remain vulnerable during this time period. As noted above, seemingly low-impact activities such as excavating holes for tree planting may impact individual nests. Some adults leave the water between mid-late October and early November and move into terrestrial habitats to overwinter. They may remain in these areas for several months - records from the south Umpqua drainage at Site OR 017 U indicate that at least two of seven transmittered turtles in 1993 not return to the water until late June - a period of use of the terrestrial habitat of at least 8 months. At least two animals (out of seven) tracked at this site in early 1994 were still in the terrestrial habitat in late April. Other information (D. Reese, pers. comm.) indicates that some animals in northern California may actually use the terrestrial habitat for a period exceeding 10 months.

Within the aquatic habitat, some activities may continue to affect turtles throughout the year. The practice of gill-netting to sample fish populations in late fall or early winter may result in direct mortality to turtles. Similarly, chemical treatment (i.e. to remove undesirable species of fish) may also affect turtles at a period when they are potentially most vulnerable. The affects of late season boating or other use (such as fishing) are unknown, but the latter is known to have a generally negative impact on turtles through direct mortality.

The documentation of extensive use of terrestrial overwintering sites by turtles in stream of riverine habitats emphasizes the need to protect these areas as part of an overall management effort. While the documentation is less extensive for use of terrestrial habitats by turtles in pond or lake systems, this may in part be an artifact of the level of disturbance at some of these sites - both pond systems studied were located in clear-cuts, and the west Eugene wetland areas are heavily disturbed by a variety of activities. As such, until further research demonstrates otherwise, it would be prudent to adopt a standardized buffer of 0.5 km on all sides of a watercourse that holds turtles. This will protect all known nest sites, all known overwintering sites, and may confer some protection on dispersal areas for some populations.

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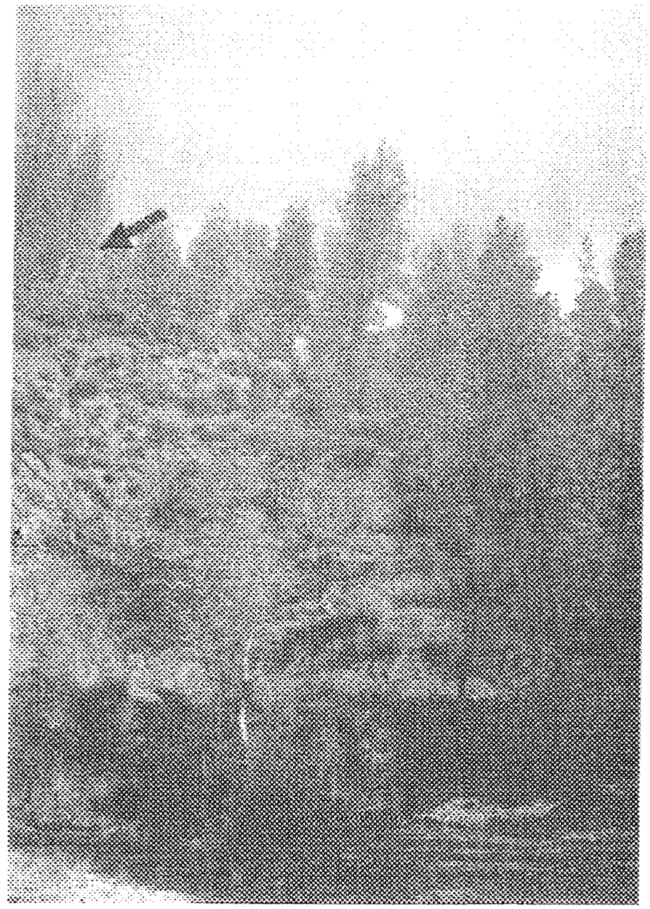

Figure 1: Overwintering site of western pond turtle on south-facing slope 187 in from stream. Arrow indicates exact site. Trinity County, California. (Site CA 014 K)

Figure 2: First overwintering site for turtles at Site OR 017 U. Arrow indicates area where 5 turtles were found. Douglas County, Oregon.

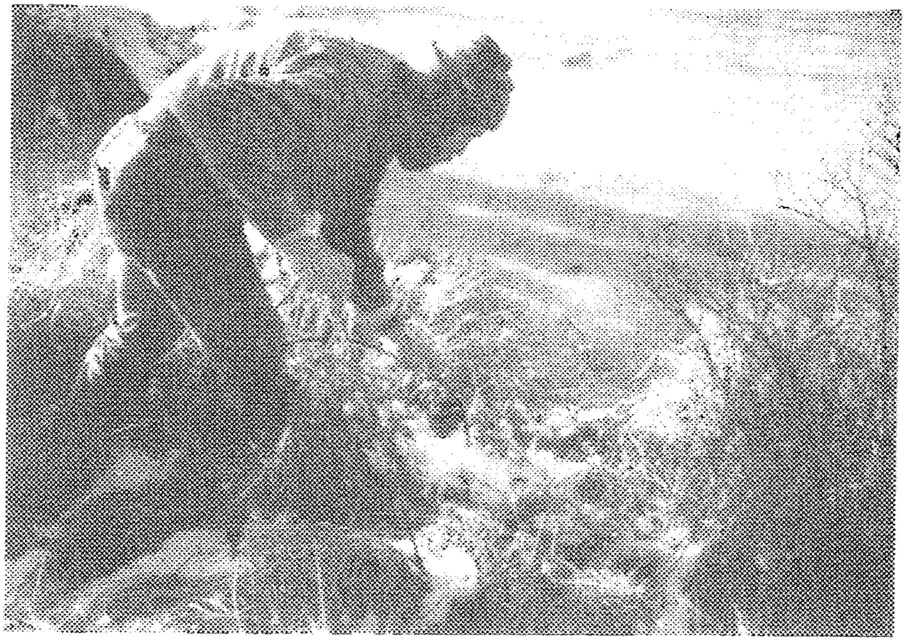

Figure 3: Overwintering site of one transmittered turtle at Site OR 039 W on 25 November, 1993.
Douglas County, Oregon.

Figure 4: Mass overwintering site of 43 turtles at Site OR 039 W on 25 November: 1993.
Douglas County, Oregon.

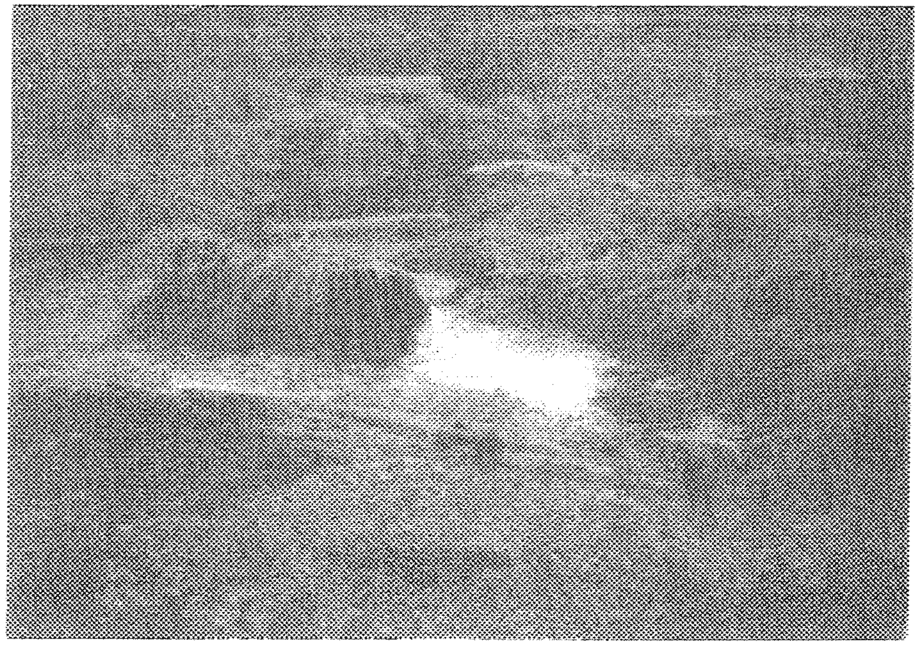

Figure 5: Overwintering site of turtle at take site near Site OR 002 U, Douglas County, Oregon.

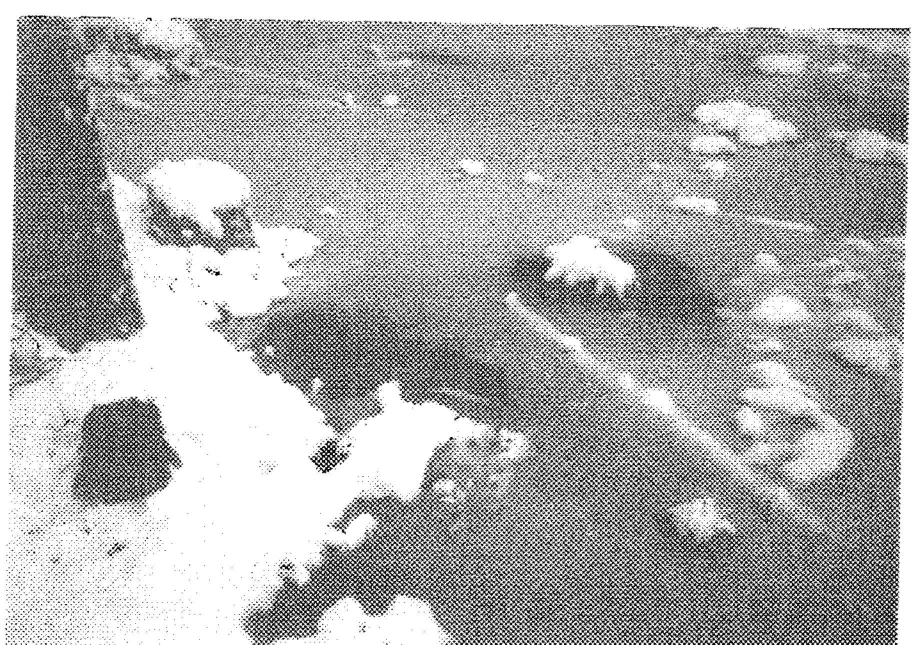

Figure 6: Overwintering site of at least two turtles at Site OR 002 U. Douglas County, Oregon.

Figure 7: Site OR 002 U, early February 1994.

Figure 8: Turtle terrestrial basking near overwintering microsite at Site OR 017 U. Douglas County, California.

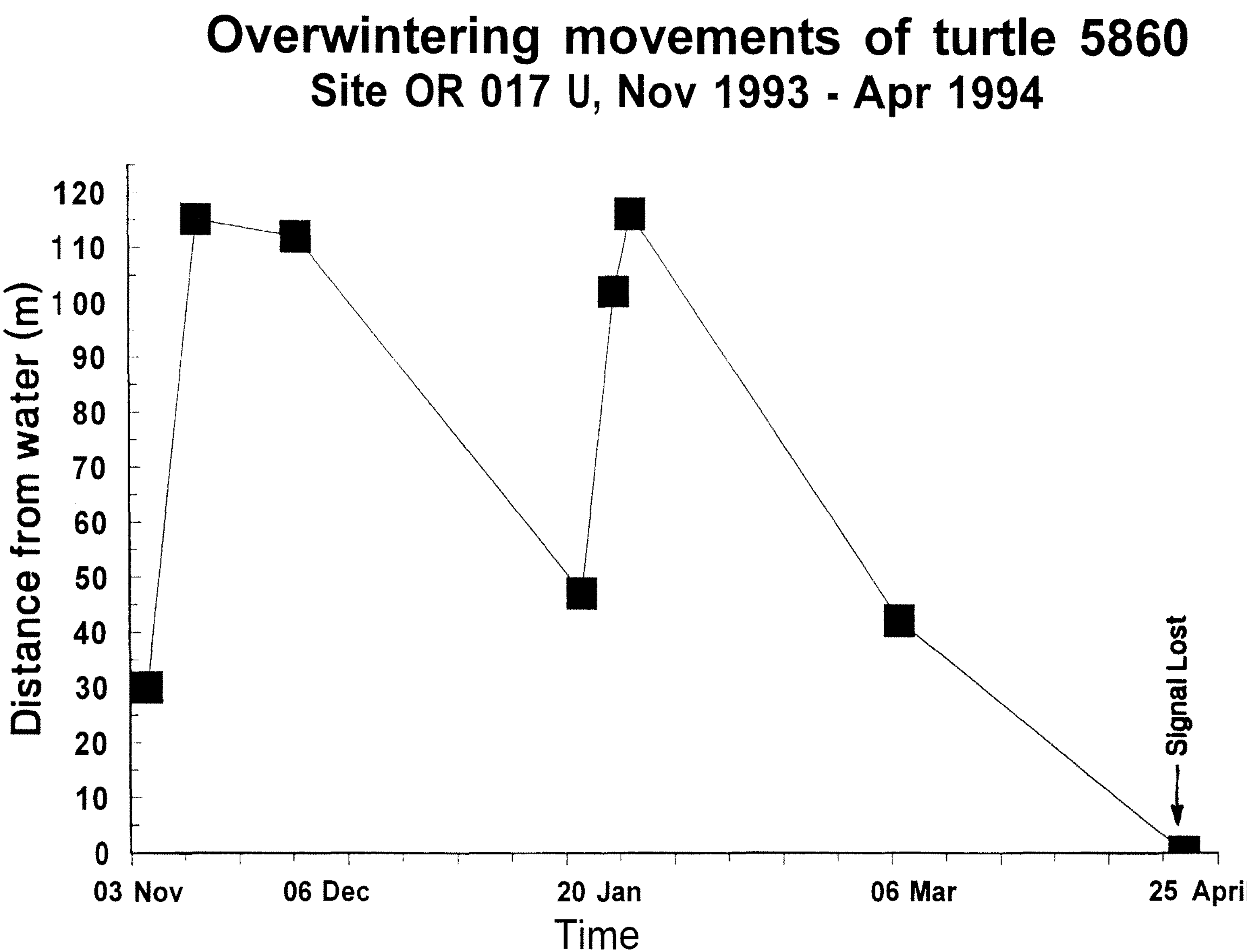

Figure 9: Overwintering movements of turtle # 5860 at Site OR 017 U.

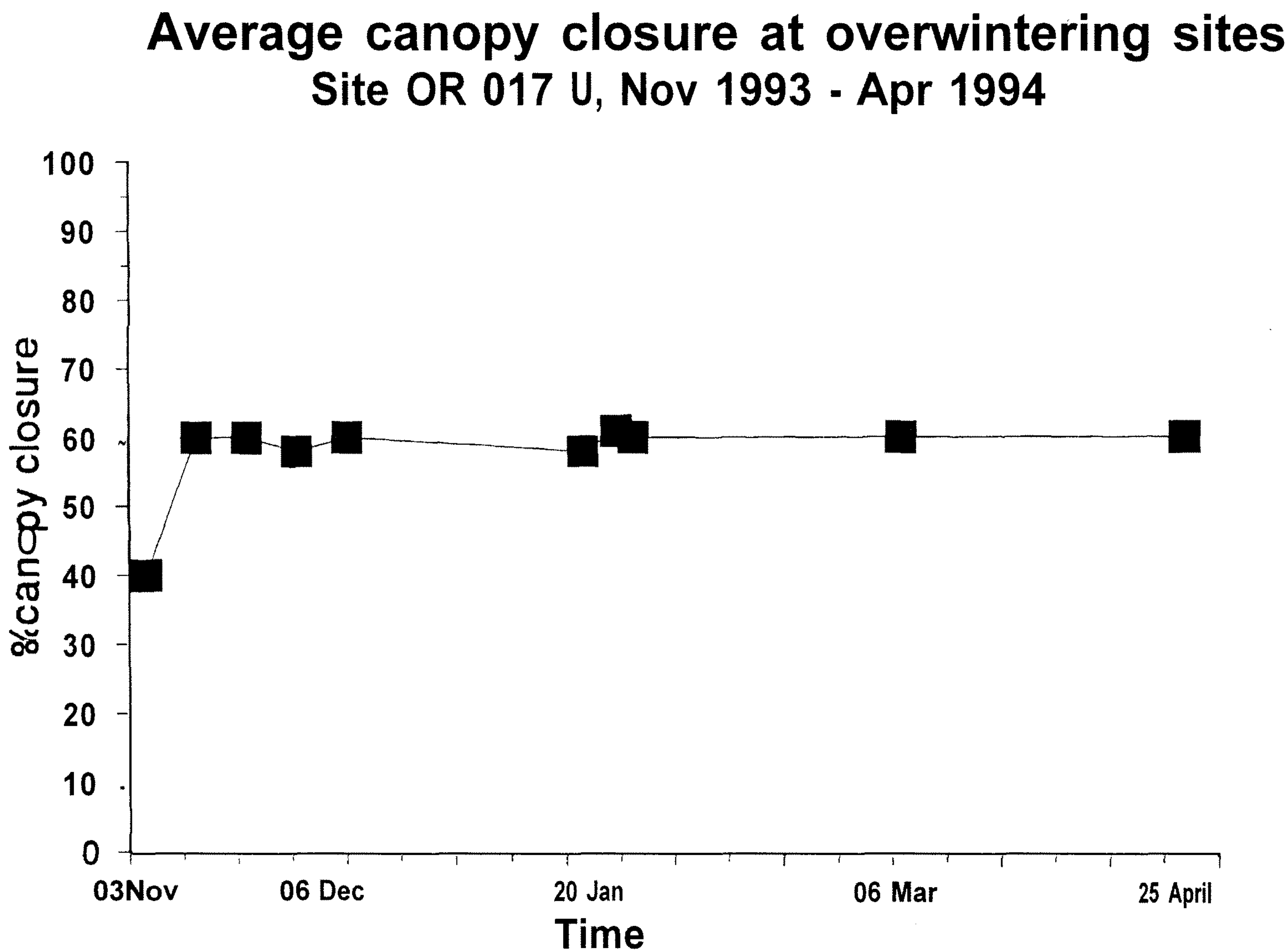

Figure 10: Average canopy closure at overwintering sites of seven turtles at Site OR 017 U-

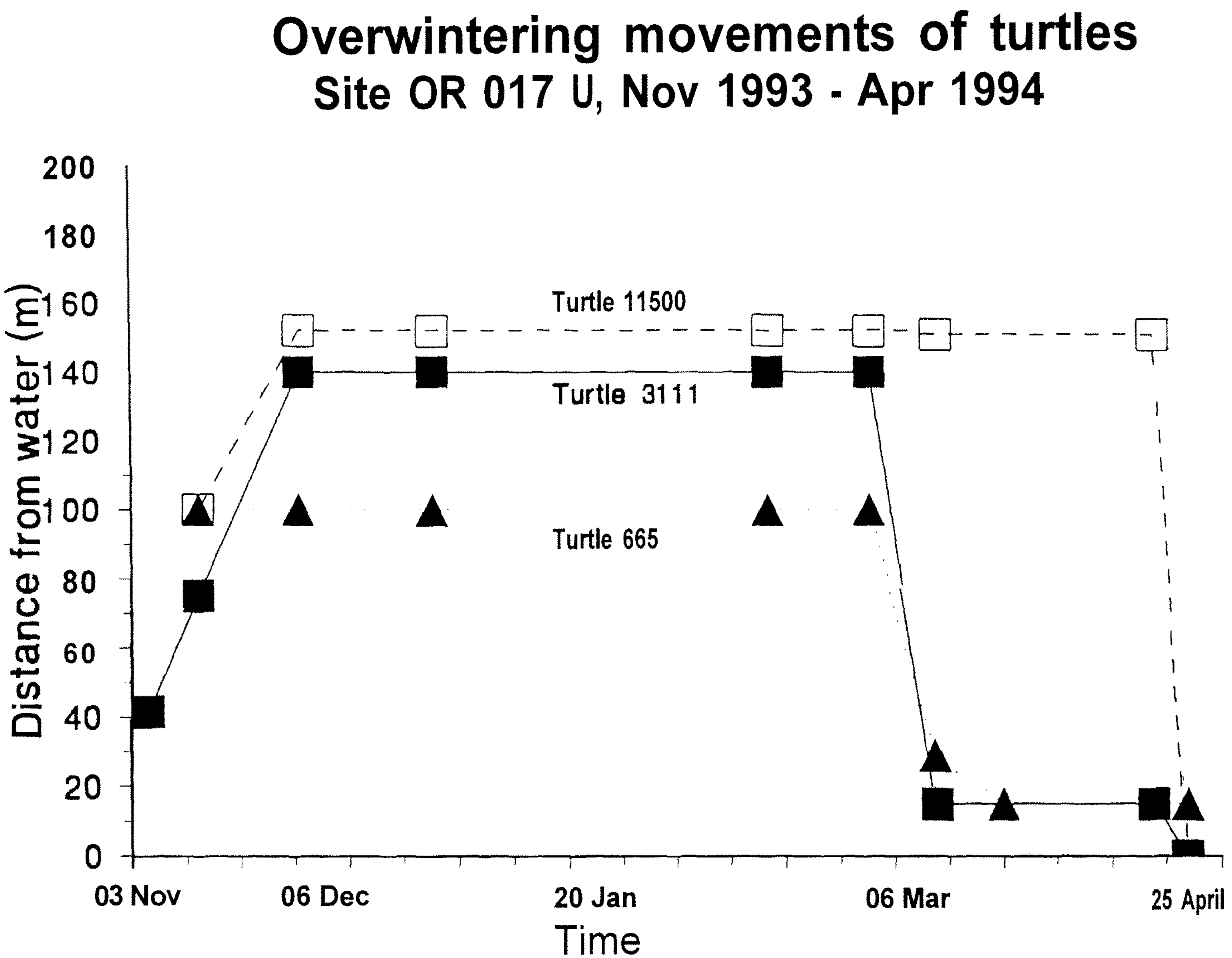

Figure 11: Summary of overwintering movements of three turtles at Site OR 017 U.

CHAPTER 9

The Effect of Introduced Turtle Species on the Status of the Western Pond Turtle *(Clemmys marmorata)* in a Central California Pond

The Effect of Introduced Turtle Species on the Status of the Western Pond Turtle *(Clemmys marmorata)* in a Central California Pond

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INTRODUCTION

The effects of introduced turtles on the status of the western pond turtle (WPT), *Clemmys marmorata,* have been noted (Holland, 1991) but never investigated. Possible effects include interspecific competition and transfer of parasites between host species. Competition between species may occur by exploitation of common resources and/or by direct interference between heterospecific individuals (Schoener, 1974). Parasite species may transfer from normal host to other species, or may proliferate as a result of poor conditions to which individuals are often exposed prior to introduction (Holland, 1991). While coexistence between competing species is possible, interspecific interaction may result in competitive displacement or even extirpation (Kaplan and Yorke, 1977). It should be noted that none of these effects are necessarily mutually exclusive. Hence, the presence of introduced turtle species in WPT habitat and the possible effects on *C. marmorata* should be of serious concern in study and management of this species.

C. marmorata is thought to have evolved in isolation from other species and is the only native freshwater turtle throughout most of its range (overlapping with the painted turtle, *Chrysemys picta,* in the northern-most parts of its range; Bury and Holland, 1993). However, several species of introduced turtle have been recorded within the range of the western pond turtle, listed in Table 1 (Holland, pers. comm.). Introduced turtles, especially the red-eared slider, *Trachemys scripta,* are becoming increasingly common, and presumably represent releases from the pet trade that may occasionally establish populations (Holland, pers. comm.). The threat to *C. marmorata* is therefore real at least in that western pond turtles do with frequency co-occur with introduced turtle species.

I report here on a study documenting the co-occurrence and providing evidence for interaction of *C. marmorata* and introduced turtle species in a pond on the University of California, Davis campus, Turtles were trapped during the 1991- 1993 seasons, marking and releasing *C. marmorata* and removing turtles of introduced species. The effectiveness of removing introduced turtles in rehabilitation WPT populations is therefore tested. I use population characteristics and size and age structures to make inferences as to the status of C. *marmorata* and *T. scripta* in the pond, and spatial and temporal analysis to compare the species' habitat use. Also, I collected blood and fecal samples for parasite analyses and purchased materials necessary for experimental investigation of the mechanism underlying interspecific interaction,

MATERIALS AND METHODS

The study site is the UC Davis Arboretum, an approximately 1.5 km section of Putah Creek (Sacramento River drainage) that was blocked off and regulated in the early 1950s to create the UC Davis Arboretum, Figure 1 (Sid England, UC Davis Environmental Engineering, pers. comm.). The pond is highly eutrophic with detritus up to two feet in depth and many species of fish, birds, and turtles, Basking occurred mostly on banks. Habitat types I and II are defined by their difference in shore cover, as shown in Figure 1 (shading along the banks represents individual plants, taken from aerial photographs).

Trapping was done once or twice daily using hoop (used 1992) and basking (used 1991-1993 traps, Basking trap design was wooden square with ramps extending over netting, nine 4'x4' (199 1- 1993) and sixteen 6'x6' (1992, 1993) (Harless and Morlock, 1977) and PVC squares with netting draped over wooden platform, four 4'x4' (1992, 1993) (Devin Reese, pers. comm.) Their placement was approximately uniform over the length of the pond and was changed to optimize catch. California Fish and Game installed two duck traps (1992) which were very effective in containing turtles for capture by hand. We used standard mark-release methods with WPTs (painted number on carapace) and removal methods with turtles of introduced species. Field data included time, number and exact location of traps and general weather conditions. The lab treatment including numbering and identifying species and sex of each turtle, taking carapace and plastron length, aging if possible (by plastron scute ring number in immature turtles), palpation (late 1992 season only), making blood smears (late 1992 season only, Chris Austin, University of Texas, pers. comm.), and saturating fecal samples in 0.25 KCr04 (late 1992 season only, Robert Fisher, UC San Diego, pers. comm.). Turtles were permanently marked by notching the lateral scutes of the carapace, tens digit on the left and ones digit on the right.

Bouts of observations (late 1992 season and 1993) were made from fixed positions along the pond for a fixed time period. We took data on the number of turtles, their species, and notes on activities. Times of bouts were varied to collect information for a wide range of times, and time period length was chosen to maximize number of turtles seen while minimizing total length of a bout.

I calculated population size estimates according to the Schnabel mark-recapture (Smith, 1966) and DeLury removal (DeLury, 1947) methods for *C. marmorata* and *T. scripta* respectively. WPT size structures are made to compare with those of Holland, 1991, and age structures for comparison with the equilibrium population size model (Figure 3) and published *T. scripta* data (Figure 4). Contingency tables (Table 4) facilitate the calculation of coefficients of association, distributed as Chi-square values, for spatial analysis (Hubalek, 1982). Observation data are taken as instantaneous estimates of the number and location of turtles at the median time of the bout.

We collected naive WPTs from Coast Range foothill sites suggested by Holland an received naive red-eared sliders from Louisiana (late 1992 season. They were treated as were Arboretum captures (see above).

Materials were purchased for an experiment investigating dynamics of turtle populations in artificial ponds. We appropriated two 1 00'x200' fisheries pond at the UC Davis Aquaculture lab, and build two 600'x2' chicken wire fences with PVC supports and 2'x3.5' basking platforms. The ponds were stocked with experimental turtles in September 1992 with six C. *marmorata,* and three *C. marmorata* and three *T. scripta,* respectively. Experimental turtles were chosen for similar sex ratio and size distribution between ponds and overlapping size distributions among species classes. Early winter storms preempted the experiments.

Materials were purchased for another experiment investigating individual turtles' habitat preferences and behavioral interaction between individuals in a small arena. The arena consisted of 6' diameter wading pools lined with astroturf, with shade screening over half, one 6" square basking block under a 150W light in each half, temperature control via an aquarium heater, and a tarp blind for observation.

Turtles were kept dry individually in buckets or in groups in coolers until defecation and/or markings were dry. UC Davis Arboretum WPTs stayed in the lab for up to 3 days, and other species individuals were kept thereafter in wading pools, including naive turtles (each sp separately). They were fed raw meat scraps and trout chow. At the end of the 1993 season, all WPTs were released into the Arboretum, and all exotics were euthanized by injection with

Nebutol or Ketamine followed by decapitation and donated to the UC Davis Museum of Vertebrate Zoology.

RESULTS

Table 2 lists the species and number of all individuals trapped over the three seasons. *C. marmorata* was one of the two most abundant species found, and the presence of juveniles was taken as evidence of recruitment, One new species of *Graptemys, G. pseudogeographica,* was found to co-occur with *C. marmorata* at the UC Davis Arboretum. This and all species found are well-represented in the pet trade. Only one other species, *T. scripta* was seen courting and also showed evidence of recruitment. Subsequent analyses regard the two populations, *C. marmorata* and *T. scripta* respectively, in the UC Davis Arboretum.

Estimates of population characteristics, Table 3, are based on total trapping of similar numbers of the two species. Average adult carapace lengths are consistent with literature values, with *T. scripta* being larger. Although population size estimates are not directly comparable due to difft methods, the two species population sizes seem to be on the same order of magnitude. Effect of removal should be noted as the size estimate for 1993 *T. scripta* population is lower than that of 1992; however, these estimates are probably underestimates since not all individuals were captured in 1993. Although sex-determination in *T. scripta* is temp-dependent and Trach populations often show biased sex ratios (Gibbons, 1990b). Therefore, the two spp co-occur and may coexist

Status of the populations can be examined by a snapshot of relative abundances of turtles of different ages, or correlates of age such as size. Since parameters such as fecundity and survivorship may vary among species, size and age structure comparisons are made within species only. Adult-biased population structures commonly observed for *C. marmorata* indicate population decline (Holland, 1991). Figure 2 compares size structures of *C. marmorata* in the UC Davis Arboretum with those of two other populations also in the California central valley. Site CA 001 S is undisturbed while bullfrogs and bass, species know to prey upon juvenile *C. marmorata,* are present at site CA 003 S (Holland, 1991). The UC Davis Arboretum population size structure shows adult bias more similar to that of site CA 003 S than that of site CA 001 S, suggesting some disturbance of this *C. marmorata* population. While two bullfrogs were collected at the site over the three seasons, their stomach contents showed no evidence of predation on juvenile turtles and no tadpoles were found (data not shown). The disturbance of the *C. marmorata* population in the UC Davis Arboretum could result from interaction with introduced turtles.

Perhaps the status (with respect to growth or decline) of the UC Davis Arboretum *C. marmorata* population can be more directly addressed by comparison of its age structure with that expected under equilibrium population size. This is modeled by assuming constant proportions ofjuveniles and adults, and that juvenile survivorship is linear with body size. Relating these proportions by parameter estimates for either adult fecundity or adult mortality and solving simultaneously with proportions of juveniles and adults summing to one gives the expected proportions of juveniles and adults under equilibrium population size. The mean of solutions derived under the fecundity and mortality approaches is taken for comparison with the UC Davis Arboretum *C. marmorata* population, Figure 3. The expected proportion of juveniles is consistent with that of undisturbed population CA 001 S, and is considerably higher than that of the UC Davis Arboretum population. Theoretical analysis suggests that this *C. marmorata* population is in a state of decline. Again, interspecific interaction may or may not be causally related.

If factors affecting *C. marmorata* are independent of interaction with heterospecifics, these factors might be expected to have a similar effect on the ecologically similar Trachemys scripta population in the same body of water. Age structure comparisons between *T. scripta* in the UC Davis Arboretum and other populations, Figure 4, suggest that this is not the case. While growing populations can have very juvenile-biased age structures, three undisturbed populations have much lower proportions of juveniles than the UC Davis Arboretum population (Parker, 1990) As expected from the greater fecundity and growth rates of *T scripta,* equilibrium populations of *T. scripta* seem adult-biased relative to *C. marmorata.* Complications such as sexual dimorphism and lack of estimated life history parameters in *T. scripta* populations of similar habitat and climate preclude extension of the equilibrium population size model to this species, These comparisons suggest that *T. scripta* in the UC Davis Arboretum is experiencing moderate population growth.

A direct test of interaction between species revolves around the effect of removal if introduced turtles on the native WPT. The above size and age structures represent data from 1991 and 1992 seasons in order to infer the statuses of turtle populations of different species in UC Davis Arboretum. Figure 5 shows age structures of *C. marmorata* and *T. scripta* for the 1993 season, after what amounts to another round of mortality, this time after the bulk of *C. marmorata* removals (during the 1992 season). Both species show a marked increase in the proportion of juveniles over the previous season, although sampling bias toward the removal of adults may contribute tot he extreme change in Trachemys age class frequencies. The increase in proportion of *C. marmorata* juveniles in response to removal of *T. scripta* suggests that the presence of heterospecifics decreases adult fecundity and/or juvenile survivorship. However the dramatic change in Trachemys scripta age structure casts doubt on the effectiveness of removal as a solution to the potential problem posed by co-occurrence of *C. marmorata* and introduced turtle species.

Tests for differential spatial and temporal habitat usage show patterns consistent with behavioral changes in response to the presence of heterospecifics. Table 4 shows contingency tables of 199 1- 1993 data used in the calculation of indexes of association (Hulabek, 1982). There is a striking negative association between the species based on presence/absence in both trapping and observation bouts ($p<0.001$), implying that turtles may avoid or be excluded from areas with turtles of other species. Trapping and observations of individuals in distant areas, even with patches of heteropecitic-favored habitat in between (data not shown), present the opportunity for choice or interaction. However, indexes of association of species with habitat type are equally significant, Table 4. Hence the data are consistent with species-specific habitat preferences as well as habitat selection changes in response to the presence of the interspecific competitors.

Figure 6 shows the temporal pattern of activity for both species versus median time of 1992 and 1993 observation bouts. Diurnal activity seems bimodal for both species, as has been documented for *C. marmorata* (Bury, 1972) and *T. scripta* (Spotila et al, 1990). Again, there seem to be differences in patterns of habitat usage between species. We observed active *C. marmorata* individuals earlier in the morning and occasionally later in the afternoon than active *T. scripta.* Again, it is difficult to interpret this data, since whether these differences represent different inherent activity schedules in the two species or a manifestation of interspecific interaction is an open question.

In addition to population survey data on the UCDArb turtle populations, blood and fecal samples were gathered for parasite analysis from *C. marmorata* (n=4 and 3 for blood and feces respectively) in the UC Davis Arboretum where they co-occur as well as both *C. marmorata* (n=12 and 12; 6 from Salt Creek California, 5 from Salt Creek California, 1 from Santa Cruz Oregon) and *T. scripta* (n=12 and 12; all from Lafayette Louisiana; Randy Sisk, pers. comm.) in native habitats where they are naive to each other. Samples may be easily collected from *T. scripta* in the Arboretum; the protocols and necessary materials are on hand in lab of H. Bradley Shaffer (Section of Ecology and Evolution, UC Davis). Fecal samples have been sent to Steve Upton care/of Robert Fisher (Department of Biology, UC San Diego) to be checked for coccidian parasites. Blood smears are stored in the Shaffer lab at UC Davis and await examination for protozoan parasites. Comparisons of the four classes of samples, naive and co-occurring *C. marmorata* and *T. scripta,* may elucidate some parasite species as vectors for interspecific competition.

Experiments with populations of naive *C. marmorata* and mixed naive *C. marmorata* and *T. scripta* were initiated near the end of the 1992 season. Although the artificial pond enclosures were destroyed by storm and no data were gathered, it should be noted that only *C. marmorata* individuals emigrated; *T. scripta* individuals did not go overland. The artificial pond enclosures and basking sites are stored at the UC Davis Aquaculture lab. Materials for the construction of arenas to be used in individual and paired behavioral experiments are also stored at the Aquaculture lab, and smaller materials for arena experiments are stored at Shaffer lab.

Together, all of these analyses, finished and unfinished, form a comprehensive body of investigations into interspecific competition. It is possible that *C. marmorata* and *T. scripta* compete through transfer of parasites, and this possibility should be tested. It is of interest to distinguish experimentally between differential habitat usage, avoidance of heterospecifics and interface competition as mechanisms for the interaction between the species. The completed analyses of the populations in the UCDArb presented above may be as strong evidence as is possible to collect regarding the effects of co-occurrence with introduced species on natural populations of *C. marmorata.* And action was taken (effective in the short term) to rehabilitate this WPT population through removal of exotic turtle species.

DISCUSSION

This study documents the co-occurrence of several species of turtle with the threatened species *C. marmorata* in the UC Davis Arboretum pond. *C. marmorata* and *T. scripta* may coexist there, since they seem equally abundant and both species were seen courting, showed evidence of recruitment and had sex ratios close to one. Comparison of ecology of *C. marmorata* and *T. scripta* Table 5 (data taken from Holland, 1991 and Gibbons, 1990a) shows that the two species are quite similar ecologically, both being quite generalist in habit. the similarity and width of the niches of the two turtle species suggest niche overlap, and therefore possible interspecific competition (Kaplan and Yorke, 1977).

Furthermore, age structures suggest that there is some disturbance of *C. marmorata* population, while perhaps strangely, the *T. scripta* population showed signs of growth. The above analyses indicate that the UCDArb WPT population was declining due to factors that at least do not adversely affect *T. scripta* in the same body of water and that the two populations are ecologically related such that removal of one species affects the population structures of both. This may be the result of exploitative competition between turtles of the two species.

The above analyses do not shed light on mechanisms of interaction between species. Habitat association data show a strongly negative spatial association, consistent with competitive displacement and habitat shift occurring between the two species (Schoener, 1974). This may also be explained by association of turtles with habitat types. The habitat types I and II in the UC Davis Arboretum (Figure 1 and Materials and Methods) differ by the former having less cover along banks and therefore greater abundance of basking sites, and having greater association with *T. scripta* If habitat type I is optimal according to this criterion, then these spatial patterns are consistent with centrifigal community organization (Rozenweig and Abramsky, 1986), where *C. marmorata* is relegated to suboptimal habitat. Considering the generalist ecology of both species, it is difficult to explain such strong habitat association with species-specific habitat preferences, but only behavioral experiments directly address this issue. Observations of conspecifics showing behavioral aggression with outcomes depending on body size for *C . marmorata* (Bury and Wolfheim. 1973) make effects due to interference with larger *T. scripta* a real possibility.

Patterns of temporal habitat usage follow more closely the reported habits of the two species when allopatric. Differences in activity schedules of the two species are of interest in themselves, and may be related to spatial differences in habitat use observed in the UC Davis Arboretum, For example, *C. marmorata* may require less basking to attain its optimal temperature than *T. scripta* Then WPTs bask more earlier and less in the hottest part of the day, and also more readily choose patches with lower abundance of basking sites. Theoretical work is being developed to determine if physiological differences between species and age classes can explain observed differences in temporal activity.

Importantly, the effectiveness of removing exotics from WPT population sites is called into question by the stronger response of the *T. scripta* age structure to removal. This is to be expected since intraspecific competition is likely to be more intense than interspecific due to complete niche overlap of conspecifics. An effect of introduced turtles can be minimized best, then, by preventing their introduction into WPT habitat. Also, this exploitative competition should depend only on the number heterospecifics. Even co-occurring turtles showing no signs of establishing populations.

Parasite transfer is explorable as a vector of interspecific competition with samples collected in this study. This could occur by transfer of parasites to which a species is adapted to a species naive to the parasite, or by interaction with another vector such as resource exploitation (Price et al, 1986). The potential asymmetry in this vector of competition should be noted, as WPTs harbor seven species, six of which are among the fifty-five species found in red-eared sliders (for species listings see Thatcher, 1954, and Esch et al, 1990). The greater number of species carried by *T. scripta* is consistent with the evolution and occurrence of *T. scripta* in sympatry with other turtle species of the family Emydidae.

The implication then is that the two turtle species undergo asymmetric population dynamics when they co-occur, and this may lead to competitive exclusion (seemingly of *C. marmorata* or non-equilibrium co-existence of competing species possible (Chesson and Rosenzweig, 199 1). However, this still may have serious impact on WPT populations and indicates an effect due to presence of heterospecifics. Basically, *C. marmorata* numbers in the UC Davis Arboretum are precluded from reaching their carrying capacity for the entire pond because they inhabit only those patches where *T. scripta* does not occur. If the *T. scripta* habitat is suboptimal for *C. marmorata,* the loss is less, but since the generalist WPTs would still be expected to occur in those patches in the absence of heterospecifics, there is some loss.

Finally, it should be recognized that introduction of exotic turtles into WPT habitat could realistically be prevented or reduced. Legislation exists in the Lacey Act to limit the trade of illegally collected turtles (Holland, 1991). It is the opinion of this author that fish and game departments should take action to reduce illegal collection of and trade in exotic turtles, as well as to educate pet turtle buyers of the risks of introduction of exotic turtles into WPT habitat.

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TURTLE SPECIES KNOWN TO CO-OCCUR WITH *CLEMMYS MARMORATA*

common snapping turtle	*Chelydra serpentina*
alligator snapping turtle	*Macroclemys temminckii*
spiny softshell turtle	*Apalone spinifera*
pond slider	*Trachemys scripta*
painted turtle	*Chrysemys picta*
Mississippi map turtle	*Graptemys kohni*
diamond-back terrapin	*Malaclemys terrapin*
Blanding's turtle	*Emydoidea blandingi*
stinkpot	*Sternotherus odoratus*
mud turtle	*Terrapene carolina*
ornate box turtle	*T. ornata*
Reeve's turtle	*Chinemys reevesi*
Malayan box turtle	*Cuora am boinensis*
snail-eating turtle	*Malaclemys subtrijuga*
Asian leaf turtle	*Cyclemys dentata*
jagged-shell turtle	*C. mouhoti*

Table 1

TURTLE SPECIES OF THE UC DAVIS ARBORETUM (n)

Clemmys marmorata	53
Trachemys scripta *elegans, gaigei* and hybrids	69
Graptemys pseudogeographica	5
Pseudemys concinna heiroglyphica	1
Chrysemys picta dorsalis	1
Chelydra serpentina	1

Table 2

POPULATION CHARACTERISTICS
UC DAVIS ARBORETUM 1991-1993

	C. marmorata	*T. scripta*
SAMPLE SIZE, n	53	37 (32)
ADULT SIZE (CL)	x= 174mm	x = 241mm
POPULATION ESTIMATE, n	N=81	N= 53 (36)
METHOD	Schnabel mark-recapture	Leslie method removal
SEX RATIO (%)	20/21 = 0.95	20/24= 0.83

Table 3

CONTINGENCY TABLES

Species Association Data
(trapping)

		T. scripta present	*T. scripta* absent
C. marmorata	present	2	31
	absent	40	7

chi-square = 48.6
$p < 0.001$

(observations)

		T. scripta present	*T. scripta* absent
C. marmorata	present	25	74
	absent	89	12

chi-square = 80.6
$p < 0.001$

Habitat Association Data
(trapping)

	Habitat Type I	Habitat Type II
C. marmorata	13	36
T. scripta	37	12

chi-square (all) = 23.5
$p < 0.001$

(observations)

	Habitat Type I	Habitat Type II
C. marmorata	44	81
T. scripta	119	46

chi-square (all) = 39.4
$p < 0.001$

Table 4

ECOLOGICAL COMPARISON

	C. marmorata	*T. scripta*
HABITAT	generalist	generalist
FORAGING	opportunist	opportunist
CLUTCH SIZE	x = 5.9, < 13	x=7, < 19
CLUTCHES PER YEAR	0.5 - 1	1 - 3
ADULT SIZE (CL)	110-210mm	230 - 280mm
HELMINTH PARASITES	7 spp	55 spp
NATURAL COMPETITORS	0 - 1 spp	> 10 spp
NATURAL RANGE	southern Washington Oregon California south to Baja	southern U.S. eastern U. S. Central America South America

Table 5

CHAPTER 10

Molecular Genetics of the Western Pond Turtle

Molecular Genetics of the Western Pond Turtle

Table of Contents

Introduction

As a part of his dissertation research, Holland (1992) collected tissue samples (primarily tips of tails) from approximately 4200 individual western pond turtles *(Clemmys marmorata)* from approximately 140+ locations throughout the range of the species. These tissue specimens were frozen in liquid nitrogen immediately after collection and later maintained at -80 degrees Celsius in the laboratories of the University of Southwestern Louisiana. Specimens were then shipped on dry ice to the Center for Population Biology at the University of California - Davis for an analysis of interspecific variation in a selected portion of the genome. The rationale for this effort was twofold 1) to provide baseline data on genetic variation throughout the geographic range of the species to assist in the identification and possible maintenance and/or management of genetically differentiated stocks and 2) to determine average levels of genetic variation within and among populations to assist in the development of guidelines for general management and mitigation strategies.

Genetic variation is the irreducible "raw material" of the evolutionary process. Recent advances both in analytical methods and applied research have allowed a heretofore unprecedented examination of the its role in both microevolutionary and ecological processes. On a systematic level, examination of genetic variation within and among populations and taxa has had a significant effect on our understanding of the processes of differentiation and speciation. In some cases, species as defined on the basis of morphological characteristics do not appear to be well-differentiated as determined by genetic analysis. Conversely, some species that appear to be very similar if not indistinguishable on the basis of morphological characteristics possess well-defined genetic differences. These and other pieces of seemingly contradictory information in fact re-enforce the dynamic view of the mosaic and hierarchical nature of the evolutionary process. The point at which species are defined on the basis of reproductive isolation (Mayr, 1942) is now generally considered to be at one end of a spectrum of differentiation, all parts of which reflect some of the incredibly complex nature of the evolutionary process.

An extension of this situation concerns genetic variation on an intra- and interpopulation level. The microevolutionary and ecological processes that constitute the short-term dynamics of an organisms natural history are in part both reflective of and dependent upon the nature of this variation. For example, in many instances a clonal population with essentially little or no genetic variation may in fact be competitively superior to a sexual population in a given environment, as long as a narrow set of conditions remains in effect. However, given the general nature of both biotic and abiotic factors such conditions are unlikely to persist. At that point, the relative nature and effect of genetic variation becomes of primary importance. Similarly, the adaptive significance of genetic variation (or lack of same) within or among populations of a sexually reproducing organism may be both reflective of and relative to the presumed stability of the general and local environment. On an applied level, this general situation is of paramount importance as it relates to both short- and long-term management efforts. Species which display high levels of geographically-related genetic variation are presumed to represent an product of differing selective environments, reduced gene flow and/or other factors. Species with little or no apparent genetic differentiation may reflect a relatively recent advent, high levels of gene flow or a common response to a general selective environment, or a combination of these and other factors. The determination of cause-and-effect relationships in these situations is often difficult for a variety of reasons. However, as a general premise, it is assumed that maintenance of existing levels of genetic variation within and among managed populations is generally appropriate as a "hedge" against environmental uncertainty. Similarly, in many situations, actions which reduce levels of both inter- and intrapopulation variation may often "narrow" the range of potential responses to changes in the environment. As is generally the case with any management plan for a species or group of species, the nature and range of "options" is often *the* critical factor in the development of such an effort. As such, efforts to begin identification and quantification of the nature and range of genetic variation within and among populations should be one part of an overall management strategy.

Analysis of genetic variation can occur on several levels and at different degrees of resolution. The degree of resolution depends in large part upon the technique utilized - allozymes provide a rather crude estimate of variation within water-soluble enzymes, and direct sequencing of DNA provides a direct estimate of differentiation on a molecular level. The interpretation of results of the evolutionary significance of this information depends upon models that have been developed and tested to varying degrees. In part because of the period of time and extent to which allozyme electrophoresis has been used, an extensive amount of baseline data exists to examine the significance of levels of variation. More recently, the improved resolution of techniques dealing directly with either nuclear or mitochondrial DNA has lead to an enormous expansion of the data available on the extent and level of genetic variation within a wide range of organisms. However, in many cases the conceptual models for interpretation of the evolutionary significance of these results has lagged somewhat behind the proliferation of data. For the purposes of this project, the lab at UC Davis utilized a technique called single-strand conformation polymorphism (SSCP). This technique is particularly useful for examining very small-scale changes in a DNA molecule, on the order of single base-pair substitutions within a given gene. Existing evidence (Orita et al., 1986) indicates that like restriction fragment length polymorphisms, SSCPs are allelic variants of Mendelian traits. As such, molecular-level estimates often to a single base-pair substitution) of heterozygosity and inter- and intrapopulation level variation within a particular gene can be made. In turn, estimates of levels of population differentiation, gene flow and migration rates may in time be developed from such data. At present, the technique produces a ultra-fine-scale resolution of differences both among individuals and within populations. Given the caveat noted above, such an analysis can be used to address some general and specific questions concerning genetic variation within a species. However, for a number of reasons discussed below, results of any such analysis should be viewed as preliminary and serve as a general guide in formulating management strategies or plans, rather than as a rationale or "bottom-line" for a particular effort.

Results

For this project, 76 specimens from throughout the geographic range of the species were examined (Fig. 1). This total includes 50 specimens from 17 localities within Oregon (Fig. 2). The results below are drawn from a report furnished by Dr. Brad Shaffer at UC Davis.

Range-wide: Variation in the 300-400 BP sequence of the cytochrome B gene appears to be relatively low across the range of the species. Of the 76 individuals assayed, 4 (possibly 5) genotypes were noted. Individuals from two locations (Site CA 03 1 CC and CA 02 1 CC) in central California possess distinct genotypes. Two individuals from site BC 034 SC (Baja California Norte) also possess a unique genotype. Two animals from a site in coastal San Diego County (Site CA 026 SC) may be slightly different from the Baja California specimens. A single individual from Santa Barbara also possesses a unique genotype. Other animals from the central Valley of California northward (including Nevada, Oregon and Washington) appear to share a common genotype.

Oregon: A total of 50 specimens from 17 localities were examined using SSCP for a 300 base pair region of cytochrome B. Three different genotypes were identified, and two were confirmed by DNA sequencing. One individual (#7497) from the Willamette drainage (exact locality unknown) was not different on the SSCP gels but revealed a 1 base-pair (out of 196) difference when sequenced. Another individual from site OR 044 R (near the mouth of the Rogue River in Curry County) possessed a distinct SSCP genotype, but attempts to sequence this sample were unsuccessful and so the question of potential difference on this level remains unresolved at this time.

Discussion

The existing data indicate an extremely high level of genetic homogeneity within most of the range of the western pond turtle. Some unique genotypes exist in several populations, primarily in central and southern California, and a single unique individual has been noted from a locality in coastal southern Oregon. The general interpretation of this information would be that historically, high levels of gene flow existed within the majority of the range of the species, such that in almost all areas, individuals share the same allele for this particular gene (cytochrome B). The apparent presence of distinct genotypes within some populations may be interpreted as differentiation fostered by isolation - the unique genotypes in central and southern California and Baja California are present in "terminal" populations presumably isolated from typical levels of gene flow by physiographic barriers. For example, the population in Baja California Norte is located in a drainage at the extreme southern end of the range of the species, and separated by dozen kilometers from the next population. The unique allele present in two central California populations may in fact represent a founder effect - one population is located in a small pond isolated from the headwaters of a stream by several kilometers of generally inhospitable habitat, This pond in turn is several kilometers from the next-nearest population of turtles and collectively the populations in this area are located in the extreme upper end of a drainage surrounded by inhospitable habitat. The Santa Barbara county locality is in a small coastal drainage that is isolated by inhospitable habitat to the north and south and by the Pacific Ocean to the west. The Rogue River site represents another population isolated by inhospitable habitat on three sides - the Pacific Ocean to the west and extensive coniferous forests to the north and south. This site is also the terminus of the downstream distribution of the species in the Rogue drainage. It may be that isolation does indeed foster moderate levels of differentiation under certain circumstances. However, these results should be interpreted with caution for several reasons. First, based upon the limited number of individuals assayed in each population, the results may represent the chance assay of a rare allele within a population - as shown by the Rogue River sample in which only one of the two individuals assayed possessed the unique genotype. Second, although there is no a priori reasons to necessarily expect every isolated population to display differentiation, other populations which exist under similar conditions apparently share the most common genotype. Third, the presence of a (possibly) unique genotype in San Diego similar (or identical to) the Baja California genotype is interesting in light of the presence of the "common" genotype in a population located between these two areas. These caveats should not be interpreted to indicate that real geographic differences do not exist, but rather that the pattern of these differences may well be complex. Resolution of this and related questions can only occur through more extensive work on the existing material

Additionally, as noted by Dr. Shaffer 'I., cytochrome B is a good, general-purpose gene that evolved at a "medium" level for mtDNA. However, it may be that *Clemmys* is indeed subdivided, but the subdivision is recent enough (in evolutionary time) that cytochrome B has not yet evolved to demonstrate these differences." Ongoing work examining variation within the D-loop region of mitochondrial DNA (a more rapidly evolving gene) will be completed by summer 1994, and the results made available to this project.

Furthermore, it should be noted that cytochrome B is only a single gene out of the tens of thousands of genes typically present in a eukaryotic genome. The actual or potential management implications of the apparent presence (or conversely absence) of significant genetic variation have been discussed at length in many articles dealing with conservation biology of a wide variety of taxa (see for example Soule, 1987). There are several points concerning genetic variation relevant to any overall management plan for western pond turtles.

Recommendations

1. A conservative strategy would be to treat all populations within the Willamette as though some level of genetic subdivision exists. The presence of structured variation among populations of *Chrysemys picta* and *Clemmys guttata* has already been demonstrated (Parker and Whiteman, 1993) on a scale equivalent to many situations that exist within the Willamette. Although determination of whether or not any such differences that might exist in *Clemmys marmorata* may (or may not) have any adaptive

significance would be difficult, a prudent course of action would be to treat any such variation as potentially adaptive and as such maintained to the greatest degree possible.

2. The reduction in regional population size within this drainage, estimated at 96-98%, has undoubtedly led to a reduction in the range and nature of genetic variation present historically. Although there is not necessarily a one-to-one correspondence of these factors, there can be little doubt that a significant loss of genetic variability has occurred. As such, management plans should be designed to maintain existing levels of variation within the region. On a practical level, this means that factors which increase the probability of the loss or diminution of existing populations or aggregations - no matter how small - should be avoided.

3. Bearing the two caveats above in mind, both short- and long-term management strategies should focus on management of turtle populations *in situ.* This should not be interpreted to contradict previous recommendations concerning translocation and population coalescence. As discussed, any such efforts should be small-scale, both in relation to distance and size, and *experimental* in nature. While such efforts may yield valuable information about possible management options for this species, for the reasons noted above and elsewhere, they cannot and should not supplement and not substitute for empirically derived and tested management practices in existing habitats.

4. Additional analysis of the available tissue samples would be of value. While the results from the SSCP analysis of cytochrome B did not reveal any definite evidence of population subdivision in the Willamette or elsewhere in Oregon, for reasons noted above this result may or may not be indicative of the level of variation that may exist. Ongoing work with SSCP analysis and sequencing of a portion of the D-loop region of mtDNA should be continued, but will probably require a small amount of additional funding. Additionally, analysis of a more site-specific marker (such as MHC) might also yield valuable information on the level and distribution of population subdivision within the area of concern.

Addendum

In a conversation with Dr. Shaffer since the preliminary draft of this report was prepared (B. Shaffer, pers. comm.), he indicated that reanalysis of the cytochrome B data has revealed that significantly more variation exists within this region than was previously thought (as in the material above). It appears that there may be one or more lineages (as defined by molecular evidence) within what is now considered to be *Clemmys marmorata marmorata,* and that *Clemmys marmorata pallida* appears to have several markers that will distinguish it from the northern subspecies. Unfortunately, this work and planned work on the D-loop region is not at a stage of preparation such that it was ready to include in this report. However, the potential implications of this situation are worth brief discussion. First, it *may* support the existing morphological data that indicates that there are at least 3 species within what *we* now call *Clemmys marmorata* (Holland, 1992).

What (if any) congruence these results may have with the morphological data remains to be seen. Second, and perhaps more important from a management standpoint, it emphasizes the need to conserve and manage populations in situ. As such, potential translocations and population coalescence need to receive even more scrutiny prior to initiation of any such efforts. Existing data (see section on translocation) indicate that such efforts may succeed in the short run, but critical long-term data on many aspects of these actions is lacking. As such, the recommendations noted above treating all populations as though they are distinct is appropriate and conservative given both existing information and other concerns.

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CHAPTER 11

Translocation as a Mitigation Strategy

Translocation as a Mitigation Strategy

The practice of "relocating" animals or plants that would be eliminated or impacted by human activities has a long history. This process, hereafter referred to as "translocation" is generally considered by professional ecologists to be at best a practice with a mixed "track record". There are several major arguments against translocation as a mitigation strategy, which are discussed in general below.

1. The translocation projects, either in concept or application, often ignore basic ecological principles. Statements to the effect that animals displaced by the proposed activity or translocated as a result of it will merely "ripple" into surrounding populations, "like a pebble tossed into a pond" or are "absorbed" by the population in the area of translocation almost invariably lack any empirical support and in fact are contradicted by the great mass of the ecological literature on carrying capacity, population demographics and dynamics.

2. These projects almost invariably lack any pretense of an effective design or plan that would allow the proper and rigorous evaluation of the effects of such an action. Briefly, in any such study there should be three major parts - a "historical" component, a "current" component and a "future" component. For example, a proposed translocation of a population of western pond turtles should involve a careful examination of population structure and dynamics of the population proposed for translocation for a period of several years prior to the activity. Concurrent studies should be conducted on the "resident" populations in one or more of the areas proposed for introduction. The study should ideally extend over several years to allow for determination (minimally) of potential annual variation in growth rates, survivorship, movement and habitat use. At the time of translocation, a significant percentage of both sexes and all size classes in the "resident" and "translocated" populations should be closely monitored by use of radio-telemetry. Periodic and systematic evaluations of weight and other variables should be conducted on both populations for a period of at least several years.

3. Populations of certain species, i.e. many invertebrates, some vertebrates with limited vagility or specialized habitat requirements, often show a considerable degree of genetic differentiation across very limited areas - sometimes only a matter of a few tens of meters. Admixture of these demes by translocation may eliminate or dilute gene pools adapted to a restrictive suite of localized conditions. Even in some wide-ranging vertebrate species, localized differentiation may occur over limited distances. As such, determination of the nature and extent of genetic structure in the "translocated" and "resident" populations should be conducted prior to any actual movement. The potential "adaptive" nature of any differences noted cannot generally be addressed without intensive and extensive studies, for a species such as the western pond turtle with a generation time approximating 10- 12 years this may be very difficult, as this time period exceeds the planning window for all but a tiny proportion of projects.

4. In many cases, the proposal is made to translocate populations or individuals to "empty" habitats - areas that appear suitable but apparently lack the presence of the species. There are three basic reasons (enumerated elsewhere) why a species may not occur in an area: 1) it has not had sufficient "time" to reach the site 2) it was once there but has since disappeared or 3) something prevents it from occurring there. For western pond turtles, the first point is probably not a matter of significant concern - existing evidence indicates that they have occupied the majority of their current range for a minimum of 4000 years. The second and third points are of major concern. In some cases, the extirpation of pond turtles is a demonstrated fact. However, it is unclear exactly what factor or factors may be responsible for the elimination of the species. In this case, it is imperative that the causal factors - predation, loss of habitat, disease or whatever- be identified prior to the re-introduction of animals to the "vacant" habitat. Based upon the known current and likely historical distribution of the species, it would appear that the majority of apparently suitable habitats that "could" contain pond turtles do not but may have contained pond turtles in the past. Observations over several hundred sites in California, Oregon, Washington, Nevada and Baja California indicate that turtles are missing from the majority of areas surveyed - on the average about 60-70% of all sites. Given the subjective evaluation of the presence of apparently suitable habitat and the presence of turtles in areas nearby, it seems likely that many of these situations reflect an elimination of the species from a given area. The third point is somewhat difficult to quantity based upon our present knowledge of actual or potential limiting factors for this species. Given the range of altitude, habitat and temperature conditions over which this species is known to exist, its absence from some areas is puzzling. However, to ascertain with any certainty the exact reason(s) for the absence of the species from any given site will require a more detailed knowledge of the ecology of the species than we now possess.

5. The problem of the potential for the transmission of disease may be very significant. Populations may harbor different types of pathogens and/or may have varying levels of infection. The stress of translocation - either on the resident or translocated population - may trigger an outbreak of pathogens to which either population may have increased susceptibility. This in turn may impact both the resident and translocated population in a negative fashion, leading to the elimination of one or the other, the diminution of one or both, or a general decrease in fitness with other short and long-term effects. For reptiles in general, we know very little about the ecology of disease transmission in natural habitats. Anecdotal evidence indicates that translocation of desert tortoises *(Xerobates aggassizi)* in the California desert may cause or aggravate outbreaks of URD (Upper Respiratory Disease) syndrome and may be responsible for significant declines in populations in many areas. Additional anecdotal information (R. Seigel, pers. comm.) on translocation of Gopher Tortoises *(Gopherus polyphemus)* in Florida indicates that a similar situation may be occurring there. As URD has been demonstrated to occur in at least two populations of western pond turtles (see notes on disease in Life History section) and is suspected in the mass mortality observed in a third population, the potential impacts of translocating turtles must be considered in light of this consideration. At this point the causal agent and mechanism of transmission is unknown, but the outcome of the condition is a high rate of mortality (approaching 35-40% or more) in populations affected.

6. It is unknown at present whether or not many species possess an active "homing" instinct. Animals displaced outside their natural home range may return to the original site, may become further displaced, or may suffer increased stress or outright mortality. If displaced within the home range, the animal may respond by attempting to return to the area from which it was removed, or it may suffer increased stress or outright mortality during such movements. Alternately, the animal may remain in the area. What little information is available on western pond turtles (L. Hunt, pers. comm.) indicates that a significant portion of a population displaced up to 2 km in the Santa Ynez River in California did return or attempted to return to the site from which they were displaced.

Two small-scale population translocations and a single individual translocation have occurred as a part of this project. Both were experimental in nature and are described below.

In June 1992 approximately 14 turtles were translocated to Site OR 050 U from a site in the city of Roseburg. The "donor" site was an extremely degraded wetland/pond habitat dominated by exotic species. Red-eared sliders *(Trachemys scripta elegans)* were captured at this site one occasion in 1992 and on two occasions in 1993. An introduced painted turtle *(Chrysemys picta)* was observed at this site in 1993 and 1994. All animals were equipped with transmitters and relocated to one of two ponds constructed by the USFS in 1990 with KV funds. A description of this site is presented elsewhere (see Site Description section).

These animal were tracked on a daily basis from early June to late August 1992, and on an intermittent but approximately weekly basis after that date. One animal (a male) apparently left the site within two weeks after release and was not observed again in the course of this study. Repeated efforts to radio-locate the animal within 2 km of the site did not produce results. Another animal (a gravid female - # 7237) was crushed by a logging truck during an overland nesting movement. Another gravid female (# 7239) was apparently drowned when a transmitter antennae became detached and lodged in vegetation. Thus, at the end of the summer season in 1992 there were approximately 11 turtles remaining in this area. A further translocation of five animals was conducted in June of 1993. Three of these animals were gravid females from the Roseburg site, and two were animals received from the NERI project in Portland. All equipped with transmitters and tracked on a daily basis between early June and late August, and then on a weekly basis after that date. Observations throughout 1993 and in early 1994 indicate that all turtles translocated to this site could be accounted for with one possible exception - two transmittered animals whose transmitter color converged (blue fades to green). Sampling in June 1994 located all but one transmittered animal and three of the five remaining untransmittered animals. Movements away from this site did occur. In 1993 two gravid females moved out of the watercourse into adjacent wetland/pond habitats up to 0.5 km away. One of these animals had returned to the original pond site by June of 1994 and the other was located moving away from the site where she had spent most of the winter. This animal was relocated to the pond site.

At least two important questions are relevant to this experiment. First, did the majority of the turtles translocated to the site remain at the site? The answer to this question is a qualified yes. Over 85% of the turtles moved to this site were still in residence as of June 1994. However, this result should be interpreted with caution. Several important factors may bear on this matter.

1) For a species that may live more than 40 years, the results from approximately 2 years of study represent only 5% of the potential life span. Generalization of long-term trends from such limited data is precarious at best.

2) At least one (and possibly more) turtles left the site shortly after translocation and were not subsequently relocated. Information from other sites (see section on movement) indicates that turtles may move in excess of 5 km and possibly further. As the surrounding area is USFS property, it is likely that the animal(s) that left the site were still within areas controlled by the Federal Government during these movements. In translocations to areas where there is a mixture of private and governmental holdings, movement into and/or potential establishment of a species on private property that might produce long-term conflicts with private property rights (for example should the species become listed under the Endangered Species Act) should be carefully considered before any such action is taken.

3) The demonstration of retention of adult animals in a site over several years does not demonstrate that this may be a reproductively viable population. Several gravid females have been translocated to this site and their movements closely monitored. The only nest that has been found to date was one predated by a skunk or raccoon in late summer 1993. Intensive searches of both pond sites for hatchlings in 1993 produced no results - however it is known that a maximum of only two females were able to produce eggs at this point. The presence of four gravid females at this site in 1993 may have led to the production of four nests. One of these was known to have been predated and the others were not located. However, trapping efforts at this site in 1994 produced a single small animal 53.5 mm in length, indicating that it was probably hatched from a 1992 clutch. The presence of at least 5 gravid females at this site in June 1994 may produce more hatchlings in 1995, but this remains to be demonstrated. As such, it will take a minimum of two and likely three-four years at this site before it can be reliably ascertained whether or not the population is capable of potential reproductive establishment at this site. Demonstration of full "establishment" will require the determination that animals hatched at the site are capable of successful reproduction - which will probably require another 10-12 years.

Between June and August 1993, approximately 12 animals were obtained from the NERI turtle project and from animals collected by the public in the vicinity of Corvallis and turned into ODFW. These animals were translocated to the EE Wilson Wildlife area managed by ODFW. No immediate follow-up was made, although plans were instituted by the NW Regional Office of ODFW to census this population during the summer of 1994. No results were available from this effort at the time of preparation of this report.

In June 1992 a single post-partum female collected from an extremely degraded habitat in the vicinity of Oakridge was translocated to Site OR 039 W. This animal was not captured during summer sampling in 1993 but was recaptured at the overwintering site (see over-wintering section) on 25 November 1993. The animal had grown approximately 1 mm in the time between release and recapture (not unusual for an animal of this size) and was within the normal weight range for an animal of this size.

The process of translocation is obviously one that has potentially serious (even lethal) consequences for not only the organisms involved, but for the animals resident in the area that will receive the translocated animals. The considerations listed and discussed above are not exhaustive nor mutually exclusive. Based upon the incomplete status of our knowledge of many aspects of the ecology of the western pond turtle, the general considerations discussed and other factors, it is apparent at this time that translocation should not be a preferred strategy in almost all cases. This does not and should not be construed to infer or imply that translocations should not take place; resolution of some of the questions noted above can only take place if monitoring at the two sites described continues. It does mean that any such effort should be treated as what it is - an experiment. Such experiments should be designed and executed in such a manner that the questions and potential answers can be addressed with statistical rigor. These experiments should also allow for their operation over a time span that is driven by ecological reality rather than political expediency. In other words, studies that seek to answer many of these questions on western pond turtles based upon one or two years data are not only useless, they may actually be counterproductive. Based upon these and other considerations, it is apparent that translocation does not suffice as a general "in-kind" or "compensatory" mitigation strategy and should not be considered as such until such time as the questions noted above are answered. However, *carefully controlled experiments* may provide these answers and will necessitate some *small scale* translocations.

APPENDICES

APPENDIX A

Field Data Form used in Western Pond Turtle Surveys 1991-1993

Western Pond Turtle Survey Form

Page____

Site Reference # OR__________ County ____________________ Date of Survey __________________

Time of Survey____________ Conditions at Time of Survey ______________________________
____

Photo Reference #s - Roll ________ Photo #'s & Orientation ______________________________
____

Site Location (DeLorme Map Reference) ____________________________ T ____ R_____ S____

Exact Site Location (Road/other) ____
____
____

Ownership/Contact (if Known) ____
____

Estimated Dimensions at Survey Site ____

Water Turbidity ___________ Current (Est.) ___________ Substrate Type ____________________

Vegetation: Woody Dominants ____
Non-woody Elements- ____
Aquatics (Emergents and Floating) ___________________________________

Habitat Disturbance Reference Sheet # ______________ Grazed (?) ____________________

Bullfrogs (Adults, subadults, larvae) ________|__________|__________
Introduced Fishes (bass/sunfish/carp/mosquitofish) ________|________|________|__________
Other species observed & numbers ____
____
____

Total # Turtles Observed: *Clemmys* _________ *Chrysemys* ________ Other (specify)______________

Clemmys: Males n = _____ # & size(s) _____ 110-130________ 130-150 _______150-170 ______ 170+ ______
Females n = _____ # & size(s) _____ 110-130 ________ 130-150 _______ 150-170______170+ ______
Juveniles n = ___ # & size(s) ______ 30-50_________ 50-70 ________ 70-90 _______ 90-100

Animals marked at site: ____
____

Basking Site(s) Description ____
____

Other Notes:____
____

APPENDIX B

Key to Common Native and Introduced Species of Turtles in the Western United States

Figure 1: Key to native and common introduced species of freshwater turtles of the west coast.

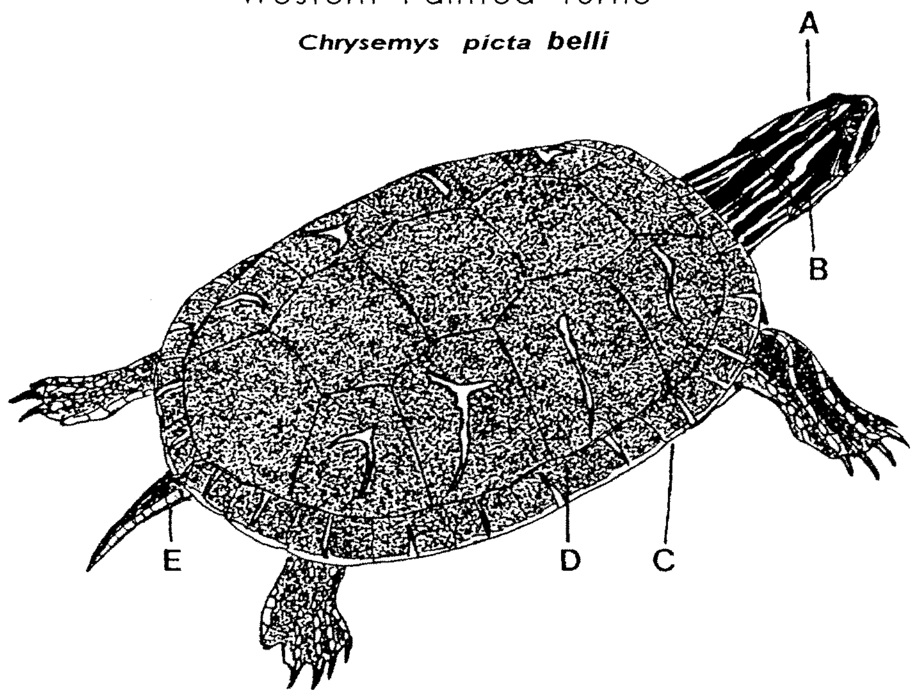
Character	Western Pond Turtle (Clemmys marmorata)	Western Painted Turtle (Chrysemys picta belli)	Common Snapping Turtle (Chelydra serpentina)	Red-eared Slider (Trachemys scripta elegans)
	NATIVE	NATIVE *	INTRODUCED	INTRODUCED
A. Head	relatively small, w/fine dark blotches, flecks or lines	relatively small , black w/yellow lines	large, uniform dark color	relatively small dark green w/small yellow or white lines
B. Neck	brown dorsally & laterally w/ dark flecks or lines, throat light & unmarked or w/ small dark flecks	black w/ several thin yellow lines, throat w/ 1 ines	dark dorsally 6 laterally, w/ numerous tubetcles, throat light and unmarked	dark green, with small yellow or white lines, large red "ear" stripe in most animals **
C. Plastron	large, cream to yellowish w/ degrees of dark suffusions	large, bright reddish-orange w/ large complex central figure	very small, cream-yellow	large, yellowish-white w/ large central figure(s)
D. Carapace	brown to black, often with numerous small dark markings	usual 1 y dark green or greenish-black w/o dark markings	dark, posterior marginals of ten serrated	light-green/olive with black and yellow lines
E. Tail	brownish, length moderate to long - 25-35% of carapace length	black w/ yellow or red stripe laterally, length short - 10-15% of carapace length	dark, length very long - 33-50% of carapace length	greenish, w/ white or yellow stripes, very short. - 10-15% of carapace length

* western painted turtles are native to the Colunbia and Willamette drainages of Oregon and Washington, and other areas of Washington including Puget Sound

** old male red-eared sliders typically lose the red "ear" marking and develop piebald melanism on the carapace, closely resembling old male western pond turtles. Old male red-eared sliders typically have elongated front claws.

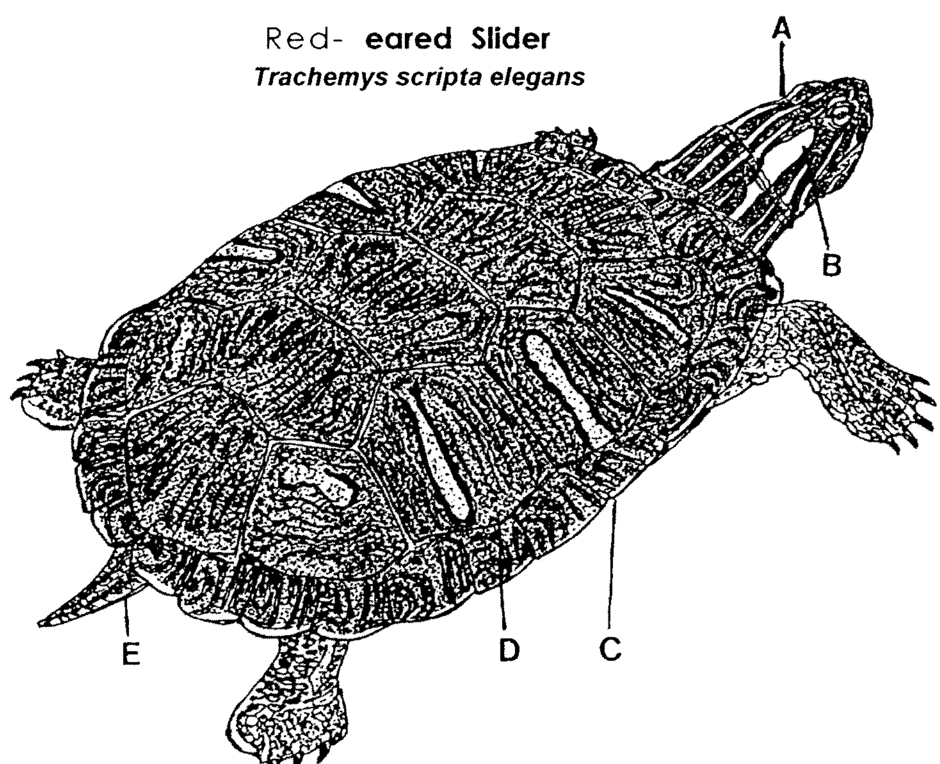
Western Painted Turtle

Chrysemys picta belli



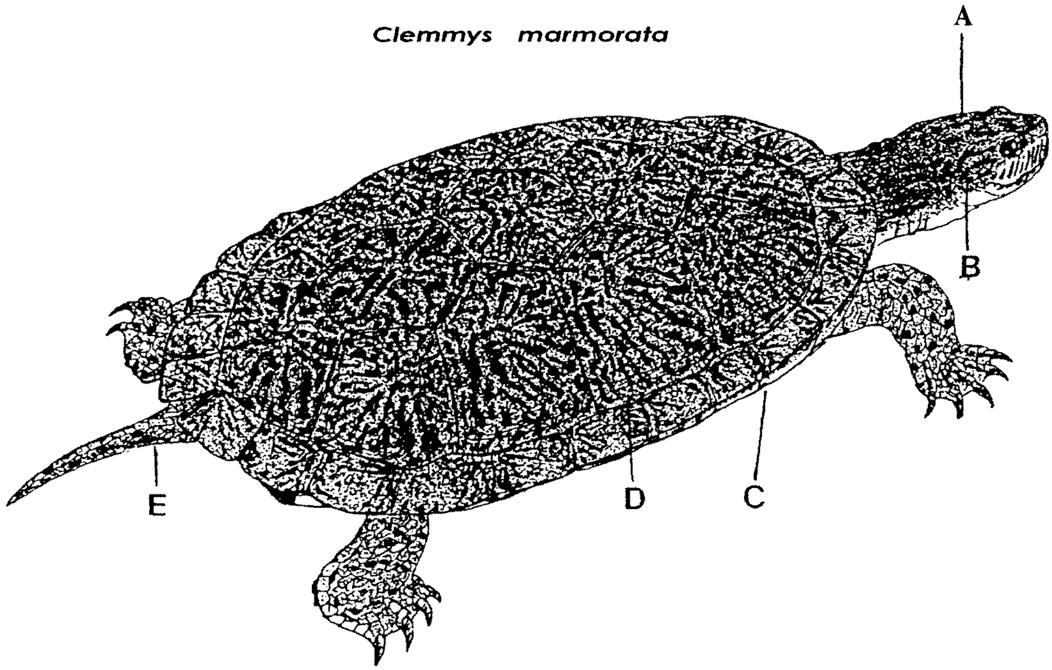
Red- **eared Slider**

Trachemys scripta elegans



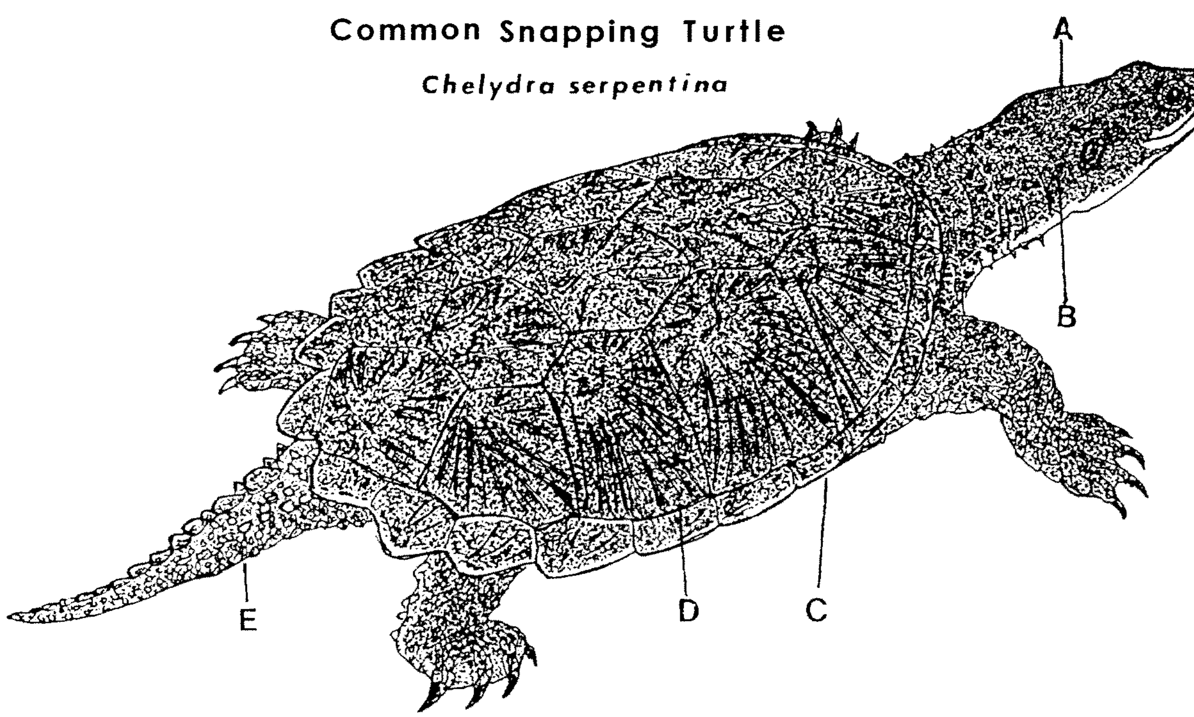
Western Pond Turtle

Clemmys marmorata



Common Snapping Turtle

Chelydra serpentina



APPENDIX C

Key to Secondary Sexual Characteristics in the Western Pond Turtle *(Clemmys marmorata)*

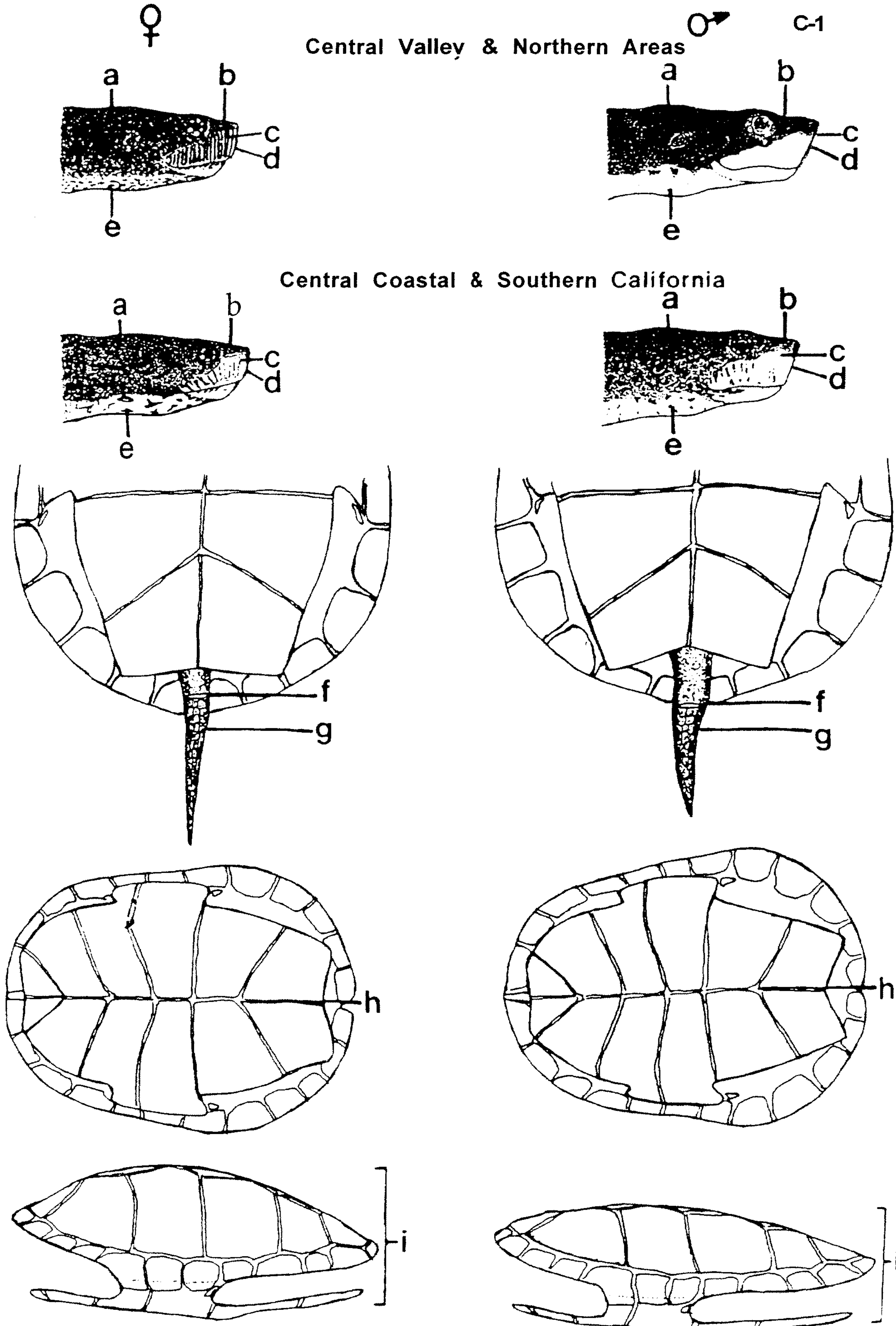


Fig. 3: Key to sexually dimorphic characters in the western pond turtle (Clemmys marmorata)

Figure 3: Key to sexually dimorphic characters in the western pond turtle (Clemmys marmorata).

Character	Female	Male
a. neck	lateral and dorsal surfaces of head and neck usually mottled or ocellate	lateral and dorsal surfaces of head and neck often uniformly colored, especially in older animals
b. nose	nose relatively short	nose relatively long
c. maxilla	maxilla often with fine dark vertical lines or "mustache"	maxilla lightly marked or or unmarked, especially in older animals
d. snout	angle of nose usually vertical or nearly vertical	angle of nose usually 10-15 from vertical
e. throat	often flecked with numerous small dark flecks	usually lightly marked or unmarked
f. vent	usually at or slightly posterior to posterior edge of carapace	usually well posterior to posterior edge of carapace
g. tail	usually relatively long and thin	usually relatively short and thick
h. plastron	area of femoral/anal seam junction usually flat	area of femoral/anal seam junction usually slightly concave
i. shell	shell relatively high/deep in relation to length of carapace	shell relatively low/shallow in relation to length of carapace

APPENDIX D

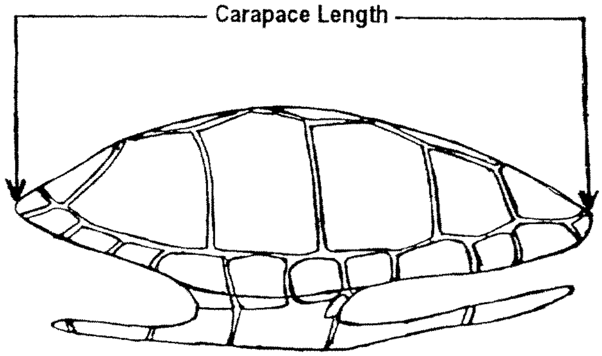
Marking System and Data Report Form for the Western Pond Turtle *(Clemmys marmorata)*

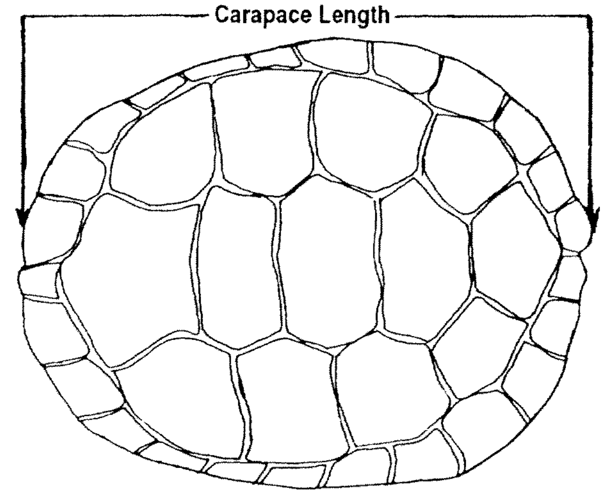
Please send a copy of the front of this form (when completed) to:

Dr. Dan C. Holland
Western Aquatic Turtle Research Consortium
2310 Alturas
Bakersfield, California
93305
(805) 325-3476

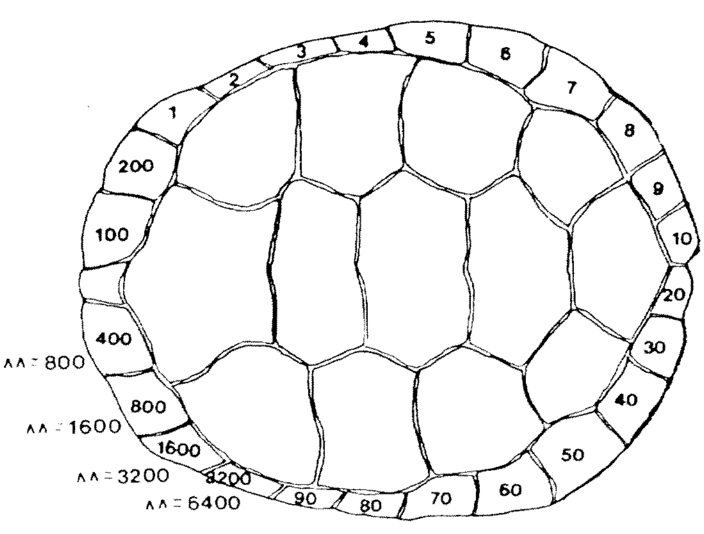
Locality information will be kept confidential, and reimbursement for postage will be furnished upon request.

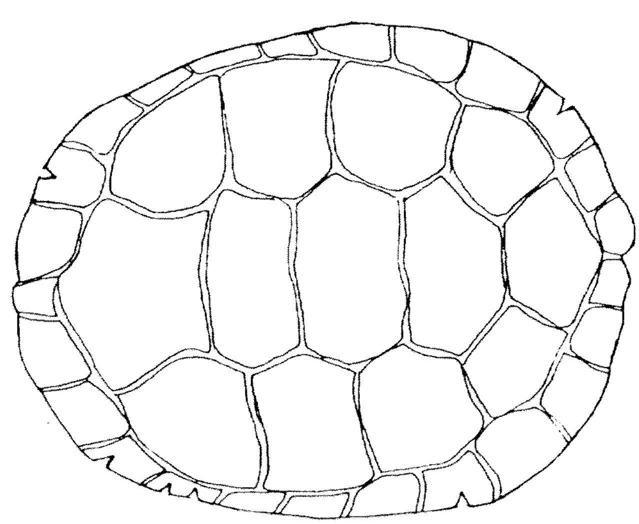
Carapace length is measured as the greatest straight-line distance in mm from the anterior end of the carapace to the posterior end, parallel to the centerline of the shell and the plastron. This usually means that the distance measured is from the "front" edge of the 2nd marginals to the "back" edge of the 12th marginals. The method of measuring is illustrated below.





Marking Code Arrangement: Marks are made by use of a small triangular file to notch one or more marginal shields. The mark should be no more than 6-8 mm deep on large adults. Small animals (<80 mm) can be marked by using small, sharp scissors to cut triangular notches 2-4 mm deep. To remove bone deposits on the file, soak it overnight in vinegar.





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APPENDIX E

Reports on Movements of the Western Pond Turtle *(Clemmys marmorata)*

Nesting and movements of western pond turtles on William L. Finley NWR, Oregon.

Progress Report
May - June 1994

Martin Drut
Consulting Wildlife Biologist

The nesting portion of the western pond turtle (Clemmys marmorata) research project on William L. Finley NWR (WLF) (Figure 1) began on 1 May 1994. Four turtles previously equipped with radio transmitters could still be located (males 4826 and 4828 and females 4832 and 4835) (Table 1). Five other turtles with transmitters were considered missing at that time. No observations were made for male 4827 from August 1993 until 21 June 1994. The next day he was recaptured in a trap and fitted with a new transmitter and released on 24 June. During captivity, he was remarked with 4928 because he was incorrectly marked 4828 when initially captured. On 26 June, 4928 was observed with 2 other radio-equipped turtles that had non-functioning radios. These turtles were thought to be females 4833 and 4834, which were missing since March 1994. Two turtles (female 4829 and male 4840) were missing since August 1993 and March 1994, respectively. 4829 was last observed in Cabell Marsh, WLF and 4840 was last observed on the Greenberry Oxbow property north of WLF. Three females without transmitters were captured on 23 June. Two (4837 and no number) were trapped on the Greenberry site and 1 (4836) was captured on WLF in Muddy Creek just north of old duck blind 1. 4836 and no number (NN) were fitted with the remaining transmitters and all 3 turtles were released to their original locations.

Male 4826

Male 4826 was located on the east side of Cabell Marsh, WLF, from 1 May to 6 May. During this period, 4826 moved little (<25 m) on any specific day. On 7 May, 4826 could not be located and an extensive search commenced. This turtle has migrated the past 2 years from Cabell Marsh to sites associated with Muddy Creek near the south boundary of WLF (approximately 4.5 km) and returns in the spring. All areas around Cabell Marsh and areas associated with Muddy Creek between Cabell Marsh and south of the southern refuge boundary were checked several times. Additional locations including Muddy Creek north from Cabell Marsh and the

Gray Creek system were checked; however, no observations of male 4826 were made since his disappearance.

Male 4828

Brown's Swamp was the location of male 4828 from 1 May to 10 May. During this period, 4828 remained in the south-central portion of the swamp and made no large movements. 4828 moved south on 10 May approximately 700 m from Brown's Swamp into Muddy Creek near old duck blind 1 on 12 May. He remained at this location until 15 May. The next day he began a 4-day move south of approximately 2 km along Muddy Creek that ended 500 m southeast of the southeastern corner of Cabell Marsh. 4828 remained in this general location until 23 May when he could not be located. Extensive searches were made south from the last known observation with no results. However, on 26 May, 4828 was relocated just north of old duck blind 1 and has remained. He was observed numerous times basking on logs near this site.

Female 4832

Northwest Cabell Marsh was the location of female 4832 for May and June. This portion of Cabell is a 2 ha flooded forest of Oregon ash (*Fraxinus latifolia*) that borders the western edge of the open-water marsh. 4832 moved short distances (<25 m) during this period from the marsh-forest edge to sites within the trees. No observations were made of this turtle on land or in any nesting activities.

Female 4835

Female 4835 resides near the second bridge on McFarland Road (south WLF boundary) and regularly moves north and south. The channel used by 4835 is a slough of Muddy Creek that starts on WLF and heads southeast onto a private hunt club where it ends 300 m south of the bridge. 4835 was south of the bridge about 100 m from 1 May to 6 May. On 6 May, she moved north of the bridge 50 m and remained north of the bridge until 20 June.

During this period, she moved between a site 50 m north and a site 200 m north 5 times (13 May-200 m, 17 May-50 m, 27 May-200 m, 7 June-50 m, 9 June-200 m). Furthermore, she made 2 extended 1-day journeys from the 200 m site north of the bridge. On 1 June, 4835 moved to a site 5 m south of the bridge and then returned north on 3 June and, on 10 June, she moved north into Muddy Creek approximately 800 m and returned 12 June. No nesting activities were observed during these periods. On June 20, 4835 was located 200 m south of the bridge and remained through June. Before 20 June, landowners dredged the channel and removed vegetation from the west bank of the slough on the hunt club. 4835 took advantage of newly opened areas after she moved south and was observed several times basking on the east bank. Generally, she slipped into the water after being observed; however, 4835 was on land 27 June within 2 m of the channel and was not observed. There was heavy shrub cover on the site and it was possible she was obscured. She was rechecked just before sundown and remained at the same location; no nesting activity was observed.

Male 4928, Females 4836 and NN

After his release, 4928 remained in Greenberry Oxbow until 28 June. He then moved from the oxbow into Muddy Creek and headed north approximately 800 m where he remained through June. Both 4836 and NN moved little (<25 m) and remained relatively close to their release sites.

Trapping

Trapping had only limited success in May and June and only 4 turtles were captured. The most successful was site was Greenberry Oxbow; 3 turtles were captured in 4 days (20 June - 23 June). One turtle was captured in 31 days at the site north of old duck blind 1 on Muddy Creek (31 May - 30 June). Six to 9 traps were placed at other sites on WLF during the trapping period with no success.

Nest Searches

Random nest searches were conducted in June in fields near known turtle basking sites and near locations of radio-equipped turtles. No observations of turtles on land, excavated nests, or any nesting activity were made.

Future plans

In July, radio-equipped turtles will continue to be monitored and random nest searches will continue in order to detect nesting sites on WLF. In August, complete results from the 1994 field season will be analyzed and compiled into a report.

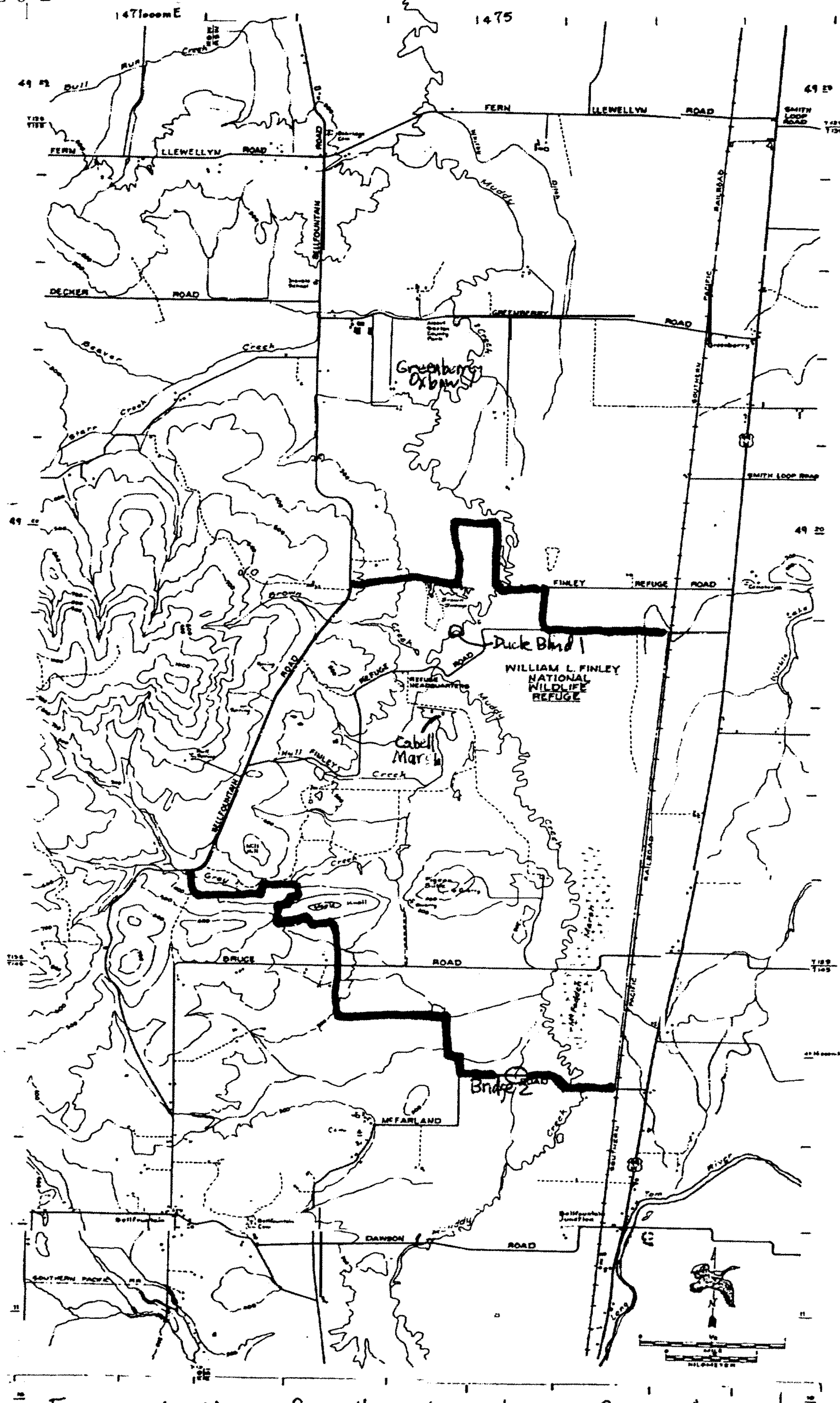

Figure 1. Map of William L. Finley NWR an[illegible]

Table 1. History of radio-equipped western pond turtles on William L. Finley NWR, Oregon.

TURTLE NUMBER	RADIO FREQ	RADIO COLOR	SEX	SIZE	CAPTURE DATE	CAPTURE LOCATION	MOVEMENT HISTORY
4826	151.762 (151.704)	blue/ green	M	192	7/24/92	NE corner of Cabell Marsh	Marked in Cabell moved during Aug '92 to south of McFarland Rd. Moved back to Cabell in Mar '93 and then back to McFarland Rd. In Aug '93, and back to Cabell Apr '94. Lost contact in May '94.
4827	(151.733) 151.836	~~black/ green~~ blue/black	M	~~175~~ 184	7/25/92 recap on 6-22-94	Muddy Ck near blind #1	Captured in a trap on Muddy Ck. In July where he stayed all winter often w/i a few meters of .805. Moved to Brown Swp. & then Greenberry Oxbow during summer '93. Lost contact in Aug '93. Recap in June '94 in Greenberry Oxbow and fitted with new radio.
4828	151.251 (141.805)	black	M	154	10/11/92 recap on 10/4/93	Blind #1 on Muddy Ck.	Usually is found winter or summer in the general area of Blind #1 or #2. Has strayed as far south ~~the Finley Rd. bridge~~ as far north as Brown Swamp. Moved to Brown Swamp Apr '94. as SE Cabell Marsh (in Muddy Creek)
4829	151.148	black	F	119	10/21/92	Muddy Ck trail south of Finley Rd.	Captured on land near the trail between Finley Rd and Cabell Marsh. Moved into Cabell Marsh in Mar '93. Lost contact summer of '93.
4840	151.791	blue/ green	F	175	9/4/93	Greenberry Oxbow	Captured with .778. Remained in the Greenberry Oxbow system until Feb '94 when lost contact with both .791 & .778. ~~Both~~ .791 & .778 may have returned to Oxbow in June '94 with non-functioning radios
4834	151.778	green	F	180	9/4/93	Greenberry Oxbow	Captured with .791. Remained in the Greenberry Oxbow system until Feb '94 when we lost contact with both .791 & .778
4835	151.231	black/ red dot	F	172	9/9/93	McFarland Rd. Slough	Generally moves north and south of 2nd bridge on McFarland Rd.
4833	150.797	black/ blue dot	M	174	9/29/93	Greenberry Oxbow	Trapped at the Greenberry Oxbow. Used this area until spring of '94 when he moved to Rice's seasonally flooded hunt club to the east and then to the flooded area south of there, Lost contact Mar '94.
4832	151.820	green/ black	F	188	8/18/93	Blind #1 on Muddy Ck.	Trapped at Comfort Station Oxbow on Muddy Ck. Spent the winter here and then in Mar '94 began moving to Cabell Marsh. Between Mar and May spent most of her time in the NW corner of Cabell.
4836	150.780	black/ green dot	F	168	6-23-94		Trapped in Muddy Ck. N of Blind #1
"47"	150.741	blue	F	153	6-23-94	Greenberry Oxbow	Captured with another female of similar size (not radioed) Left front foot has only a single digit

FILE: turtle summary