Five Year Plan for Studying and Managing Western Painted Turtles at Smith and Bybee Lakes

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Prepared For

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SMITH AND BYBEE LAKES FIVE-YEAR WESTERN PAINTED TURTLE STUDY GOALS, METHODS, STAFF AND BUDGETS

Turtles in Oregon

Oregon is home to two native turtles species, the western painted turtle (*Chrysemys picta bellii*) and the western pond turtle (*Clemmys marmorata marmorata*). Both species are freshwater turtles and both are habitat generalists, capable of living in most freshwater environments including ponds, streams, rivers, lakes and sloughs. Both turtle species are listed as Critical on the Oregon Department of Fish and Wildlife's Sensitive Species List and both are protected by Oregon law. In addition, the western pond turtle is a Candidate Species for listing under the U.S. Endangered Species Act.

A population of western painted turtles is known to live at Smith and Bybee Lakes. To date, no western pond turtles have been recorded, but it is possible some may inhabit the site.

The western painted turtle is found from the Midwest to the Pacific Northwest and is the largest of the four painted turtle subspecies that inhabit North America. The Willamette River drainage is the southwestern limit of its range. Painted turtles prefer slow-moving or standing water with abundant aquatic vegetation and sites for hauling out of the water to bask. They are active during the day in the warm months of the year. Painted turtles feed in the water and are omnivorous with vegetation making up the bulk of the diet, but they are very opportunistic and take animal material, living or dead, when possible. Painted turtles have well-developed senses of sight, smell and hearing. Adult turtles are vulnerable to few predators. If they survive to adulthood, painted turtles can live more than 30 years.

The western painted turtle has a dark green shell (carapace) with red edges and seams. The dark green or black head and legs are striped with red and yellow and the underside of the shell (plastron) is marked with a beautiful pattern of red, yellow, and black. Painted turtles can grow to a shell length of 250 mm and weigh over 1400 grams.

Painted turtle males become sexually mature in the fourth or fifth year; females, which are larger, mature at the age of six to ten years. In summer, females nest on land using their hind legs to dig a flask-shaped nest into which they lay a clutch of 1 to 23 eggs. The nest environment is critical for the development of the embryos, determining the length of development, gender and size of the hatchlings. Hatchlings may emerge in the fall or overwinter in the nest. Common predators of turtle eggs are raccoons, skunks, and coyotes. Introduced fish and bullfrogs, herons, raccoons, and otters prey on hatchlings.

Historically the western pond turtle ranged from Puget Sound to the Sierra San Pedro Martirs in Baja California Norte, chiefly west of the Sierra-Cascade crest. In Oregon, the largest number of pond turtles now inhabit the southwest part of the state and only a handful of breeding populations remain in the Columbia and Willamette River drainages.

Western pond turtles can reach a shell length of about 200 mm and a weight of about 1000 grams. The shell is usually brown to black and sometimes has a pattern of fine yellow reticulations. The head and legs are dark brown with

cream blotches and reticulations. Pond turtles have well-developed senses of sight, hearing and smell. Their diet is primarily carnivorous, mostly invertebrates, and food is ingested in the water. As with all turtles, western pond turtles nest on land. Common predators of their nests are raccoons, skunks, coyotes and red fox. Introduced bullfrogs and large-mouth bass as well as herons, otter and raccoons prey on small turtles. Introduced fish and turtle species are competitors for food and habitat. Longevity for pond turtles is not well documented but is estimated at about 40 years.

Western Painted Turtles at Smith and Bybee Lakes

If measures to encourage a healthy population of western painted turtles are to be integrated into the management of Smith and Bybee Lakes, sufficient information about the condition of the existing population and its use of the entire site must be collected. To date, no comprehensive study of western painted turtles has been conducted at the site, or along the Lower Columbia River. The brief research efforts that have been conducted confirm that a reasonable number of turtles exist at Smith and Bybee Lakes and that there appears to be some reproductive success in the population. There are concerns for the population from the level of nest predation and possible illness. It is not known how many turtles live at Smith and Bybee Lakes, whether the population is stable, increasing or decreasing, whether enough young survive to maintain the population, or how the turtles use the habitat for nesting, overwintering, or other seasonal activities. It is also not known how the age or gender of turtles influences their of use the site seasonally. Additionally, the impacts of human and non-human activities on the turtle population have not been charted. Without collecting baseline information for a number of years about the behavior and habits of western painted turtles throughout the entire Smith and Bybee Lakes management area, it will be impossible to formulate management guidelines to keep the turtle population viable, and to provide for the range of activities required by other wildlife and humans at the site. The five-year study is a reasonable beginning to develop a preliminary understanding of the western painted turtle and to formulate effective management strategies for its survival at Smith and Bybee Lakes.

Research Background

The appendices include selected references and a summary and evaluation of western painted turtle research efforts that have been conducted at Smith and Bybee Lakes and on the Lower Columbia River. Relevant information from previous research is incorporated in the discussion for each of the goals.

Review of Six Turtle Research Goals

Following is a list of the six research goals most relevant to management efforts for turtles at Smith and Bybee Lakes.

Goal 1. Demographics

The first and most important task in developing a management plan for western painted turtles at Smith and Bybee Lakes is to conduct a comprehensive survey of the entire site and assess the general condition of the population. Studies, primarily by Barclay, at Smith and Bybee Lakes have resulted in a good preliminary data base of 172 field marked individuals. This data base includes photographs and measurements of 96 females, 59 males and 17 juveniles. Surveys done by Hayes established that the blind slough and ponds along North Marine Drive are one site of dense turtle activity. The presence of dead and sick turtles observed by Barclay and DeLorenzo at Smith and Bybee Lakes indicates a need to monitor the health of the population. Based on previous research the wide range of ages and presence of juveniles at Smith and Bybee Lakes appear to indicate that there is recruitment in the population. However, establishing a clear picture of the condition of the turtle population within the whole management area requires systematic trapping over several years.

The trapping time and methods proposed for this and other goals is based on evaluating the success of studies conducted at Ridgefield National Wildlife Refuge, Burlington Bottoms and Smith and Bybee Lakes .

Goal 2. Nesting

Determining what land areas female turtles use to nest and when females nest is critical to managing those areas to avoid disturbing nesting activity, and to protect hatchlings in the nest and as they emerge from nests. Observations at Ridgefield National Wildlife Refuge, Smith and Bybee Lakes and Burlington Bottoms suggest that females may reuse specific nesting areas. Nest sites appear to be clustered rather than random. The 1997 Beilke surveys at Burlington Bottoms seem to indicate that nesting activity is occurring during the evening hours and the greatest activity occurs before July. In 1993 Hayes found the first evidence of successful breeding with the capture of a hatchling turtle. Observations in 1997 and 1998 at Burlington Bottoms have shown that hatchlings emerge from the nest in the same and the year following eggs being laid. Hatchling western painted turtles overwintering in the nest can survive being flooded for at least brief periods. Management options for nesting areas need to consider the appropriate level of protection for nesting females and hatchlings emerging from nests.

Goal 3. Impacts

Measuring the effects of human and non-human activities on the turtle population at Smith and Bybee Lakes is important so that management plans can incorporate the need for a variety of activities at the site without negative consequences to the turtle population. No studies exist to guide the evaluation of various impacts on turtles. The most straightforward and efficient method to approach this goal is a comparative study between Smith and Bybee Lakes and a comparable site with limited human use and activity. Burlington Bottoms, a

417-acre site between Highway 30 and the Multnomah Channel of the Willamette River across from Sauvie Island, with what appears to be a comparable western painted turtle population, is an excellent location for comparing turtle reactions to various stimuli. Burlington Bottoms is a Bonneville Power Administration wildlife mitigation site managed by Oregon Department of Fish and Wildlife (ODFW) and is not open to the public. Only site management and research activities, which involve a limited number of people and activities, are permitted. A partnership with Oregon Department of Fish and Wildlife to create a project to compare turtle behavior simultaneously at each site would yield valuable information for structuring activities at Smith and Bybee Lakes for the mutual benefit of turtles and other needs. Each agency would cooperate to coordinate the field work and data analysis required and each agency would pay for the research effort on their respective site.

Goal 4. Overwintering

Western painted turtles hibernate for several months each year. Management of the species must include protecting hibernation areas from disturbance as the turtles are immobile and helpless. In addition, there may be transit routes to hibernation sites which also need protection. Preliminary data from Burlington Bottoms indicate that western painted turtles in the Pacific Northwest may overwinter underwater, as do painted turtles in the eastern part of their range. Hibernation sites may be different from the summer locations used by the turtles. To date, only reproductively active females have been tracked to overwintering sites at Burlington Bottoms. Hibernation sites for adult males, juvenile and hatchling turtles could be different than for females.

Goal 5. Basking

Successfully managing the turtle population at Smith and Bybee Lakes means providing an environment that can effectively support the turtle population. Being able to bask at the times and for the intervals needed is vitally important for the survival of the turtles. As reptiles, turtles regulate their body temperature by changing their environment—their bodies assume the temperature of the surrounding habitat as they do not maintain a constant body temperature like mammals. Finding appropriate aquatic and non-aquatic places to bask is critical for turtles to regulate their body temperature and maintain health. Basking is used to absorb warmth and vitamin D3. Basking helps kill pathogens on the shell and skin, maintains proper metabolic function, digests food and incubates eggs prior to nesting. Basking requirements vary by age and gender of turtle. Turtle populations without safe, undisturbed or adequate basking structures are subject to illness, increased mortality and reduced reproductive success. Managing for success of the turtle population at Smith and Bybee Lakes includes ensuring that turtles have sufficient places and time to bask.

Goal 6. Habitat Use

In addition to specific habitat requirements identified in the previous goals, an overall understanding of the turtles' use of Smith and Bybee Lakes is important to planning for the successful maintenance of the population and integrating those needs into other requirements for the site. It is important to

know by age and gender how the turtles use the site seasonally. Use of aquatic and non-aquatic habitat needs to be documented by season, age and gender. Identifying seasonal transit routes by age and gender is also important. Documenting this information will result in the ability to manage the turtle population productively and accommodate other needs of the site.

Five Year Turtle Monitoring Protocol

The turtle monitoring plan is designed as a five-year plan. The first year of the study is designed to test and refine the field and statistical protocols for the subsequent four years of the study. Frequent review and revision of techniques will be employed to evaluate and modify study methods to achieve the best results. Especially in the first year of the study it is important to review the field study effort every two weeks during the active field season, and do data entry and analysis monthly to review quality of data and techniques. In subsequent years of the project, less intensive review and revision can be employed. The second through fifth years of the study will be devoted to developing a data base from which preliminary management decisions can be developed. A five-year study is a good beginning for developing management techniques for such long-lived species

Individual research activities and budgets are included for each of the six study goals, subdivided by primary and secondary priorities. All six goals or a combination of goals can be pursued simultaneously. Economies will result from conducting work on more than one goal at a time, as many costs are not additive if the activities are conducted simultaneously. As no research has reviewed the entire site, it is important that all four subareas be covered for each goal. As information about the location of turtles at the site is developed, those areas would be the primary focus of the research effort.

Staffing

The assumption is that all of the research can be conducted by a paid field supervisor with an intern assistant for relief/backup and a team of trained volunteers thereby keeping labor costs low. Initial training and ongoing quality control monitoring by qualified professionals is important to insure that information is collected properly.

Study Sites

The Smith & Bybee Lakes area has been divided into four study subareas to facilitate organizing research efforts and analysis of turtle use. Suggested divisions are: 1. the ponds and the blind slough along North Marine Drive, 2. Bybee Lake, 3. Columbia River slough and adjacent ponds, and 4. Smith Lake from its connection with Bybee Lake. These subareas are based on assumptions and predictions about where most turtles will be found, but can be revised, if necessary, as the study progresses. See Figure 1 on page 7 which shows the proposed subareas.

Volunteers

Most of the research effort can be conducted by trained volunteers. Qualified volunteers are available for and eager to work on this study. Careful recruitment and training will result in the creation of a dependable, efficient and competent field team. Several organizations have volunteer programs from which to recruit suitable candidates for this project: Metro's naturalist and zoo volunteer programs, Oregon Department of Fish and Wildlife, Portland Audubon Society, The Nature Conservancy and Friends of Smith and Bybee Lakes. Life science programs at local colleges and universities are also a good source of motivated volunteers.

Safety

The protocol assumes several safety guidelines. All field work will be conducted with people working in pairs; each pair will remain in sight and sound of one another at all times. Each pair of field workers should be equipped with a cell phone. All field workers will wear a uniform—hat, t-shirt, identification badge—to create an official appearance to enhance the safety and recognition of field personnel. Any team of researchers in the field after dark will be accompanied by a professional security guard.

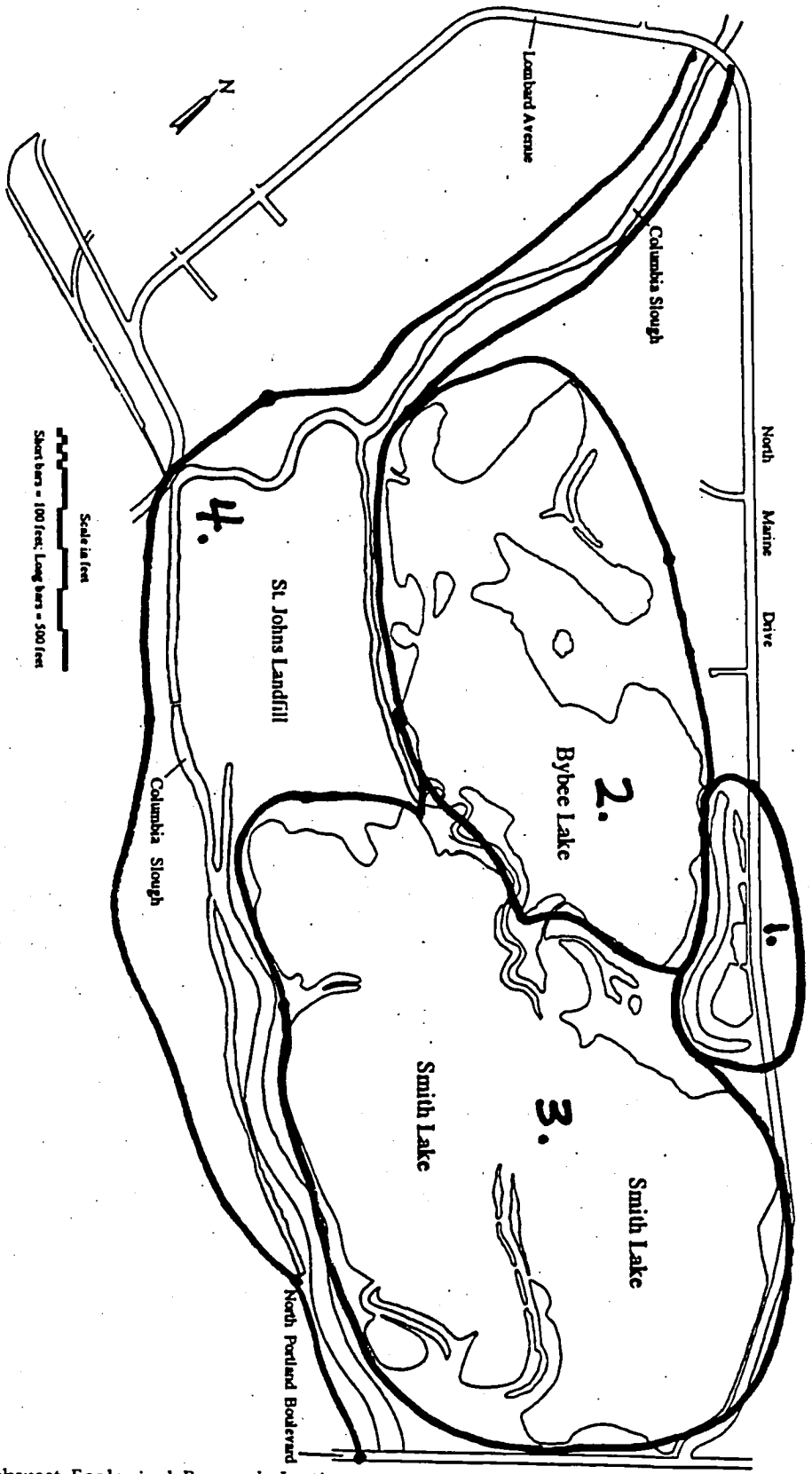

Figure 1. Four turtle study subareas.

Handling Turtles

Particular care must be taken in doing research which requires handling live animals. The priority is always the humane treatment of the turtles. Achieving research goals must never take precedence over properly caring for the turtles.

For example, the fast growth rate, especially in young western painted turtles, requires special attention with radio telemetry because turtles may shed the outer layer of their shell once or twice a season meaning transmitters can also be shed. To protect the turtles from loose transmitters which could injure or drown them, each turtle with a transmitter must be caught and checked every few weeks during the summer growing season. Transmitters must be removed at the end of the project.

The budget includes the cost for training researchers in the proper handling and evaluation of turtles, especially with procedures such as implanting pit tags (internal computer chip identification), attaching transmitters and marking turtles with shell notches.

Arrangements in advance of the research effort need to be made for the possible collection and disposition of non-native turtle species and of sick or injured native turtle species to be cared for by wildlife rehabilitators and/or qualified reptile veterinarians licensed to treat native reptiles by Oregon Department of Fish and Wildlife. The budget includes these costs.

Permits

Before any research effort can begin involving the handling of turtles, the Oregon Department of Fish and Wildlife must approve the project and issue a scientific permit. Securing a permit requires submitting a written proposal to ODFW. One of the conditions of being granted a permit is the submission of an annual summary of results to ODFW.

Training

Qualified consultants will be needed to train the staff and volunteers in the various field techniques and to conduct ongoing quality control monitoring and training. Included in the budget and in each goal is a training and oversight component.

Part of field research training should include how to deal effectively with the public. Thought should also be given to how field researchers identify their activities so as not to encourage members of the public to interfere with the research effort or try to collect turtles illegally.

Budget

The budget identifies the itemized costs for addressing each of the six research goals. A budget for year one and a budget for subsequent years of the study are included. Activities and budget for each goal are presented independently. Goals can be pursued individually or in combination. As the attached timeline indicates, all or a combination of goals can be accomplished simultaneously by the same team of field researchers. Some of the same activities are required for a combination of goals, for example trapping and marking turtles. Such overlap is one example of an economy of pursuing more than one goal simultaneously.

Price ranges for some items indicate the possibility of donations (i.e., in-kind equipment or using volunteer labor to assemble field equipment). Only currently known opportunities for donations or reductions in cost are identified—additional effort could uncover more opportunities for cost reductions. Economies of scale would result from pursuing multiple goals as well as leveraging resources. The budget assumes a paid supervisor in the field at all times managing a team of trained volunteers. The budget assumes reimbursement of mileage costs for volunteers.

The budget also assumes the maximum number of field days to complete each task and the maximum number of days for consultant oversight. It assumes each person working in the field commutes individually for a daily round trip of 50 miles.

HIGH PRIORITY TURTLE STUDY GOALS

1. Demographics

Goal:
Assess the status of the western painted turtle population at Smith and Bybee Lakes. Set management goals in order to maintain a viable population based on the status of the population.

Objectives:
- Estimate size of population.
- Describe and evaluate age distribution and gender ratio.
- Initiate trend analysis—determine if overall population or components of it are stable, increasing or decreasing.
- Assess the health of individuals in the population.

Methodologies:
—capture/mark/recapture

Using small funnel traps and large, winged hoop nets, conduct trapping effort covering all four subareas, five days consecutively, twice a month from approximately March through September. Traps to be deployed during the day and also left overnight. Vary the time of day each subarea is trapped.
For each turtle caught:
- identify new or recapture
- record weight
- measure plastron length
- measure carapace length
- determine gender (M, F, juvenile, hatchling)
- identify age class (adult > 100 mm, juvenile 50-100 mm, hatchling < 50 mm)
- count annuli on shell
- conduct general health check for obvious illness or injury
- photograph profile, plastron and carapace
- photocopy plastron of each turtle (optional)
- palpate all adult turtles to help determine gender
- shell notch each turtle using a unique number
- install pit tags (internal computer i.d. chip) in turtles that can safely tolerate them (turtles over about 50-70 mm)
- mark turtles, >100 mm carapace length, with a temporary (6-8 weeks) quarter-size dab of low-contrast green nail polish to facilitate visual surveys.

—visual surveys

Conduct comprehensive land and water visual surveys 10 days per month, at times and in areas not simultaneously being live trapped. Identify numbers of turtles, whether marked or unmarked, gender and age class. Record basic weather conditions. Vary the time of day each subarea is surveyed.

Staffing	Person Days
Visual and trapping surveys, six-person team, 14 five-day sessions, March-September	
Project supervisor	70
Five volunteers	350
Management and coordination	
Project supervisor	14
Data entry and analysis	
Project supervisor	7
Volunteer	7
Report preparation, interim and final	
Project supervisor	14
Training and Monitoring	
Train project supervisor and volunteers, first five-day session	
Qualified consultant	10
Quality control monitoring and training, one day per trapping session	
Qualified consultant	13

There will be on the job field training for the first five-day reconnaissance trapping/survey effort, followed by ongoing monitoring to assure field worker reliability. The assumption is two experienced turtle research people on hand for each day of the first five-day trapping/survey effort and one consultant one day of each subsequent five-day research effort.

Data Analysis

Using non-parametric statistical analysis and descriptive statistics, characterize size, health and density of population, gender ratios and age distribution and estimate trends. Begin to assess status of population. Each month of research effort, produce interim report with current field data. Map location of turtles found by gender and age group. Produce final report at end of field season to provide preliminary evaluation of the turtle population. Consider preliminary management goals for the population. Evaluate first year of research and revise subsequent years of research accordingly. Years two through five of the study would confirm the estimated size of the population and attempt to ascertain whether the population is stable, increasing or decreasing and why.

2. Nesting

Goal:
Manage Smith and Bybee Lakes for reproductive success and survival of hatchling turtles in order to maintain a viable turtle population.

Objectives:
- Identify and describe nesting behavior by gravid females including site fidelity, location, conditions and timing.
- Identify and describe successful and unsuccessful nests.
- Identify hatchling overwintering locations.
- Identify times of hatchling emergence from nests.
- Identify type of disturbance to nesting females and hatchlings when possible.

Methodologies:
—live trapping to locate 20 gravid females

Using small funnel traps and large, winged hoop nets, conduct trapping effort five days consecutively, covering all four subareas, twice a month from approximately April 15 through June 30, or until 20 gravid females are located. Traps to be deployed during the day and also left overnight. Vary the time of day each subarea is trapped.

For each turtle caught:
- identify new or recapture
- record weight
- measure plastron length
- measure carapace length
- determine gender (M, F, juvenile, hatchling)
- identify age class (adult > 100 mm, juvenile 50-100 mm, hatchling < 50 mm)
- count annuli on shell
- conduct general health check for obvious illness or injury
- photograph profile, plastron and carapace
- photocopy plastron of each turtle (optional)
- palpate all adult turtles to help determine gender
- shell notch each turtle using a unique number
- install pit tags (internal computer i.d. chip) in turtles that can safely tolerate them (turtles over about 50-70 mm)
- mark turtles, >100 mm carapace length, with a temporary (6-8 weeks) quarter-size dab of low-contrast green nail polish to facilitate visual surveys.

—radio telemetry to determine nest sites

Track gravid females 12 to 18 hours per day until each turtle nests, approximately June 1 through August 18. In order to track females leaving the water to nest on land, locate each transmittered turtle every two hours for 12 to 18 hours per day. Identify nest by plotting location using physical measurements and compass points. Photograph each nest and characterize its location in detail: slope, aspect, vegetation, soil type, etc. Place exclosures on half the nests, if possible, permanently, but at least for a few days to discourage predators. Leave half the nests unprotected to try to determine which nests are left undisturbed and which are found by predators. Begin identifying characteristics of successful and unsuccessful nests. At the end of the project, capture females and remove transmitters.

—hatchling monitoring

Beginning about 60 days after date nest is laid, monitor nests daily for emergence of hatchlings. Use short term radio telemetry daily to locate of up to 20 hatchlings at a time for the first week after leaving nest. Monitor nests daily from approximately September through October and March through April to confirm fall and/or spring emergence. After one week of monitoring, capture hatchlings and remove transmitters.

—day and night visual surveys and observations from blinds.

Conduct visual surveys approximately April 15 though August 15 in conjunction with trapping effort and telemetry surveys to locate adult females, nests and hatchlings. Based on surveys conducted in 1997 and the opinions of professional herpetologists, night surveys may be particularly important for the Smith and Bybee turtles as they may have adapted their behavior to nest late at night to avoid human and other interference. Because of potential risks associated with working after dark a security guard is budgeted to accompany field researchers working at night.

Staffing	Person Days
Trapping Effort April 15-June 30	
Six person team, five five-day trapping sessions	
Project supervisor field time	25
Five volunteers field time	125
Daily telemetry surveys to locate turtle nests June 1-August 15.	
Two person team, daily daytime surveys	
Project supervisor field time	76
One volunteer field time	76
Two person team, nighttime surveys	
Project supervisor field time	76
One volunteer field time	76
Daily telemetry to monitor hatchling emergence, September-October and March-April	
Two person team, daily (half days)	
Project supervisor	61
One Volunteer	61
Management and coordination	
Project supervisor, one day per week	17
Data entry and analysis	
Project supervisor	7
One volunteer	7
Report preparation, interim and final	
Project Supervisor	15
Training/Monitoring/Security	
Training of project supervisor and volunteers, first five-day session	
Qualified consultant	10
Quality control monitoring and training, one day per trapping session	
Qualified consultant	5
Night security (half time), April 15-August 15	
Guard	61

There will be on the job field training for the first five-day reconnaissance trapping/survey effort which includes telemetry training, followed by ongoing monitoring to assure field worker reliability. The assumption is two experienced turtle research people on hand for each day of the first five-day trapping/survey effort and one consultant one day of each subsequent five day research effort.

Data Analysis

Compare nesting and hatchling data collected at Smith and Bybee with data collected at Burlington Bottoms regularly through the nesting season to gain insights to improve the research effort and evaluation of data.

Using non-parametric statistical analysis and descriptive statistics, along with principal components analysis, characterize the time, conditions and location of nesting, and dates of hatchling emergence. Begin to develop characteristics of successful and unsuccessful nest characteristics. Each month of research effort, produce interim report with current field data. Map location of nests. Produce final report at end of field season incorporating any available data from Burlington Bottoms. Formulate preliminary protection and habitat enhancement measures for females nesting, nests and emergent hatchlings. Evaluate first year of research. Use second through fifth years of study to determine variations in nesting locations and behavior, and develop appropriate protection measures.

3. Impacts

Goal:
Manage impacts of human and non-human activities on turtle population in order to minimize negative effects to turtles.

Objectives:
- Develop a partnership with the Oregon Department of Fish and Wildlife (ODFW) and the manager of Burlington Bottoms to coordinate research activities.
- Identify and describe types, times, duration and locations of human and non-human activities
- Evaluate the relationship between human/non-human activities and the turtle population, and their potential impacts on turtle behavior.

Methodologies:
—comparative visual surveys

In partnership with ODFW and its manager of Burlington Bottoms, compare Smith and Bybee turtle behavior to the relatively undisturbed turtle population at Burlington Bottoms. Conduct visual surveys one day per week, varying the day of the week, from May through September. Monitor turtle behavior at three comparable habitats: one at Burlington Bottoms, a relatively undisturbed site at Smith and Bybee and a heavily used site at Smith and Bybee. Record water and air temperature, number of humans and their activity levels, and number of turtles and their behavior. Two person teams will work at each of the three locations.

—experiments to measure turtle response to various activities

Design and conduct simultaneous experiments at Burlington Bottoms and Smith and Bybee Lakes in order to compare turtle behavior. Compare turtle responses to canoe activity, different types of noise on land and human movement on land. Record turtle response, including flight distance. Conduct experiments concurrently at Smith and Bybee and Burlington Bottoms two days per month May through September, two people at each location.

Staffing	Person Days
Comparative visual surveys, three sites, one day per week, May-September.	
Metro—Smith & Bybee, two sites	
Project supervisor	22
Three volunteers	66
ODFW—Burlington Bottoms, one site	ODFW
Experiments	
Metro— Smith and Bybee	
Project Supervisor	10
Volunteer	10
ODFW—Burlington Bottoms	ODFW
Management and coordination	
Project supervisor	3
Date entry and analysis	
Project supervisor	3
Volunteer	3
Report preparation, interim and final	
Project supervisor	7

Training/Monitoring

Training of project supervisor and volunteers, first day of visual surveys and first day of experiment session	
Qualified consultant	4
Quality control monitoring, one day per month each for surveys and experiments	
Qualified consultant	10

There will be on the job field training for the first reconnaissance survey and experiment efforts, followed by ongoing monitoring to assure field worker reliability.

Data Analysis

Compile and analyze data monthly and prepare monthly interim reports. Use non-parametric and principal components analysis to measure differences in turtle behavior at different sites and under different conditions. Prepare final report at end of season summarizing effects of human and non-human activities on turtles. Make preliminary assessment of management changes to mitigate any negative effects. Evaluate first year of research and revise subsequent years of research accordingly. Continue visual surveys and experiments in years two through five to document effects of various impacts on turtle behavior.

SECOND TIER TURTLE STUDY GOALS

4. Overwintering

Goal:
Manage Smith and Bybee Lakes in order to protect overwintering sites used by western painted turtles.

Objective:
• Identify and describe locations, site fidelity, conditions and timing of overwintering sites by age and gender.

Methodologies:
—mark/capture/recapture/radio telemetry

Place a total of 20 transmitters on turtles: 7 adult males, 7 adult females and 6 juveniles. Initiate trapping effort in August, two days per week for three weeks or until 20 suitable animals have been captured.

Using small funnel traps and large, winged hoop nets, conduct trapping effort two days per week, covering all four subareas, in August. Traps to be deployed during the day and also left overnight.

For each turtle caught:

- identify new or recapture
- record weight
- measure plastron length
- measure carapace length
- determine gender (M, F, juvenile, hatchling)
- identify age class (adult > 100 mm, juvenile 50-100 mm, hatchling < 50 mm)
- count annuli on shell
- conduct general health check for obvious illness or injury
- photograph profile, plastron and carapace
- photocopy plastron of each turtle (optional)
- palpate all adult turtles to help determine gender
- shell notch each turtle using a unique number
- install pit tags (internal computer i.d. chip) in turtles that can safely tolerate them (turtles over about 50-70 mm)
- mark turtles, >100 mm carapace length, with a temporary (6-8 weeks) quarter-size dab of low-contrast green nail polish to facilitate visual surveys.

Using radio telemetry, locate each animal regularly through fall and winter (from about September 1 through April 15). Locate animals twice a week (half a day) in September, October, March and April and once a week from November through February to determine location and timing of hibernation for males, females and juveniles. Record basic weather conditions. Recapture turtles monthly from March through September to check condition of transmitter attachment. Remove transmitters at end of season.

Staffing	Person Days
Trapping effort, six-person team, two days per week, August.	
Project supervisor	8
Five volunteers	40
Radio telemetry to locate turtles, two person team, twice a week for 20 weeks and once a week for 18 weeks,	
Project Supervisor	29
Volunteer	29
Management and coordination	
Project supervisor	3
Data entry and analysis	
Project supervisor	3
Volunteer	3
Report preparation, interim and final	
Project supervisor	5

Training/Monitoring

Trapping, first two-day session, and telemetry training, first two days.	
Qualified consultant	7
Ongoing quality control monitoring	
Qualified consultant	5

There will be on the job field training for the two-day reconnaissance trapping/survey effort and the first two days of radio telemetry work, followed by ongoing monitoring to assure field worker reliability. The assumption is two experienced turtle research people on hand for each day of the first two-day trapping/survey effort and the first two days of radio telemetry work; and one consultant one day periodically to monitor research effort.

Data Analysis

Analyze data monthly and create monthly interim report. Compare Smith and Bybee Lakes data to available information from Burlington Bottoms and existing data about western pond turtle hibernation. Map location of identified overwintering sites by gender and age. Create final report incorporating field data collected, Burlington Bottoms and western pond turtle information. Begin to formulate preliminary techniques for protecting overwintering sites. Evaluate first year of research and revise subsequent years of research accordingly. Use second through fifth years of the study to document variations in overwintering behavior to predict locations and times of overwintering and develop techniques for protecting overwintering sites.

5. Basking

Goal:
Manage Smith and Bybee Lakes in order to provide for and protect basking habitat used by western painted turtles.

Objectives:
- Identify and describe aquatic and non-aquatic basking structures and habitat.
- Identify and describe daily and seasonal use of basking structures by age and gender.

Methodology:
—visual surveys

Conduct visual surveys in all four subareas of study site one day per week from March 15 through October 15. Identify age and gender of basking turtles, times of day and duration of basking. Characterize non-aquatic basking sites by slope, aspect, distance to water, distance to land, type of surrounding vegetation, depth of water, air and water temperature, and wind direction and velocity. Characterize aquatic basking sites by distance to land, vegetation type, depth of water, air and water temperature, and wind velocity and direction. Photograph basking structures. Distinguish basking structures used by age and gender of turtle.

Staffing	Person Days
Visual surveys, six-person team, one day per week, March 15-October 15.	
Project supervisor	30
Volunteers	150
Management and coordination	
Project supervisor	7
Data entry and analysis	
Project supervisor	4
Volunteer	4
Report preparation, interim and final	
Project supervisor	7
Training/Monitoring	
Initial field training	
Qualified consultant	2
Ongoing quality control training and monitoring	
Qualified consultant	6

There will be on the job field training for the visual surveys followed by ongoing monitoring to assure field worker reliability. The assumption is one experienced turtle research person on hand for the first two days of visual surveys and one consultant one day per month thereafter.

Data Analysis

Compile and analyze data monthly and write a monthly interim report. Using principal components analysis, characterize the types of aquatic and non-aquatic basking structures use by time of day, season, age and gender of turtles. If data are available, compare basking structure use by turtles at Burlington Bottoms. Use final report at end of season to suggest enhancement to basking opportunities for turtles at Smith and Bybee. Evaluate first year of research and revise subsequent years of research accordingly. Use the remaining four years of the study to document variations in basking behavior in order to develop management strategies to provide sufficient opportunities for turtles to bask successfully.

6. Habitat Use

Goal:
Manage Smith and Bybee Lakes in order to provide for and protect aquatic and non-aquatic habitat used by western painted turtles throughout the year.

Objectives:
- Identify and describe aquatic and non-aquatic seasonal habitat use by hatchlings, juveniles and adults, and by gender.
- Identify use of habitat transit routes by age and gender.

Methodologies
—mark/capture/recapture/radio telemetry

Using small funnel traps and large, winged hoop nets, conduct trapping effort five days consecutively covering all four subareas, twice a month from approximately April 15 through June 30, or until 20 turtles (7 males, 7 females (3-4 gravid),6 juveniles) are located. Traps to be deployed during the day and also left overnight. Place transmitters on 6 hatchlings as they emerge from previously identified nests.

For each turtle caught:
- identify new or recapture
- record weight
- measure plastron length
- measure carapace length
- determine gender (M, F, juvenile, hatchling)
- identify age class (adult > 100 mm, juvenile 50-100 mm, hatchling < 50 mm)
- count annuli on shell
- conduct general health check for obvious illness or injury
- photograph profile, plastron and carapace
- photocopy plastron of each turtle (optional)
- palpate all adult turtles to help determine gender
- shell notch each turtle using a unique number
- install pit tags (internal computer i.d. chip) in turtles that can safely tolerate them (turtles over about 50-70 mm)
- mark turtles, >100 mm carapace length, with a temporary (6-8 weeks) quarter-size dab of low-contrast green nail polish to facilitate visual surveys.

Using radio telemetry, locate each animal regularly year around. For adults and juveniles, locate each animal twice weekly from May through July, once a week from August through October, twice a month from November through February and once a week from March through April. Gravid females to be followed daily from May through July or until they nest. Using short term transmitters, follow hatchlings daily for up to 60 days after time of emergence in fall and/or spring.

Turtles, especially juveniles and small adults, to be recaptured monthly, from March through September, to check to make sure their transmitters are secure.

—visual surveys

Conduct visual surveys in conjunction with trapping effort and telemetry surveys to locate turtles. Record basic weather conditions.

Staffing	Person Days
Trapping effort April 15-June 30.	
Six person team, five five-day trapping sessions	
Project supervisor field time	25
Five volunteers field time	125
Radio telemetry	
—for non-gravid females, adult males, juveniles.	
Twice weekly May-July, weekly August-October and March-April, twice monthly November-February	
Two person team, 58 days (half days)	
Project Supervisor	29
Volunteer	29
—for gravid females, daily May through July	
Two person team	
Project supervisor	92
Volunteers	92
—for hatchlings	
Two person team, daily (half days)	
September-October and March-April	
Project supervisor	61
Volunteer	61
Management and coordination	
Project supervisor	14
Data entry and analysis	
Project supervisor	15
Volunteer	15
Report preparation, interim and final	
Project supervisor	15
Training/Monitoring	
First five-day survey/trapping/telemetry session	
Two qualified consultants	10
Ongoing quality control monitoring and training	
Qualified consultant	10

There will be on the job field training for the first five-day reconnaissance trapping/survey effort and radio telemetry effort, followed by ongoing monitoring to assure field worker reliability. The assumption is two experienced turtle research people on hand for each day of the first five-day trapping/survey/telemetry effort and one consultant one day of each subsequent five day research effort.

Data Analysis

Compile and analyze data monthly and prepare monthly summary. Using non-parametric and principal components analysis, characterize the turtles' habitat use by time of day, season, age class and gender, including gravid females and emergent hatchlings. Map habitat use by season, gender and age. Compare with available data collected at Burlington Bottoms. Write final report at end of first full year including preliminary management considerations for habitat protection and enhancement, seasonal closures, etc. Evaluate first year of research and revise subsequent years of research accordingly. In years two through five of the study, confirm understanding of the overall use of the site turtles and verify that preliminary management techniques are adequate to maintain the population.

SHARING INFORMATION

Share research information collected with organizations and agencies interested in native turtles, such as Natural Heritage Database, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Western Painted and Pond Turtle Working Groups.

Encourage opportunities for supplementary research and public education/participation in the conduct of the study, especially volunteer opportunities.

ADAPTIVE MANAGEMENT

Use adaptive management approach in order to give Metro the opportunity to alter management activities over time, in response to the success or failure of management actions. The information obtained from monitoring and evaluation will be used to develop and analyze management activities including: effectiveness of habitat maintenance and restoration activities; and species occurrence and response to management activities. Data collected can suggest such things as: vegetation management to enhance nesting and basking areas; seasonal or permanent closures of nesting or transit areas used by turtles; adjustments in recreation patterns including land and water trails to minimize negative impacts to turtles; suggestions for adjustments to human activities to minimize negative effects on turtles. By assessing the turtle population, appropriate management activities can be developed.

HISTORICAL SURVEY

In addition to search of scientific literature which is included with this plan, collect existing data about the site and its human and natural history as related to turtles.

Methodology:

Recruit a college student or interested volunteer to conduct comprehensive human and natural literature review beyond scientific literature search; review human and natural history collections in the Pacific Northwest and perhaps interview Pacific Northwest Native Americans about the role of the western painted turtle in their culture. The goal will be to develop a wide perspective on the cultural and natural history of the species with a specific focus on Smith and Bybee Lakes. Such information could provide insights into the turtle's current status and provide a basis for public information and education programs as well as possible ideas for successful coexistence of humans and western painted turtles.

SMITH AND BYBEE MANAGEMENT OBJECTIVES AS RELATED TO THE TURTLE STUDY

1. Control water level in order to manage lakes' environmental system.
   Related turtle study activities:
   - Identify overwintering locations.
   - Identify transit routes.
   - Identify nest locations.
   - Identify type of, time of, and use of aquatic, riparian, upland habitat.

2. Provide for and maintain habitat diversity representative of lower Columbia River floodplain wetlands.
   Related turtle study activities:
   - Characterize, monitor and provide enhancement of habitat for native turtle population.
   - Describe nest characteristics and maintain nest areas.
   - Identify and protect turtle habitat.
   - Provide recommendations for control of native and non-native predators of turtles.

3. not applicable

4. Implement monitoring program to assure early detection of potential environmental problems, and to quantify management programs.
   Related turtle study activities:
   - Monitor status of turtle population.
   - Monitor effectiveness of turtle management efforts.
   - Develop long-term assessment protocol.
   - Monitor human and non-human predation and competition impacts.

5. Provide access to Smith and Bybee Lakes which supports appropriate types and levels of recreation.
   Related turtle study activities:
   - Identify turtles' use of habitat and recommend site management to avoid turtle conflicts with humans.
   - Assess impact of human activities on turtles and recommend site management to benefit turtles and humans.

6. Encourage appropriate types and levels of recreational activities which are compatible with environmental objectives.
   Related turtle study activities:
   - see #5

7. Incorporate Smith and Bybee Lakes into the Metropolitan Wildlife System Project, Metro's Regional Natural Areas Program, and the 40 Mile Loop recreation trail system.
   Related turtle study activities:
   - Identify appropriate location of trails to protect critical turtle habitat.
   - Identify potential non-disruptive areas for public viewing of turtles.
   - Assess human impacts on turtle habitat.
   - Incorporate needs of public while eliminating negative human impacts on turtles.
   - Use comparative data from other western painted turtle sites in decision-making activities.

8. Develop upland areas in a manner which is compatible with the preservation of the wetlands and use of the lakes for passive recreation.
   Related turtle study activities:
   - Identify turtle use of upland habitat (nesting, transit, overwintering).
   - Recommend management plans to accommodate human needs while minimizing negative impacts to turtles.

9. Provide opportunities for wetland and environmental system research and education.
   Related turtle study activities:
   - Create opportunities for public education about turtles.
   - Contribute to habitat and natural history data about one of the few remaining populations of western painted turtles in the lower Columbia.
   - Create opportunities for research at the site and encourage cooperative/comparative studies with other sites.

10. Develop appropriate funding strategies to implement environmental and recreational improvement projects.
   Related turtle study activities:
   - Seek funding for turtle research and enhancement projects.
   - Provide data to determine the need for minimization and mitigation of human impacts and enhancement of turtle habitat.

11, 12, 13. not applicable

Smith and Bybee Turtle Study Annual Budget for Year One			
BUDGET BY GOAL (3/98)	**1. DEMOGRAPHICS**	**2. NESTING**	**3. IMPACTS**
	STAFF		
Supervisor days @ $10-15,000 p/year			
management & coordination	14	17	3
field work	70	238	32
data entry and analysis	7	7	3
report preparation	14	15	7
Volunteer Days			
field work	350	338	76
data entry and analysis	7	7	3
Volunteer Mileage			
Miles @ $0.315 p/mi. (50 mi rt p/person day)	17,850 @ .315 = $5623	17,250 @ .315 = $5434	3950 @ .315 = $1244
REQUIRED FOR ALL SIX GOALS			
Equipment			
Cell Phones @ $210 each	3 @ 210 = $630	Single Purchase, See Goal 1.	Single Purchase, See Goal 1.
Cell Service @ $156 each annually	3 @ 156 = $468	"	"
35 mm camera w/ macro	Metro	"	"
Binoculars	Metro or staff	"	"
Spotting Scopes	Metro or staff	"	"
Two Canoes	Metro	"	"
Personal Flotation Device	Metro	"	"
Supplies			
Clipboards, Pens, Pencils, Photocopies	Metro	"	"
Waterproof Paper and Notebooks	$100	"	"
Aerial Photos with UTM coordinates	Metro	"	"
First Aid Kits	Metro	"	"
Film & Processing @ $15 p/roll	12 @ 15 = $180	"	"
Field Uniform = Hat, T-Shirt, I.D. Badge	Metro	"	"
Turtle Rehabilitation $0-100	0-$100	"	"
Miscellaneous	$100	"	"
Consultant			
Training/ Monitoring Field Staff @ $0-200 p/person day	23 @ 0-200 = $0-4600	15 @ 0-200 = $0-3000	14 @ 0-200 = $0-2800
REQUIRED FOR FEWER THAN SIX GOALS			
Equipment			
Dip Nets @ $40	2 @ 40 = $80	Single Purchase, See Goal 1.	
Hoop Net with 2 100' wings @ $735 each	2 @ 735 = $1470	"	
Funnel Traps @ $100 each (or Construct for $25)	12 @ 25-100 = $300-1200	"	
200 mm Calipers @ $148 each	1 @ 148 = $148	"	
Caliper=Pistol Grip Clamp+Ruler @ $15 each	1 @ 15 = $15	"	
5 kg Scale @ $130 each	1 @ 130 = $130	"	
Wind Velocity Meter @ $15			
Pit Tags @ $5 each	300 @ 5 = $1500	20 @ 5 = $100	
Pit Tag Reader $400-625	2 @ 400- 625 = $800-1250	Single Purchase, See Goal 1.	
Adult Telemetry Transmitters @ $165 each		20 @ 165 = $3300	
Hatchling Telemetry Transmitters @ $165 each		20 @ 165 = $3300	
Telemetry Antenna @ $150 each		2 @ 150 = $300	
Telemetry Receiver @ $1000 each		2 @ 1000 = $2000	
Nest Exclosures @ $25 each (Construct for $15)		10 @ 15-25 = $150-250	
Viewing Blinds @ $100 (or Construct for $25)		3 @ 25-100 = $75-300	Single Purchase, See Goal 2.
Compass		Metro	
100' Tape Measure		"	
Jon-type Boat, Motor, Transport	Metro	"	
Supplies			
Batteries & Charger $50	1 @ $50	Single Purchase, See Goal 1.	
Disinfectant: chlorhexidine, bleach, alcohol @ $50	1 @0-50 = $0-50	"	
5 Gallon Buckets @$0-2.50 each	10 @ 0-2.50 = $0-25.00	"	
Bait for traps @ $0-1 p/can p/day	980 @ 0-1 = $0-980	210 @ 0-1 = $210	
Attach Transmitter to Turtle @ $10 each		20 @ 10 = $200	
Radiograph Gravid Females @ $0-48 each		20 @ 0-48 = $0-960	
Photocopy Turtle Plastron @ $0-.80 each (Optional)	300 @0-.80 = $0-240	20 @ 0-.80 = $0-16	
Night Field Work			
Night Vision Scope @ $500 each		1 @ 500 = $500	
Head Lamps @ $15 each		3 @ 15 = $45	
Flashlights		Metro	
Night Security Guard @ $0-15 p/hr		488 hrs. @ 0-15 = $0-7320	

Smith and Bybee Turtle Study Annual Budget for Year One			
BUDGET BY GOAL (3/98)	**4. OVERWINTERING**	**5. BASKING**	**6. HABITAT USE**
	STAFF		
Supervisor days @ $10-15,000 p/year			
management & coordination	3	7	14
field work	37	30	207
data entry and analysis	3	4	15
report preparation	5	7	15
Volunteer Days			
field work	69	150	307
data entry and analysis	3	4	15
Volunteer Mileage			
Miles @ $0.315 p/mi. (50 mi rt p/person day)	3600 @ .315 = $1134	7700 @ .315 = $2426	16,100 @ .315 = $5072
	REQUIRED FOR ALL SIX GOALS		
Equipment			
Cell Phones @ $210 each	Single Purchase, See Goal 1.	Single Purchase, See Goal 1.	Single Purchase, See Goal 1.
Cell Service @ $156 each annually	"	"	"
35 mm camera w/ macro	"	"	"
Binoculars	"	"	"
Spotting Scopes	"	"	"
Two Canoes	"	"	"
Personal Flotation Device	"	"	"
Supplies			
Clipboards, Pens, Pencils, Photocopies	"	"	"
Waterproof Paper and Notebooks	"	"	"
Aerial Photos with UTM coordinates	"	"	"
First Aid Kits	"	"	"
Film & Processing @ $15 p/roll	"	"	"
Field Uniform = Hat, T-Shirt, I.D. Badge	"	"	"
Turtle Rehabilitation $0-100	"	"	"
Miscellaneous	"	"	"
Consultant			
Training/ Monitoring Field Staff @ $0-200 p/person day	12 @ 0-200 = $0-2400	8 @ 0-200 = $0-1600	20 @ 0-200 =$4000
	REQUIRED FOR FEWER THAN SIX GOALS		
Equipment			
Dip Nets @ $40	Single Purchase, See Goal 1.		Single Purchase, See Goal 1.
Hoop Net with 2 100' wings @ $735 each	"		"
Funnel Traps @ $100 each (or Construct for $25)	"		"
200 mm Calipers @ $148 each	"		"
Caliper=Pistol Grip Clamp+Ruler @ $15 each	"		"
5 kg Scale @ $130 each	"		"
Wind Velocity Meter @ $15		3 @ $15 = 45	
Pit Tags @ $5 each	20 @ 5 = $100		26 @ 5 = $130
Pit Tag Reader $400-625	Single Purchase, See Goal 1.		"
Adult Telemetry Transmitters @ $165 each	20 @ 165 = $3300		20 @ 165 = $3300
Hatchling Telemetry Transmitters @ $165 each			6 @ 165 = $990
Telemetry Antenna @ $150 each	Single Purchase, See Goal 1.		Single Purchase, See Goal 1.
Telemetry Receiver @ $1000 each	"		"
Nest Exclosures @ $25 each (Construct for $15)			4 @ 15-25 = $60-100
Viewing Blinds @ $100 (or Construct for $25)			Single Purchase, See Goal 2.
Compass	"	Single Purchase, See Goal 2.	"
100' Tape Measure	"	"	"
Jon-type Boat, Motor, Transport	"		"
Supplies			
Batteries & Charger $50	Single Purchase, See Goal 1.		Single Purchase, See Goal 1.
Disinfectant: chlorhexidine, bleach, alcohol @ $50	"		"
5 Gallon Buckets @$0-2.50 each	"		"
Bait for traps @ $0-1 p/can p/day	112 @ 0-1 = $0-112		720 @ 1 = $720
Attach Transmitter to Turtle @ $10 each	20 @ 10 = $200		20 @ 10 = $200
Radiograph Gravid Females @ $0-48 each			4 @ 0-48 = $0-192
Photocopy Turtle Plastron @ $0-.80 each (Optional)	20 @ 0-.80 = $0-16		26 @ 0-.80 = $0-20.80
Night Field Work			
Night Vision Scope @ $500 each			Single purchase, See Goal 2.
Head Lamps @ $15 each			"
Flashlights			"
Night Security Guard @ $0-15 p/hr			"

Smith and Bybee Turtle Study Annual Budget for Years Two through Five			
BUDGET BY GOAL (3/98)	**1. DEMOGRAPHICS**	**2. NESTING**	**3. IMPACTS**
	STAFF		
Supervisor days @ $10-15,000 p/year			
management & coordination	14	17	3
field work	70	238	32
data entry and analysis	7	7	3
report preparation	14	15	7
Volunteer Days			
field work	350	338	76
data entry and analysis	7	7	3
Volunteer Mileage			
Miles @ $0.315 p/mi. (50 mi rt p/person day)	17,850 @ .315 = $5623	17,250 @ .315 = $5434	3950 @ .315 = $1244
	REQUIRED FOR ALL SIX GOALS		
Equipment			
Cell Phones	Purchased Year One	Purchased Year One	Purchased Year One
Cell Phone Service @ $156 each annually	3 @ 156 = $468	Single Purchase, See Goal 1	Single Purchase, See Goal 1
35 mm camera w/ macro	Purchased Year One	Purchased Year One	Purchased Year One
Binoculars	Metro or staff	"	"
Spotting Scopes	Metro or staff	"	"
Two Canoes	Metro	"	"
Personal Flotation Device	Metro	"	"
Supplies			
Clipboards, Pens, Pencils, Photocopies	Metro	Single Purchase See Goal 1	Single Purchase, See Goal 1
Waterproof Paper and Notebooks	$100	"	"
Aerial Photos with UTM coordinates	Metro	"	"
First Aid Kits	Metro	"	"
Film & Processing @ $15 p/roll	12 @ 15 = $180	"	"
Field Uniform = Hat, T-Shirt, I.D. Badge	Metro	"	"
Turtle Rehabilitation $0-100	0-$100	"	"
Miscellaneous	$100	"	"
Consultant			
Training/ Monitoring Field Staff @ $0-200 p/person day	23 @ 0-200 = $0-4600	15 @ 0-200 = $0-3000	14 @ 0-200 = $0-2800
	REQUIRED FOR FEWER THAN SIX GOALS		
Equipment			
Dip Nets @ $40	Purchased Year One	Purchased Year One	
Hoop Net with 2 100' wings @ $735 each	"	"	
Funnel Traps @ $100 each (or Construct for $25)	"	"	
200 mm Calipers @ $148 each	"	"	
Caliper=Pistol Grip Clamp+Ruler @ $15 each	"	"	
5 kg Scale @ $130 each	"	"	
Wind Velocity Meter @ $15			
Additional Pit Tags @ $5 each	50 @ 5 = $250	20 @ 5 = $100	
Pit Tag Reader $400-625	Purchased Year One	Purchased Year One	
Replace Adult Telemetry Transmitters @ $165 each	3 @ 165 = $495	3 @ 165 = $495	
Refurbish Adult Transmitters @ $80 each		20 @ 80 = $1600	
Replace Hatchling Telemetry Transmitters @ $165 each		3 @ 165 = $495	
Refurbish Hatchling Transmitters @ $80 each		20 @ 80 = $1600	
Telemetry Antenna @ $150 each		Purchased Year One	
Telemetry Receiver @ $1000 each		"	
Nest Exclosures @ $25 each (Construct for $15)		"	
Viewing Blinds @ $100 (or Construct for $25)		"	Single Purchase, See Goal 2.
Compass		Metro	
100' Tape Measure		"	
Jon-type Boat, Motor, Transport	Metro	"	
Supplies			
Batteries & Charger	1 @ $50	Single Purchase, See Goal 1.	
Disinfectant: chlorhexidine, bleach, alcohol @ $50	1 @0-50 = $0-50	"	
5 Gallon Buckets @$0-2.50 each	10 @ 0-2.50 = $0-25.00	"	
Bait for traps @ $0-1 p/can p/day	980 @ 0-1 = $0-980	210 @ 0-1 = $210	
Attach Transmitter to Turtle @ $10 each		20 @ 10 = $200	
Radiograph Gravid Females @ $0-48 each		20 @ 0-48 = $0-960	
Photocopy Turtle Plastron @ $0-.80 each (Optional)	300 @0-.80 = $0-240	20 @ 0-.80 = $0-16	
Night Field Work			
Night Vision Scope @ $500 each		Purchased Year One	
Head Lamps @ $15 each		Purchased Year One	
Flashlights		Metro	
Night Security Guard @ $0-15 p/hr		488 hrs. @ 0-15 = $0-7320	

Smith and Bybee Turtle Study Annual Budget for Years Two through Five			
BUDGET BY GOAL (3/98)	**4. OVERWINTERING**	**5. BASKING**	**6. HABITAT USE**
Supervisor days @ $10-15,000 p/year			
management & coordination	3	7	14
field work	37	30	207
data entry and analysis	3	4	15
report preparation	5	7	15
Volunteer Days			
field work	69	150	307
data entry and analysis	3	4	15
Mileage			
Miles @ $0.315 p/mi. (50 mi rt p/person day)	3600 @ .315 = $1134	7700 @ .315 = $2426	16,100 @ .315 = $5072
REQUIRED FOR ALL SIX GOALS			
Equipment			
Cell Phones	Purchased Year One	Purchased Year One	Purchased Year One
Cell Phone Service @ $156 each annually	Single Purchase, See Goal 1	Single Purchase, See Goal 1	Single Purchase, See Goal 1
35 mm camera w/ macro	Purchased Year One	Purchased Year One	Purchased Year One
Binoculars	"	"	"
Spotting Scopes	"	"	"
Two Canoes	"	"	"
Personal Flotation Device	"	"	"
Supplies			
Clipboards, Pens, Pencils, Photocopies	Single Purchase, See Goal 1	Single Purchase, See Goal 1	Single Purchase, See Goal 1
Waterproof Paper and Notebooks	"	"	"
Aerial Photos with UTM coordinates	"	"	"
First Aid Kits	"	"	"
Film & Processing @ $15 p/roll	"	"	"
Field Uniform = Hat, T-Shirt, I.D. Badge	"	"	"
Turtle Rehabilitation $0-100	"	"	"
Miscellaneous	"	"	"
Consultant			
Training/ Monitoring Field Staff @ $0-200 p/person day	12 @ 0-200 = $0-2400	8 @ 0-200 = $0-1600	20 @ 0-200 =$4000
REQUIRED FOR FEWER THAN SIX GOALS			
Equipment			
Dip Nets @ $40	Purchased Year One		Purchased Year One
Hoop Net with 2 100' wings @ $735 each	"		"
Funnel Traps @ $100 each (or Construct for $25)	"		"
200 mm Calipers @ $148 each	"		"
Caliper=Pistol Grip Clamp+Ruler @ $15 each	"		"
5 kg Scale @ $130 each	"		"
Wind Velocity Meter @ $15		Purchased Year One	
Additional Pit Tags @ $5 each	20 @ 5 = $100		26 @ 5 = $130
Pit Tag Reader $400-625	Purchased Year One		"
Replace Adult Telemetry Transmitters @ $165 each	3 @ 165 = $495		3 @ 165 = $495
Refurbish Adult Transmitters @ $80 each	20 @ 80 = $1600		20 @ 80 = $1600
Replace Hatchling Telemetry Transmitters @ $165 each	3 @ 165 = $495		1@ 165 = $165
Refurbish Hatchling Transmitters @ $80 each	20 @ 80 = $1600		6 @ 80 = $48
Telemetry Antenna @ $150 each	Purchased Year One		single purchase, see goal1.
Telemetry Receiver @ $1000 each	"		"
Nest Exclosures @ $25 each (Construct for $15)			Purchased Year One
Viewing Blinds @ $100 (or Construct for $25)			"
Compass	"	"	"
100' Tape Measure	"	"	"
Jon-type Boat, Motor, Transport	"		"
Supplies			
Batteries & Charger	Single Purchase, See Goal 1.		Single Purchase, See Goal 1.
Disinfectant: chlorhexidine, bleach, alcohol @ $50	"		"
5 Gallon Buckets @$0-2.50 each	"		"
Bait for traps @ $0-1 p/can p/day	112 @ 0-1 = $0-112		720 @ 1 = $720
Attach Transmitter to Turtle @ $10 each	20 @ 10 = $200		20 @ 10 = $200
Radiograph Gravid Females @ $0-48 each			4 @ 0-48 = $0-192
Photocopy Turtle Plastron @ $0-.80 each (Optional)	20 @ 0-.80 = $0-16		26 @ 0-.80 = $0-20.80
Night Field Work			
Night Vision Scope @ $500 each			Purchased Year One
Head Lamps @ $15 each			"
Flashlights			"
Night Security Guard @ $0-15 p/hr			Single Purchase, see Goal 2.

Annual Timeline for Each Year of the Five Year Turtle Study

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total Person Days												
1. Demographics												
Visual Surveys & Trapping			60	60	60	60	60	60	60			
Mgmt., Data Entry & Reports			4	4	4	4	4	4	4	14		
2. Nesting												
Trapping Effort				30	60	60						
Radio Telemetry			31	30		60	122	122	30	31		
Mgmt., Data Entry & Reports			4	4	4	4	4	4	4	3	15	
3. Impacts												
Visual Surveys					16	16	20	16	20			
Experiments					4	4	4	4	4			
Mgmt., Data Entry & Reports					2	2	2	2	1	7		
4. Overwintering												
Trapping/Install Transmitters								48				
Radio Telemetry	5	5	10	9					9	10	5	5
Mgmt., Data Entry & Reports	0.5	0.5	2	2					2	1	1	5
5. Basking												
Visual Surveys			12	24	30	24	30	24	24	12		
Mgmt., Data Entry & Reports			2	2	2	2	2	2	2	1	7	
6. Habitat Use												
Trapping/Install Transmitters				30	120							
Radio Telemetry												
general population	1	1	3	2	4	4	4	4	2	2	1	1
hatchlings			31	30					30	31		
gravid females					61	61	62					
Mgmt., Data Entry & Reports	1	1	6	6	6	6	6	1	5	5	1	15
Note that labor required for each goal is not additive.												
Paid staff and volunteers can pursue one, all or a combination of goals concurrently.												
Example of Pursuing Goals 1 and 2 Concurrently												
Demographics & Nesting												
Total Days Goals 1 & 2 Separately			99	128	128	188	190	190	98	48		
Total Days Goals 1 & 2 Concurrently			79	79	64	90	125	125	79	3	20	
Days Saved—Goals Concurrent			20	49	64	98	65	65	19	45	-5	

Appendices

SUMMARY AND EVALUATION OF PAST FIELD WORK ON WESTERN PAINTED TURTLES AT SMITH AND BYBEE LAKES AND THE LOWER COLUMBIA RIVER

SUMMARY

Barclay, Elayne at Smith and Bybee Lakes in 1994 and 1995.

The focus of this research work was diet, but other information was collected as well. Capture effort was almost entirely restricted to the blind slough and ponds near Marine Drive. Fieldwork began in May 1994 and ended in August 1995. Turtles were captured over 7 consecutive day time intervals every four weeks starting in early May and ending in August. Turtles were captured using a variety of methods that included dip net, baited traps (4 in 1994 and 6 in 1995), and hand capture. The baited traps were swim-in funnel traps that were baited with sardines or salmon smolts. Traps were placed in areas where turtles had been observed basking or foraging. The traps were in place by 0800-1000 and were checked as frequently as every two hours, but not less than twice per day. Traps were removed between 1700-2000. Turtles were captured with a dip net from a boat after they resurfaced from diving away from a basking site. Hand capture of turtles consisted of slowly approaching a turtle with a boat, or by wading, until it could be grabbed. A total of 172 individuals were captured, consisting of 96 females, 59 males, and 17 juveniles. Nest sites that had been disturbed by predators were discovered in the summer of 1995. A total of 32 nest sites were recorded. Nest sites appeared to be clustered rather than randomly scattered.

Beilke, Sue at Burlington Bottoms in 1995, 1996, and 1997

Several days were spent trapping in July 1996. No turtles were caught even though traps were left out 24 hours. One gravid female was captured on land. In late July fifteen disturbed nest sites were found.

More intensive monitoring occurred in 1996. Survey and trapping effort began in March and continued through September. Visual surveys began in mid-March (turtles were basking at that time) and continued through September. Field work occurred once every week until July then once every other week. Surveys were conducted from a canoe and from land. Two people were in the field for each day of surveying or trapping effort. Trapping began in mid-April and continued through the end of September for a total of 16 trapping days. Thirty-six individuals were caught, none were hatchlings. Surveys for nests didn't start until June 1 because of high water from snow melt. All nest surveys occurred during the day. No intact nests were found, but 32 disturbed nests were located. Nest sites were clustered in two areas rather than scattered randomly.

Surveys in 1997 increased in intensity and broadened in scope. Surveys collected information on demographics, nesting and over-wintering behavior. The following explains details of the survey protocol.

Demographics:

Visual surveys along with capture/mark/recapture efforts occurred from March 15th through October 15th. Visual observations and trapping efforts occurred on a weekly basis, usually 2-3 days per week, 6-8 hours per day. The focus of

this project was in the southern half of the site, covering approximately 150 acres. A total of 120 western painted turtles were captured and marked, (this does not include the recaptures), 5 hatchlings which were captured but not marked.

Nesting Behavior:

An attempt was made to locate nesting females and nest sites, establish when nesting occurs, observe successful and unsuccessful nests, etc. Two methods were used: 1) Ten adult females were trapped and fitted with radio transmitters; this effort began in mid-April and continued through the nesting season (August 10th). The ten females were followed on a daily basis as much as possible (8-12 hours per day). 2) Visual observations on land were not conducted on a daily basis until June 15th (again because of high water) and continued through August 15th. The hours of observation were usually from 1630 until sunset. Information on location of nesting sites from 1995 and 1996 was used to decide to place one observation blind near the historical known nesting area to determine if this site was being used again in 1997, and another blind was placed on the edge of the slough which connects the two lakes on the site, since this was known to be a travel corridor for the turtles.

A total of 21 nests were located, 4 of these were destroyed by predators, the remaining were covered with wire exclosures to protect them from predators, and also to allow study of hatchling emergence later in the year or the following spring. During evening observations, females were observed in some phase of nesting a total of 60 times during 33 evenings of observations. It is impossible to determine exactly how many turtles we observed since it was known that many were repeat turtles that were seen more than once during the evening and often on consecutive evenings. The ten females fitted with transmitters were observed during the nesting process a total of 16 times, 5 times in June and 11 times in July. When possible, females were captured after they had completed the nesting process in order to mark them if they had not previously been marked, weigh and measure them, etc.

The nests located in June and July were monitored in fall starting in early September (occurring on a daily or every other day basis when possible); a total of 7 nests had activity, with hatchlings being observed in 6 of these nests, one as late as November 20th. Two hatchlings were observed on two separate occasions as they left the exclosures and moved away from the nest sites and were followed as long as possible.

Overwintering Behavior:

The 10 females that were fitted with transmitters in spring were followed in later summer through the fall and winter of 1997 to determine what habitat they were using for overwintering sites, etc. Telemetry work was conducted on a twice weekly (6-8 hrs. per day) schedule from mid-August through mid-October, then went to once per week from mid-October through November, and then once every two weeks from December through the end of February, 1998.

All of the females had moved from South Lake, where they had spent the summer, back to Horseshoe Lake by mid-August; they continued to move around the lake (e.g. moving from one side of the lake to another, a distance of several hundred feet) through mid-October, then did not appear to move at all after the middle of October. No turtles appeared to winter on land; this is not

conclusive, since one turtle "disappeared" in November and has not been relocated since.

DeLorenzo, Teresa of The Turtle Project, Northwest Ecological Research Institute. Western painted turtles released at Smith and Bybee Lakes in 1993, 1995, and 1996.

Seven turtles captured by the general public were turned over to Teresa DeLorenzo for rehabilitation. They were marked and measured and then released at the lakes in June 1996 (shell notch numbers 11-17). Other rehab turtles from unknown origins have been released at the site and have measurement records. They are numbers 39 (May 1993), 40 (May 1993), and 53-56 (June 1995).

DeLorenzo, Teresa of The Turtle Project, Northwest Ecological Research Institute. 1997. Results of preliminary surveys and interviews to determine terrestrial habitat use by western painted turtles *(Chrysemys picta bellii)* at Smith and Bybee Lakes, Marine Drive Extension Project. Unpublished report for CH2MHill September, 1997.

Visual surveys for terrestrial activity of turtles and evidence of nesting between the blind slough and ponds near Marine Drive and the Columbia River occurred from June 17th through August 11, 1997. Daily surveys occurred from July 4 through the 22nd. Surveys took place either in the early morning or early evening hours. A total of 128 hours were spent in the field. In addition to looking for signs of terrestrial activity, surveyors also recorded general field conditions, human and wildlife activity, and the presence of aquatic turtle activity in the immediate vicinity. Data was also collected on turtle activity through interviews with members of the general public using the area and employees of nearby businesses.

Two turtles were observed nesting, but their nests were subsequently destroyed. The remains of nine disturbed nests were found and mapped. No undisturbed nests were detected. Some physical characteristics of the destroyed nest sites were recorded such as, distance from water, type of substrate, and type of vegetative cover. A comparison was made between data collected at Smith and Bybee Lakes and data from Burlington Bottoms.

Engler, Joe at Ridgefield National Wildlife Refuge Complex in 1995 and 1996.

Trapping started in July 1995. River "S" Unit: July (166 trap days), August (10 trap days), September (20 trap days). Captured 20 turtles. Bachelor Island (Turtle Lake): July (67 trap days), August (18 trap days). Captured 54 individual turtles. Found 7-8 disturbed nests on the refuge complex. One of the nest sites was underwater during the floods for an undetermined period of time, but hatchlings emerged after the nest was dug up on purpose in April 1996.

Trapping effort in 1996 decreased to approximately 75% of what it had been in 1995. Trapping started at the end of April and continued until mid-August. Only 5 traps were set out per day of trapping. Data has not been summarized, but is available for analysis. A gravid female was found in the same spot as the overwintered nest that emerged in spring 1996. By the end of the 1996 trapping

season, a total of 110 individuals had been marked in the refuge complex. The majority of marked turtles (60) were from Turtle Lake on Bachelor Island.

No trapping was done in 1997. Note: ten hoop traps may be available to borrow from Ridgefield in 1998.

Gaddis, Phillip K. 1985. Final report: Distribution and ecology of native turtles. Unpublished report, Oregon Department Fish and Wildlife.

Field work was done in 1985 starting in early May and continuing through early July, mostly on Sauvie Island. Fifty person-days were spent surveying for turtles and 28 person-days were spent studying population structure and movements on the Pope Lake Unit of Sauvie Island. An undetermined "remainder" of time was spent surveying for the presence of turtles at other locations on Sauvie Island, in the Tualatin River Valley, at Oaks Bottom Park, and in the sloughs and ponds along the Columbia River from Smith and Bybee Lakes (only one day was spent) to the Troutdale airport.

Survey technique:

Area was scanned with binoculars or 20x scope from shore and/or canoe. The following information was recorded: the water temperature and the number and species of turtle observed, the number of basking logs, and the abundance of snails and bullfrogs. Surveys were done on sunny days.

Trapping:

All trapping was done in the Pope Lake Unit or Steelman Lake on Sauvie Island. Thirteen turtles were caught and marked. Captured turtles were shell notched (need to find out the numbers and system used) and numbers were painted on the carapace. Five wire mesh funnel traps were used for a total of 234 trap days. Two floating oil drum traps were used for 32 trap days. Several basking traps were used on three occasions. Twenty-one individuals were captured.

Results:

Turtles appeared to be abundant where critical habitat features were present: abundant basking sites, heavy growth of submerged aquatic macrophytes, abundant snails, and water with no current and at least one meter deep. Exotic turtle species were present. Turtles stayed within 50-100m radius areaon a day-to-day basis between longer distance moves. Major shifts in location occurred with changes in water level. Turtles were observed moving up to 1/4 mile in less than 4 hours. The population appeared to be made up almost entirely of individuals at least 10 years old.

Hayes, Marc at Smith and Bybee Lakes in 1993.

Field work occurred from March-July. Seven rectangular funnel bait traps were used once (May 10, 1993) in the ponds near Marine Drive. No turtles were captured. Aquatic areas were surveyed visually during the day, the area was scanned with binoculars or scope to find turtles. Surveying occurred twice a month from March 1993- July 1993. In April and May surveys were 3 times a month with 2-4 observers. Turtles were first observed in early April. There were 368 sightings of turtles. Over 70% of the turtles were observed in the ponds and the blind slough near Marine Drive. Other locations where turtles were seen include the Columbia slough, North Canal, and the outflow near the control structure.

The blind slough area was also surveyed by swimming. One day in April and one day in May were spent with 2 or 3 people who conducted two swim surveys of the length of the channel. Turtles were captured if possible. Eighteen turtles were captured, measured and marked with shell notch numbers 12-28, 30. One hatchling was caught.

Holland, Dan. 1994. The western pond turtle: habitat and history, final report. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Sightings of western painted turtles were recorded if observed during surveys for pond turtles. Visual surveys for western pond turtles were conducted throughout the Willamette Valley drainage using binoculars and spotting scopes. Holland began surveys in the Willamette Valley in 1987 and continued through 1989. More surveys were conducted in 1991 and 1992. Some surveyed sites were in the lower Willamette and Columbia Rivers.

EVALUATION

There are no published accounts in the literature of field work done on the western painted turtle in the lower Columbia River. Most of the field work that has been done in the lower Columbia has been unsystematic or sporadic, but nevertheless, has yielded some important information.

1. The work at Ridgefield has shown that hatchlings of the western painted turtle in the Pacific Northwest can overwinter in the nest and can survive being flooded for a brief time.
2. Observations at Burlington Bottoms have shown that hatchlings can also emerge from the nest in the same year they are laid as well as the following spring.
3. Preliminary data from Burlington Bottoms indicate that painted turtles in the Pacific Northwest probably overwinter underwater, as do painted turtles in the East, rather than in terrestrial habitat, as do pond turtles. They may move to a site different from their summer location. To date, only reproductively active females have been followed to their over-wintering sites.
4. Observations at Ridgefield, Smith and Bybee Lakes, and Burlington Bottoms indicate that females probably reuse specific nesting areas. Nest sites appear to be clustered rather than random.
5. The study by Barclay, focused on diet, indicates that turtles are taking advantage of the food resources found exclusively in the blind slough and ponds near Marine Drive and that certain periods of the summer are more important for foraging than others.
6. The wide range of ages and presence of juveniles at Smith and Bybee Lakes appear to indicate that there is recruitment into the population, but a clear picture of the demographics of the turtle population within the management area needs systematic trapping over several years to establish.
7. Studies at Ridgefield, Burlington Bottoms and Smith and Bybee Lakes show that trapping is a reliable method of capturing turtles and gives an idea of the trapping effort required for a comprehensive study.
8. Studies at Smith and Bybee Lakes have resulted in a good preliminary data base of known individuals with measurements, photographs, etc.
9. The surveys done by Hayes established the blind slough and ponds as a site of dense turtle activity at Smith and Bybee Lakes and found the first evidence of successful breeding with the capture of a hatchling turtle.
10. The DeLorenzo surveys at Smith and Bybee Lakes and the Beilke work at Burlington seem to indicate that turtle nesting activity is occurring during the evening hours and the greatest activity occurs before July.
11. The presence of dead and sick turtles observed by Barclay and DeLorenzo at Smith and Bybee Lakes indicate a need to monitor the health of the population.

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RESEARCH TECHNIQUES

Reference	Focus of Study	Site Information	Methods	Statistics Used	Radiotagging Information
Balcombe and Licht, 1987	Ecology, 5 year study	1,000 ha site	Hand-net from boat and shore. Shell notched. Nesting females captured only after they finished nesting. Captured 437 individuals, recaptured 46, two weeks to 4 years later.		
Bennett, et al., 1970	Terrestrial activity of 3 species of aquatic turtle (no painted)	Ellington Bay on Savannah River Plant, 10 ha	Collected in pitfall traps along drift fences. Numbers were painted on their back.		Radioactive pins placed in holes drilled in carapace and cemented in place. Relocated using portable beta-gamma survey meter.
Bider and Hoek, 1971	Sampling techniques for turtle population studies	0.4 ha pond 3 feet deep	Annual spring census of population for six years used cold-water hand collecting. Censused immediately after ice melt and before May 1. Turtles easily caught as they emerged from hibernation before they began to bask. Used a blind to approach turtles. 3'x4'x2" piece of Styrofoam with 2' square removed from one side. The U-shaped float was disguised with clumps of aquatic vegetation. It took about 3 hours to collect plants and build blind. Using a long handled net the collector waded up to turtles and netted them or caught them by hand. Turtles shell notched and kept in a tank until the census was completed. Blind tripled the proportion of population captured versus muddling and hand capture without the blind. Technique does not bias the sample for age or sex. Capture rate of 5-6.5 per man-hour.	Lincoln Index used to estimate population size	
Buhlmann and Vaughan, 1991	Ecology of *Pseudemys concinna*	3 pools along 78km stretch of New River Gorge National River	July-August turtles were captured using basking traps constructed from chicken wire and attached to lower sides of basking logs. Also used a fyke net trap. Turtles were shell notched for identification. Also marked turtles with two 3.3 cm diameter Petersen disc tags (Floy Tag Mfg. Seattle, WA). Tags were attached one on each side of the 9th or 10th marginal scute by drilling one hole through which galvinized wire was passed. Tag colors were unique for each study site and between the sexes. Observed basking tagged turtles to calculate marked to total ratios and determine movement between study sites. Differences in basking frequency between the sexes was calculated.	Schnabel and Lincoln-Petersen population estimators.	One adult of each sex was radio-tagged from Oct.13 1984 to July 15 1985 to locate hibernacula and determine patterns of movement. Used 75g transmitters (Telonics, Mesa, Arizona) attached to the posterior left carapace by drilling two holes through which galvanized wire was passed. Clear rubber silicone was used to further secure the transmitters and conform to shell shape to prevent entanglement

Cagle, 1950	Life history of slider		Trapping was the most productive method. Used hoop nets, box traps, and basking traps. Hoop nets most satisfactory for collecting. Box trap of wooden frames used in shallow (8" to 1') water. Basking traps (square wooden frame with a net or wire bag suspended from it, inner edges of wood frame covered with inclined pieces of sheet metal which prevented turtles from climbing out) used only when not possible to check traps regularly. Could remain in traps for long periods because food and air available. Found trapping results influenced by water temperature, availability of food, water turbidity, and phase of activity cycle. Results vary with trap location, bait, type of trap, and time of day the trapping period includes. Hard to trap systematically because of all these variables. Hand collecting necessary to supplement because traps did not capture hatchlings to one year olds. Captured by wading through shallow water in early spring and watching for disturbance of water surface as heads withdrawn. Field observations from 20' towers built in shallow water to observe basking, feeding, courtship, and terretorialism. Also had observation shelters on the shore. Marked with shell notches and small juveniles also toe clipped to aid identification.		
Christiansen and Bider, 1986	Reproductive ecology	0.4 ha pond	As soon as ice melts in spring a majority of the 120 individually marked turtles were caught with a dip net from a boat. At end of May all females over 4 years of age were recaptured and x-rayed. After nesting, females were captured and the transmitter removed and x-rayed to see if all eggs deposited. Her carapace marked with red paint for identification later. Turtles recaptured at seven day intervals and x-rayed to determine the presence of a second clutch.		Each gravid female was fitted with a plastic cap containing a radio transmitter and tracked until she nested.

2.

Christiansen and Bider, 1987	Nesting activity and hatchling success for 3 summers	0.4 ha pond	By hand or dipnet. All females over 4 years old x-rayed		Radio transmitter attached with wire to holes in marginal scutes. The 18 radio-tagged females were followed until nesting occurred, then transmitter relocated to another gravid female. Only one of transmitters failed in 3 summers.
Clark and Gibbons, 1969	Diet of *Pseudemys scripta*	Two farm ponds on Savannah River Plant, 0.8-1.2 ha each	Most of turtles were collected in baited swim-in traps or by hand. The swim-in traps were not successful in capturing 1 and 2 year old turtles, most of these were collected by hand or with dip-nets from a boat. A basking trap caught a few small turtles. Traps were checked daily.		
Congdon et al., 1992	Habitat use	University of Michigan's E.S. George Reserve, 4 ha of water deep enough to trap, 1.5 ha of seasonally inundated habitat	Intensive aquatic trapping started in early May and continued through mid-Sept. from 1977-1986. Traps were either 80,120, or 140 cm in diameter and consisted of 3 metal hoops overlain with 3.9cm webbing which formed a funnel opening at one end. All sizes and types of traps caught all turtles except hatchlings. 55 traps baited with fish or whole kernel corn. Trap locations were changed at 2 week intervals. Each year 10 unbaited fyke (10m long V-shaped wings made of 3.9cm mesh netting suspended between floats and sinkers and attached directly to bait traps) and 15 drift traps (15m of netting suspended between floats and sinkers that were stretched between stakes to make an aquatic drift fence with unbaited traps at each end) were also placed in the marsh and remained there for the summer. A grid system was established over the study site in an X, Y array, (117 stakes, every 8m).		

Congdon and Gatten Jr, 1989	Movements and energetics of nesting	E.S. George Reserve	Long-term study found females by surrounding study site with drift fences. Physically followed the nesting turtles through the nesting process.		
Congdon and Tinkle, 1982	Reproductive energetics		Used x-ray techniques to determine number and size of eggs of marked turtles for a 4 year period to explore the relationship of egg size and number to body size of females and of egg size to clutch size, as well as variation of reproductive output among clutches within and among years.		
Davis and Sartor, 1975	Observing aquatic turtles		Observed aquatic movements of turtles by placing a 1/8" diameter dowel in the nucal scute. A hole in the scute was made with a drill and dowel secured with epoxy. Maximum length of dowel 50 cm for largest turtles. Color coded end of poles with paint or flagging for individual identification. Movement hindered in heavy vegetation. Helped by connecting two short dowels with a piece of rubber tubing to make more flexible.		
DePari, 1996	Overwintering of hatchlings	5,500 ha swamp in the 2,781 ha Great Swamp National Wildlife Refuge	Natural nests located by direct observation of nesting females. Nests covered with 1.3cm wire mesh screening to prevent predation and hatchling escape. Nests were checked regularly (hatchlings were subsequently killed).		
Ernst, 1972	Temperature-activity relationships	White Oak Bird Sanctuary	Captured in hoopnets with a dip net, by hand, or by muddling. Marked by shell notching. Observations were made at varying times and durations with 7x50 binoculars or by sitting motionless behind bushes along a raised bank of the study site. Taylor min-max thermometers were installed at a depth of 1m in the pond and at ground surface in the surrounding woods. Readings were taken 2x/month.		
Ernst, 1987	Growth	White Oak Bird Sanctuary	Turtles were captured in hoopnets with a dip net, by hand, or by muddling. Marked by shell notching. 929 turtles caught.		

Frazer, 1990	Turtle trapping	Sheriff's Marsh, 30 ha grass-sedge, 5.6 ha open water	Used 60 traps. Found turtles escaped from baited hoopnet traps much more frequently than expected. Over 24 hour period 16 out of 20 escaped. Found significantly more turtles caught in traps that already had a turtle in them than those that didn't.		
Frazer et al., 1990	Growth rate	same as above	Turtles were captured with baited hoop net traps or dip nets from a boat. Marked with shell notches or drilled holes in marginal scutes. One to two intensive trapping trips of about one week in summer and early fall.		
Feuer, 1980	Trap design		Describes two types of traps their advantages and disadvantages and explains how to build them and use them.		
Gibbons, 1968	Population structure	Sheriff's Marsh, 30 ha grass-sedge, 5.6 ha open water Study sites were 1.6 km of winding channel and extensions, a 2.2 ha lake, and a 0.4 ha pond.	Five capture techniques were used. Most effective was looking for turtles in the water from a boat and capturing with net or by hand. 13 funnel traps of 3" wire mesh attached to underwater drift fence 6 feet long and 2 feet high. Most traps never moved from original location, restricted to use in shallow water. Several baited funnel traps used also. Underwater diving was extremely successful under certain circumstances. Dry suit, fins, underwater face mask and a snorkel used, best in spring and fall when water clarity high and vegetation minimal. Attempts to muddle for turtles not successful at capturing much. Captured 1,010 from July 1964- Oct 1966. 408 recaptures of 258 marked individuals.	Lincoln Index used to estimate numbers in each age, sex, and size class. Based on six collection periods (April-May 1965, June-July 1965, Aug-Oct. 1965, March-May 1966, June-July 1966, Aug-Oct 1966).	
Gibbons, 1969a	Ecology and population dynamic of *Deirochelys reticularia*	Ellington Bay Savannah River Plant, government reserve. Surface area of study site 10 ha	Collected with terrestrial traps and swim-in traps made of chicken wire from July 1967-Sept.1968. Marked on marginal plates. Terrestrial activity was determined by the use of drift fences and pitfall traps encircling 41% of the periphery of the site constructed of chicken wire. 20l buckets buried at 10m intervals, one on each side of the fence. Some hatchlings were caught in the pitfall traps even though they could fit through the mesh of the drift fence. Preserved specimens from two museum collections were dissected to determine size at maturity and to gather information on reproductive potential and cycles.		
Gibbons, 1969b	Terrestrial activity and population structure of 6 species of aquatic turtle (none painted)	Same as above	Drift fence in place winter 1967 to 1968 (same procedure as above). First turtle captured March 11, traps checked daily afterward.		

Gibbons and Greene, 1979	X-ray photography		Technique is 100% accurate for determining clutch sizes. Procedure can be performed using any stationary or portable x-ray machine. X-rayed using non-screened cardboard cassettes at 200mA and 70 kV peak for 0.7 s at a distance of 1 meter.		
Hart, 1983	Diet and habitat of *Pseudemys scripta*	Bayou flows for 10km through swamp, max. depth 5m.	Collected between Sept.1976-Sept.1978 in all months but January. Captured in funnel traps baited with fresh fish. Traps placed on the bottom in early morning and checked again in evening.		
Iverson, 1979	Trap design		Funnel trap design using chicken wire. Detailed instructions.		
Janzen, 1994	Effect of nest habitat on sex of hatchling	40 ha island in Mississippi River	Four year study found natural nests by daily surveying of nesting habitat from late May through early July. Drift fences affected females migrating to nest. When encountered on way to nest, females walked along them until they entered wire mesh funnel trap, turned and nested inside the fence, or dropped into a pitfall trap. Decided not to use drift fences because of these effects..		Radiotransmitter attached with silicon sealant to one random female as she laid her first clutch of the year and removed July 4th after she laid her 3rd clutch.
Lefevre and Brooks, 1995	Effect of body size and sex on basking behavior	1.7 ha bog	Nineteen day study. Captured using canoes and dipnets from May 2-June 5, hoop traps baited with fish from June 2-June 13, and hand-capture of nesting females from June 14-July 5. Turtles were shell notched and adults were fitted with numbered metal tags. Alpa-numeric code were painted on backs of adult turtles to allow identification during basking observations. Males different color paint than females, juveniles used only two digits and smaller sized numbers. Surveyed basking turtles every hour from 0800-1900 between July 6-Aug.1. Embankment divided into 10m intervals. Recorded daily min-max water temperature 10cm and 0.5m below the surface. Extremes in daily air temperature recorded with a multichannel, digital data logger.		
Legler, 1954	Nesting		Nesting habits studied by obtaining turtles from the water by dipnets and basking traps and picked up by hand near nesting sites.		

Legler, 1960	Trap design		Detailed instructions for building hoop net funnel traps.		
Lindeman, 1990a	Effect of drought	Turnbull National Wildlife Refuge, 3 waste water lagoons and a natural lake, total surface area was 1.6 ha at both sites.	Primary capture methods were dipnet, basking trap, and seining. Compared population size between 1987 and 1989 with seven weekly sampling periods from June-July 1989 to generate 6 Lincoln-Petersen estimates of population size. For each estimate, only the preceeding sampling occasion was used as a pre-censusing period to avoid violation of the closure assumption and inflated estimates.	Lincoln-Petersen population estimate	
Lindeman, 1990b	Explores 2 assumptions often violated in population estimates of turtles in mark/recapture studies (closed population model and equal probability of capture)	Same as above	Same as above. The Schnabel and two sample Lincoln-Petersen method are valid only if assumptions are not violated. The assumption of closure is probably violated for any estimate calculated using data collected over several weeks or months and especially if from more than one active season. He recommends the model of Jolly and Seber since it is intended for use in an open population and can be used to estimate birth plus immigra- tion and death plus emigration as well as estimating population size. Mark-recapture data from two populations used to estimate population size by using data from short-term intensive samples of each population during July, 1987, in closed population estimates, and by using all data collected throughout 1986-1987 field seasons in Jolly-Seber estimates. Assumption of equal catchability was tested for each of the two long-term data sets. Sampling occurred on 7 different occasions, each no more than 5 days in length, between early May and mid-Aug.1987. Sampling limitations may prevent a researcher from collecting an adequate amount of recapture data over a short period of time when working with turtle populations, resulting in an estimate with a large standard error and a wide confidence interval.	Schnabel and two sample Lincoln-Petersen method tested. Recommends the model of Jolly and Seber. Equal catchability was tested.	
Lindeman, 1996	Life history in Pacific Northwest	Same as above	Primary capture methods were dipnet, basking trap, and seining.	Tested equal capture probability.	

MacCulloch, 1978	Basking trap design		Design of a basking trap used successfully in Lindeman study. Cheap and simple.		
MacCulloch and Secoy, 1983a	Movement	15.5km stretch of river, width from 7-20m, depth 2m, aquatic vegetation scarce or absent, basking sites plentiful. Stretch of river divided into 31 sections 500m each.	Trapping 4-6 times per week May-August and weekly Sept.-Oct.1978 and 1979. Covered entire area twice with motorboat. Turtles captured by hand or in basking traps.		
MacCulloch and Secoy, 1983b	Demography, growth, and diet	Same as above with addition of series of oxbows at a golf course	Same procedures as above, but added baited traps in 1981. 152 turtles captured in 3 years of study.	Population size estimated by the modified Schnabel multiple recapture method.	
McAuliffe, 1978	Seasonal migration movements	Oxbow of river divided into 6 major areas by man-made or natural features, total of 8.5 ha of surface water in spring, decreased to 1 ha in dry summers	Two year mark-recapture study using baited hoop traps, muddling, dip-netting, and hand capture techniques to establish movements. Adults were given individual markings by drilling holes in marginal scutes. Juveniles were notched. Hatchlings were toe clipped to identify them. *Intensive trapping*: 20 traps within a 0.4 km section of river for one day.	Estimated population size using Lincoln Index.	
Mitchell, 1985	Female reproductive cycle and life history	4 ha lake	Collected monthly in 1980 and 1981 with sardine-baited funnel traps. Some captured by hand and with dipnet.		

Mitchell, 1988	Population ecology and life history	Most of study area is located in a closed golf course. Area classified as urban, open to shoreline fishing and surrounding area used for recreational activities.	Censused population starting May 1979-Oct.1981 in all months except Jan. Most turtles caught in funnel traps baited with fish. Traps checked twice daily except for early spring and late fall when checked every other day. Supplemented with hand and net captures. Tried basking trap, but not successful.	Differences in catchability due to behaviors related to age and sex tested with the conditional probability of capture method. Capture frequencies for each age and sex group were tested against the Poisson distribution to determine if they were random. The use of Bailey's triple catch equations to estimate population size avoids much of assumption violation risks. Method requires the identification of three capture periods and assumes that each turtle has an equal and random chance of being caught in each year. Provides the most unbiased use of capture data to estimate population size.	
Parmenter, 1980	Feeding ecology	1,200 ha reservoir near nuclear reactor, and a 7 ha site, both with lots of aquatic vegetation and little open water, third site 3 ha farm pond, no aquatic veg.	Baited funnel traps and drift fence. Traps inspected twice/day		

Petokas and Alexander, 1979	Basking trap design		Describes the construction of basking trap used for painted turtles. It retains most turtles entering it.		
Rathbun et al., 1992	Nesting behavior and movement of *Clemmys marmorata*	6.2 km long arroyo 6-12 m wide	Captured, x-rayed, radio-tagged, and marked 4 turtles with a large number painted on carapace with white nail polish. Rarely could not find turtles during radio-searches.		Cedar Creek Bioelectronics Laboratory 164 MHz radio transmitters. Each unit with an attenae was encased in epoxy and attached to turtles with 5-minute epoxy near the midline of the third vertebral shield. Units were 10 grams, dental acrylic used to contour them to carapace. Battery life 60 days. All transmitters dead by August.
Ream and Ream, 1966	Comparison of trapping methods	Site 17.84 ha with dense vegetation	Sept.1960-Oct.1962 used 5 methods to capture the maximum number of turtles. Baited funnel traps, hand/net capture, three types of basking traps. Turtles attracted by other individuals on basking sites or in traps. Observations from tower in cattail marsh suggested attracted to sites already occupied by others. Best results combination of basking trap and hand capture (4 turtles caught in basking trap for every 1 by hand). Radio-located at least 4 times per week. and 0-49 times per day. Air and water temperature and weather conditions recorded at each relocation. Reproductive status monitored by palpation. Daily activity was obtained from direct observation, trapping records, and radiotelemetry		
Rowe and Moll, 1991	Activity and movements of *Emydoidea blandingi*	Chain of Lakes State Park, Fox River site (5 ponds, 125 ha) and Pentapond site (25 ha)	Daily activity investigations from May 12-Aug. 23. Turtles were captured using baited hoopnet traps and by hand. Traps were checked four times each day between specific time periods. Air and water temperatures and weather conditions recorded during each trap check. Turtles marked with notches in marginal scutes.		Single-stage radiotransmitters (Custom Electronics) on 12 turtles (6.5.1). Transmitters enclosed in paraffin or beeswax, encased in dental acrylic, and wired to the rear of the carapace.

Schwarzkopf and Brooks, 1985	Basking behavior	1.7 ha bog	Caught in dip nets and in basking traps and marked with numbered metal tags wired through holes drilled in rear marginal scutes. Tags could be read at 60m. Recorded extremes in water and air temperature with min-max thermometers. Water surface temperature recorded every hour using Omega Engineering model 650 type-T thermocouple thermometer attached to block of wood floating at surface.		
Scribner et al., 1993	Female reproductive success	E.S. George Reserve (565ha), 3 sites: East Marsh (4 ha), SW Swamp (7.3 ha), Cattail Marsh (3.2 ha)	Most females and some males were captured during the nesting season at drift fences that completely or partially surrounded each study site or during intensive searches of nesting areas each day of nesting season. Hatchlings captured as they left nest found by observing nesting females. Also captured with hoop net traps or basking traps. Marginal scutes of carapace notched.		
Sexton, 1959	Spatial and temporal movements	Five bodies of water within the E.S. George Reserve	Attempted to capture every turtle in population by using baited funnel traps, basking traps, terrestrial drift fence, muddling, dip net, seining. Attempted to thoroughly net each pond within a 3-4 day period. 878 caught between March 1953 to Sept.1957.		
Snow, 1980	Second clutch frequency	100 ha	58 Females located by physical search of nesting sites and captured by hand. Individually marked with fingernail polish numbering of carapace.		
Snow, 1982	Nest predation	Same as above	Nests found by searching nesting areas for females.		
St. Clair, et al., 1994	Growth and maturation	6 kettle lakes	Captured turtles by snorkling or from canoe with dipnet. Marked with filed notches in marginal scutes.		

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Stone et al., 1993	Temporal changes	2 man-made ponds, 1.6 ha and 1.4 ha	Drift fence with pitfall traps constructed completely surrounded one study site (#10 cans on both sides of fence at 10m intervals). Fence 20cm tall made of aluminum stapled at 3m intervals to wooden stakes. Traps checked daily from Sept.1 1972 to March 31 1974. From Aug. 31 1988 to May 5 1990 traps were checked daily, from March to Nov. and at least every third day from Dec. to Feb. Aquatic funnel trap stations were established around the margins of each pond at approximately 10m intervals. Trapping from spring-fall. Traps checked daily usually. Data showed that a trap will catch the same number of turtles if checked the day after setting or on some succeeding day. Pitfall traps biased toward hatchlings and gravid females. Several species captured with painted being one of them. Turtles marked by filing notches in marginal scutes.		
Thornhill, 1982	Comparative reproduction	Lake Baldwin 817 ha, oxbow of Dry Lake 1.6 ha, Diewald's Lake 0.8 ha	Turtles caught by hand, hoop, and trammel nets every two weeks. Traps checked twice per day. Marked with notches in marginal scutes.		
Tinkle et al., 1981	Nesting frequency and success	E.S. George Reserve, 565 ha	Traps, drift fences, and hand capture. Movements among aquatic habitats monitored by trapping and intercepting at drift fences during overland movement. Fences adjacent to known nesting areas. Females palpated and if gravid, x-rayed, provided most of the information on clutch size. Checked all known nesting grounds several time per day. Found nests marked with numbered stake a standard distance and direction from nest. In fall erected low fences 15cm high and 1.2m in diameter around each nest.		
Wilbur, 1974	Population estimates		Most successful method of capture was with a net from a boat. Also used muddling and baited funnel traps. A 115m drift fence of chicken wire erected with 20 pitfall traps.	Analysis of mark-recapture model assumptions from a population study of painted turtles.	
Wilbur, 1975	Demography		Same as above.	Bailey's triple-capture method to estimate population size.	

Zweifel, 1989	Ecology		Most captures were made with baited funnel traps as well as by hand and dip net. Several traps in one pond for a number of days, generally until no new captures, then transferred to another pond. Larger turtles were drilled with an electric drill for permanent marks, smaller turtles notched.		

Timing of Nesting

Author, Year, Location	Time of Year	Time of Day
Balcombe and Licht, 1987 Ontario	June 7 - June 23, June 12 - July 3	
Christens and Bider, 1987 Quebec	Nesting season 20 - 34 days	Tendency to nest in late afternoon and evening. '83 average start time:1920 (range 1700-2030), '84 average start time:1700 (range 1500-1945), '85 average start time:1754 (range 1530-1920). During 3 years of study, only one nested in morning.
Congdon and Gatten, 1989 Michigan	Mid-to-late-May through early July	24% before noon, 76% after noon (1700-1900), peaked between 1600-1800. Mostly complete before dark.
Ernst, 1971 Pennsylvannia	June 5 - July 14	
Gemmell, 1970 Minnesota	June 9 - July 14	
Holland,1937 British Columbia		late afternoon or evening
Iverson and Smith, 1993 Nebraska	31 May - 5 July, 19 May - 3 July, 21 April -14 June, 6 June - 11 July, 5 April - 21 July, 3 April -10 July, 13 June - 12 July, 31 March - 10 July	1600 to dark, never observed to nest at other times
Janzen, 1994, Illinois	Only in June (n=303)	
Legler, 1954, Minnesota	Earliest nesting observed June 16 and as late as July 14, reported by others as June 1 to July 28	Most females captured on land in evening between 1700 - 1800, none observed in early morning. None observed to nest when raining heavily.
Lindeman, 1992 Idaho	Late May to early July	Located nesting females by searching grassy areas around ponds in evening
MacCulloch and Secoy, 1983 Saskatchewan	Late June to early July	
Mahmoud, 1968 Wisconsin	.	1600 to 2300 or between 0500 and 0900
Mitchell, 1985 Virginia	First clutch laid mid-to-late May and second about 3 - 4 weeks later	
Mitchell, 1988 Virginia urban lake	May 30 - July 13	Of 6 females observed nesting, 4 nested at dusk and two in early morning
Ratterman and Ackerman, 1989 Iowa	Late May and early June, searched along roads and in fields near open water	
Schwarzkopf and Brooks, 1986 Ontario	June 14 - July 12 and June 9 - July 11	Area monitored for nesting females and completed nests morning and evening

Snow, 1982 Michigan	Early June to mid-July, 50% of turtles nested before June 18	Searched for nests from 1800 - 2200 through direct observation
Tinkle et al, 1981 Michigan	30 days from late May to late June.	Found that some turtles nested in morning rather than the usual late afternoon hours

Nesting Habits

Author, Year, Location	Site Fidelity	Clutch Frequency	Other
Christens and Bider, 1987 Quebec	Number of females exhibiting site fidelity increased from '83 - '85. 8 females that nested more than once per year from '83 - '84 showed fidelity for a particular direction from pond. From '84 - '85, 8 of 11 exhibited nest-site fidelity. From '83 - '85, several females traveled long distances to nest within 10m of their previous site.		
Iverson and Smith, 1993 Nebraska wildlife refuge		Confirmed three clutches in one year	Females very wary of humans and would leave nest site if they observed a human as far as 60m away. Observer effects precluded patrolling area for fear of altering nesting patterns (after disturbance by human during initial nesting attempt, several days later nested on opposite side of lake, 595m from disturbance).
Janzen, 1994 Illinois			66% of nests produced hatchlings of only one sex. Higher proportion of all male nests on beach exposed to more wind
Lindeman, 1992 Idaho	Second clutch in same year observed 4 times. All pairs of nests closely situated. Females from different years tended to nest near sites of previous nests (12.5m and 3.5m from previous nests). Females occupied areas away from preferred nesting sites,	Double clutching observed 4 times	

	discounting the possibility that they merely nested adjacent to limited home ranges.		
MacCulloch and Secoy, 1983 Saskatchewan	Females nested within a few meters of one another		
Schwarzkopf and Brooks, 1986 Ontario		52.8% of observed sample of mature females laid one clutch and 11.8% laid two in first year of study. 72.7% laid one clutch and 13.1% laid two clutches in following year. 50.9% of observed sample of mature females reproduced in two consecutive years for first year of study and 42.6% in second year. Nesting twice in one year did not seem to effect the tendency to nest the preceding or following years.	
Schwarzkopf and Brooks, 1987 Ontario	No significant difference between mean distance of successive nests of same individual and distance between random pairs of nests in same year.		Nest distribution was clumped. Slope had significant effect on % males produced.
Snow, 1980 Michigan		33% laid a second clutch	
Tinkle et al, 1981 Michigan		Observed nests never exceeded 50% of the # of reproductive females. 3.9% double clutched	Estimate total # of constructed nests with formula: T + X where $\frac{\text{\# observed nests destroyed}}{\text{total \# of observed nests (T)}} = \frac{\text{\# unobserved nests destroyed}}{\text{total \# of unobserved nests (X)}}$
Vogt and Bull, 1982 Wisconsin	Nesting at precise site of hatching has disadvantage that sex-ratio would often become female-biased. Also possibility of disturbing nests of close relatives (reduce inclusive fitness) or earlier clutch of same female.		

Nest Site Characteristics

Author, Year, Location	Distance from Water	Soil	Vegetation	Slope
Balcombe and Licht, 1987 Ontario			Nesting area mowed grass	
Christens and Bider, 1987 Quebec	Some females traveled long distances to find suitable nest sites (328m through tall grass and uneven terrain). 16 nests from first year ranged 1.1 - 328.1m, mean: 89.4m, second year, 17 nests ranged 16.2 - 617.5m, mean: 82.1m, third year 18 nests ranged 18.6 - 620.5m.	Nests predominantly in clay soil. Out of 51 nests, 37 in clay, 8 in loam, 4 in sand, and 2 in undifferentiated fill material. Clay preferred, but also proportional to distribution of soil types in area. Mortality higher in loam and undifferentiated soil than clay.	Constructed on bare earth in open, never under canopy of vegetation, but vegetation did grow over some of nests later in season	
Congdon and Gatten, 1989 Michigan	185 nests, mean distance: 60m range 1 - 164 m			
DePari, 1996 New Jersey		Silt/clay loam; silt/clay loam mixed with gravel; and sand. Plugs formed in soil with clay, no plug in sand. 93.1% nests in silt/clay loam or silt/clay loam with gravel, 5.2% in sand, 1.7% "other". Hatchlings from nests in sand were significantly smaller (plastron length and weight) than those from soil or soil mixed with gravel. Sand nests more likely to emerge in fall than hatchlings from soil nests.		

Gemmell, 1970 Minnesota		Low moisture content of sandy soils may cause desiccation of eggs	Used garden beds, cultivated fields, and shoulders of dirt roads	
Holland, 1937 British Columbia	10 - 30 yards from water	Favorite substrate coarse sandy soil. Actual site of nest difficult to determine even after watching its formation.		Usually in a south-facing sloping bank
Janzen, 1994 Illinois		Moist loam	Level grassy areas. More highly male biased sex ratios were produced in nests with more vegetation cover than nests with less.	
Legler, 1954 Minnesota	Distance to water for 16 nests: 52, 49, 48, 46, 44, 44, 44, 43, 43, 41, 39, 33, 26, 26, 25, 23 yards. Others within 1 yard to 250 yards. Females searching for nest site caught crossing road more than 500 yards from water	Nest sites identified by characteristic caps of hard earth. Nest mostly in clay soil in preference to black loam soil nearby.	Most sites exposed to direct sunlight most of day, never under canopy of vegetation or in forested areas	
Lindeman, 1991 Idaho			All nests constructed on patches of bare ground amid grasses and other herbaceous vegetation	
Lindeman, 1992 Idaho				Preferentially selected sites for egg deposition on south-facing slopes
MacCulloch and Secoy, 1983 Saskatchewan	Five nests about 5 meters from water	Man-made bank constructed of sand and clay. All nests in clay.	Grassy	Slope facing south-southeast, gradient approximately 30 degrees
Mahmoud, 1968 Wisconsin	20 - 500 feet	Soil types selected were sandy, loamy, clay, or loose gravel	Used a variety of habitats for nesting (shrubby fields, floodplains, open beaches, roadsides, gravel or soil roads, and pastures). Always	

			accessible to direct sunlight. Females covered and filled nest opening with grass and twigs obtained from immediate surroundings.	
Mitchell, 1988 Virginia urban lake			14 out of 15 nests were in open, away from canopy cover.	
Ratterman and Ackerman, 1989 Iowa	1 - 500 m, most over 100 m	Nests found in sand, sandy loam, loam, and clay/loam soils		
Schwarzkopf and Brooks, 1987 Ontario		Nested in open sandy or sandy gravel where soil temperatures warmer than vegetated areas		Significantly more nests on slopes than randomly selected sites. Slope had significant effect on % males produced.
Snow, 1982 Michigan		Roadside ditches and barrow pits along with roads commonly used for nesting		

Nest Predation

Author, Year, Location	Predator	Degree of Predation	Distance from Edge	Time after Deposition
Christens and Bider, 1987 Quebec	Raccoon thought to be responsible. All disturbed nests had eggs scooped out with no egg shells scattered about, giving impression of false nest. Burger (77)* reports raccoon holes are circular to rectangular in shape with dirt piled all around and no trace of shells. When skunk seen in vicinity, shells scattered about.	43.8% of known nests destroyed (n = 16)	100% of nests within 30m of water were disturbed (n = 4) as opposed to 25% of nests more than 30m away from water.	All but one preyed upon on same night they were laid. One 32 days later.
Gemmell, 1970 Minnesota			High predation on nests along shoulder of roads, low in cultivated fields.	
Legler, 1954 Minnesota			Nests closer to water preyed upon more frequently than those further inland.	
Snow, 1982 Michigan	Skunk 59%, raccoon 10%, fox 10%, chipmunk 12%, unknown 8%. Chipmunks carried away eggs before eating them. Visits from predators more frequent after June 18. Predators foraging economically may allocate all available time to areas of greatest nest abundance (spend more time searching in areas where they had previously found nests).	55% nests.		All within 72 hours.
Temple, 1987 (species NOT *Chrysemys picta*)	Skunks, raccoons, and opossum tracks found. Coyote, red fox, and dogs also present.	64% of known nests (n=22)	10 out of 12 nests located near (<50m) an edge were destroyed as opposed to 4 out of 10 far (>50m) from edge.	10 of 14 loses occurred during first half of incubation period, 7 of 10 soon after being laid.
Tinkle et al., 1981 Michigan		21% known nests		14% on same night

*Burger, J. 1977. Determinants of hatchling success in diamondback terrapin, *Malaclemys terrapin*. AM. MIDL. NAT. 97:444-464.