SPECIES ASSESSMENT FOR SPOTTED BAT (EUDERMA MACULATUM) IN WYOMING

prepared by

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Introduction

This Species Conservation Assessment was prepared as part of a Species Conservation Project funded by the Wyoming Bureau of Land Management. It represents a complete review of the current published information available for the species, includes consultation with experts, and addresses as much as is known concerning the distribution, biology, ecological niche, and conservation planning being conducted for this species on a state and range-wide level. The reader will note a number of areas in which biological and ecological data are not well known for this species, and that distribution data are based on relatively few specimen and observation records.

Systematic surveys of suitable habitat for *Euderma maculatum* have not been completed in many U.S. states or Canadian provinces, and data are lacking for the expected range in Mexico. Wyoming is one of the many states in which suitable habitat has not been identified and quantified, and surveys of known suitable habitat have not been completed. Although based on only a few records, general distribution is known for the Bighorn Basin in Wyoming; but recent records in southwestern and central Wyoming indicate that additional work is needed to identify potential habitat in those areas. Surveys of potential habitat are needed to verify distribution and delineate local populations. Because Wyoming may include habitats that are at the upper altitudinal range of *E. maculatum*, distribution in Wyoming, and an understanding of population structure and dynamics of *E. maculatum* in the state may be very significant for management of the species across its range.

E. maculatum is identified as a priority species in the Western Bat Species: Regional Priority Matrix (Western Bat Working Group 1998), indicating that all management entities including state

wildlife agencies and federal land management agencies should give this species priority in management planning. While there is still much to be learned about the species, what is known should be applied whenever potential impacts to the species or its habitat are likely based on private, state or federal actions. Habitat use, prey species, roosting sites, foraging areas, distances to foraging areas, and conservation needs may vary somewhat over the range of the species. However, lack of specific state or local data should not be a deterrent to application of management strategies that are presented in this assessment. The best available range-wide and regional information should be used to develop local management, and refined as state or local data become available.

Continued collection and refinement of data, state and federal agency recognition of the need to manage this species, and state and federal development and implementation of effective management strategies may be major factors in precluding the need to list this species under the Endangered Species Act.

Natural History

Morphological Description

Best (1988) examined 67 specimens from throughout the range, grouped into northern, southern, central and western populations, for morphological variation. Specimens were from diverse habitats. Thirty-six males, 25 females and six bats of undetermined sex were analyzed. Five external characters were recorded from specimen tags, and length of forearm and nine cranial measurements were taken from the specimens. Character heterogeneity between sexes and among the four populations was tested using one-way analysis of variance.

Of 16 characters examined, 15 characters exhibited considerable overlap between sexes, while only one character exhibited a statistically significant difference. Females were larger in length of forearm, although there was considerable overlap between sexes. Best (1988) speculated that because of the large geographic area and diverse habitats included in the analysis, sexual dimorphism may have been masked by inter-population variation or habitat characteristics. Ten of 16 characters exhibited geographic variation, similar to documentation by Best in other groups of mammals. Williams and Findley (1979) reported females to average >4% larger than males.

Identification

E. maculatum is one of the most distinctly colored bats in the U.S., and certainly is the most distinctive of Wyoming bats (Figure 1). The body is black dorsally with a white spot on each shoulder, and a large white spot at the base of the tail (Figure 2). The ventral coloration is black with white-tipped hair, giving it a white appearance. (Grinnell 1910 *in* Watkins 1977) noted that the "death's-head" ventral pattern was unique among bats, and speculated that it may be an adaptive function to remain inconspicuous since the pattern is also found in moths and crepuscular birds such as poorwills and nighthawks. Only an Old World bat in the Genus *Glauconycteris* even has roughly a similar appearance (Zeveloff 1988). The pinkish, hairless ears are 45 to 50 mm in length with a simple tragus. The ears are erect in active individuals, but in a state of rest or torpor, are folded and curled back against the body in a "ram's horn" position.

Membranes of wings and tail are thin and pliable, pinkish-red in living specimens and gray in preserved specimens (Easterla 1965). The nose lacks large glandular masses and the nostrils are small, similar to other vespertilionids. Easterla (1971) described a bare, non-glandular throat patch about 10 mm in diameter that is hidden by fur unless the head is tipped back. Poche (1981)

described the potential for this patch to act as a heat exchange mechanism during high roost temperatures. The auricle and tragus are large, the tragus lacks a basal lobe, and is united with the posterior basal lobe of the auricle.

With a total length of 107 to 115 mm, forearm 48 to 51 mm, tail 47 to 50 mm long, and length of ear 45 to 50 mm (Watkins 1977), this species is one of the larger vespertilionid bats in Wyoming. Sexes are similar in pelage. Altricial young lack the distinctive pelage pattern at birth (Easterla and Easterla 1974). No North American bat has coloration and pelage pattern similar to the spotted bat, therefore identification is generally unmistakable. Tables of measurements for specimens examined can be found in Handley (1959).

E. maculatum is the only bat in Wyoming to emit an echolocation call audible to the human ear. Three bat species other than *E. maculatum* that occur in Wyoming have vocalizations that are audible to the unaided human ear: pallid bat (*Antrozous pallidus*), big free-tailed bat (*Nyctinomops macrotis*), and Mexican free-tailed bat (*Tadarida brasiliensis*) (Priday and Luce 1999). *E. maculatum* and *A. pallidus* are by far the more common (Priday and Luce 1999) and likely to be heard. Only one record of *N. macrotis* exists for Wyoming (Bogan and Cryan 2000), and three records for *T. brasiliensis* (Bogan and Cryan 2000, Priday and Luce 1998). Although both *A. pallidus* and *T. brasiliensis* vocalize, they do not consistently use audible echolocation calls, therefore are distinct from *E. maculatum*.

The voice of *E. maculatum* is best described as a soft, high-pitched metallic squeak or a chirp. *E. maculatum* occasionally clicks its teeth together and makes a grinding noise (Handley 1959), and is known to emit clicking or ticking sounds prior to taking flight (Easterla 1965) similar to several other bat species.

Taxonomy and Distribution

Taxonomy

E. maculatum is of Order Chiroptera, Sub-order Microchiroptera, Family Vespertilionidae, Subfamily Vespertilioninae, and Group (Tribe) Plecotini (Williams et al. 1970, Frost and Timm 1992). There is only one species in the genus Euderma and it is known only from western North America (Watkins 1977). No subspecies are currently recognized (Handley 1959, Best 1988).

According to Handley (1959) the first description of the species was in 1891: *Histiotus maculatus* J. A. Allen, Bull. Amer. Mus. Nat. Hist., 3:195, February 20, type from near Piru, Ventura Co., California. According to Miller (1897:49) in Watkins (1977) this was "probably at mouth of Castaic Creek, Santa Clara Valley, 8 mi. E of Piru Los Angeles County, California." The first use of current name combination, as amended, came several years later (*Euderma maculatum* H. Allen, 1894:61; Watkins 1977).

Frost and Timm (1992) evaluated morphological and karyological characteristics and recommended that *E. maculatum* and *Idionycteris phyllotis* be considered sister species within the genus *Euderma*. Other research, (Tumlison and Douglas 1992, Bogdanowicz et al. 1998, Hoofer and Van Den Bussche 2001), supported generic distinction between the two species. The two genera remain separate at the current time.

Distribution and Range

In 1959, *E. maculatum* was thought to occur from northwestern Mexico to southern Canada (Hall and Kelson 1959). The range map for the species was not significantly different when

distribution was revised in 1981 (Hall 1981). Scattered records indicate a range from Durango, Mexico to British Columbia (Watkins 1977, Woodsworth et al. 1981).

E. maculatum is widely distributed across western North America (Figure 3) from the southern Canadian province of British Columbia, south through eastern Oregon, Idaho, south-central Montana, central and western Wyoming, western Colorado and Nevada, to southern California; southwestern Arizona, New Mexico and west Texas; to central Mexico; Queretaro, Mexico (Easterla 1970; Schmidly and Martin 1973; Watkins 1977; Leonard and Fenton 1983; Navo et al. 1992, Perry et al. 1997, Pierson and Rainey 1998). Occurrence has been documented in British Columbia in Canada; Colorado, Montana, Wyoming, Idaho, Nevada, Utah, California, Arizona, New Mexico, and Texas in the United States; and the states of Durango and Queretaro in Mexico. The states of Sonora, Chihuahua, Coahuila, Durango, Nuevo Leon, Zacatecas, San Luis Potosi, Jalisco and Guanajuato in Mexico are included in the range of the species in Hall (1981) but no specimen or observation records are known to exist.

E. maculatum occurs from 57 meters below sea level (Grinnell 1910 *in* Watkins 1977) to the high transition zone of the mountains in Yosemite National Park, California (Ashcraft 1932 *in* Watkins 1977). A record from, the summit of Mount Taylor in New Mexico at 3,230 m (Reynolds 1981) is the highest elevation occurrence documented. Recent surveys in California (Pierson and Rainey 1998) documented several localities above 2,000 m, the highest of which was 2,926 m in Deadman Canyon, Sequoia National Park. Distribution in Nevada is between 540 and 2,130 m (Nevada Bat Working Group 2002).

Until recently, distribution in Wyoming was thought to be confined to the Bighorn Basin, based on two historical records (Bogan and Cryan 2000). However, of 34 new records (11

locations) reported in Priday and Luce (1999), seven locations are in the Bighorn Basin, one is in southwestern Sweetwater County near the northern end of Flaming Gorge Reservoir, one is in northern Fremont County east of Riverton, and two are in southwestern Johnson County. With the exception of the Sweetwater County observation, all of these observations were made incidentally during mist net surveys of roost sites in caves and abandoned mines, and none of the 34 observations were part of a systematic survey for *E. maculatum*.

Therefore, the current distribution map for Wyoming in Priday and Luce (1998, 1999) may not represent the true range for the state, and is even less likely to represent all areas of local occurrence (Figure 4). Other parts of the state that contain habitat suitable for *E. maculatum* have not been adequately or systematically surveyed

Some *E. maculatum* habitat in Wyoming has been systematically surveyed without documenting occurrence. Surveys conducted in 1997 at 12 low elevation sites on the Shoshone National Forest, 1460 to 2750 m, and considered potential *E. maculatum* habitat, resulted in no audible calls recorded (Priday and Laurion 1998). Exact locations of the surveys are listed (Priday and Laurion 1998). These survey locations were at locations and elevations just above public lands managed by BLM, but may or may not be similar in habitat and suitability for *E. maculatum*.

Garber (1991) mist netted and used a QMC Mini-2 Bat Detector at 30 sample sites on Bridger-Teton National Forest and 22 sample sites on Targhee National Forest in 1991 without detection of *E. maculatum*. The sample sites ranged from 1840 to 3035 m elevation. Garber (1991) opined that these two National Forests are above the upper elevational limit for *E. maculatum* at northern latitudes, and are not part of the current distribution of the species. Conceivably, lower elevation public lands managed by BLM and adjoining the southern end of the Bridger-Teton

National Forest, containing juniper or sagebrush habitats, are suitable habitat for *E. maculatum.* These areas have not have been adequately surveyed (Garber 1991).

E. maculatum is not listed as a species that occurs in South Dakota (Higgins et al. 2000, Schmidt 2002), and occurrence in Nebraska is unlikely (Jones et al. 1985), therefore the eastern part of the state is probably not within the range of the species and should be the lowest priority for surveys.

Range extensions for the spotted bat have been reported over the last 30 years from several sources: Big Bend National Park in Texas (Easterla 1973), northwestern Colorado (Finley and Creasy 1982, Navo et al. 1992, Storz 1995), Oregon (McMahon et al. 1981, Barss and Forbes 1984, Rodhouse, University of Idaho, pers. comm.), southern Utah (Poche and Bailie 1974, Poche 1975 & 1981, Ruffner et al. 1979), southern British Columbia (Woodsworth et al. 1981), northern California (Bleich and Pauli 1988, Pierson and Rainey 1998), New Mexico (Perry et al. 1997). Wyoming (Priday and Luce 1999), and Utah (Toone 1991, Storz 1995).

Abundance

E. maculatum has often been considered a rare species (Snow 1974, Watkins 1977), but recent data are changing that perception. From 1891 when the species was first described until 1965, only 35 specimens were reported in the scientific literature (Watkins 1977). An additional 18 specimens were reported between 1965 and 1977 (Watkins 1977).

E. maculatum is locally abundant in some situations. Rabe et al. (1998) found *E. maculatum* locally common north of Grand Canyon National Park in Arizona. Easterla (1973) found them locally abundant at sites in Texas, and data from British Columbia also suggest local abundance

(Woodsworth et al. 1981, Leonard and Fenton 1983). Fenton et al. (1983) sampled for *E. maculatum* in 80 areas within the expected geographical distribution. They found *E. maculatum* in 10 of 80 areas. Thirty-four of 142 sites sampled (24%) within the 10 areas at which the species was present, detected *E. maculatum*. Navo et al. (1992) found *E. maculatum* locally common, though not abundant, in Dinosaur National Monument.

Fenton et al. (1983) believed capture records to be a reliable indicator of abundance for this species. Berna (1990) supported this hypothesis. When conducting general bat surveys along the Kaibab Plateau in Arizona in August 1988, he captured 8 bats, three of which were *E. maculatum* (38%). Likewise, Doering and Keller (1998) documented *E.maculatum* at five of 11 (45%) of their sample sites in the Bruneau-Jarbidge River area of southwestern Idaho. Findley and Jones (1965) sampled ponderosa pine forests in New Mexico in 1961 and 1962. Of 107 bats captured, 7 (7%) were *E. maculatum*. Toone (1991) documented *E. maculatum* at 50 of 60 (83%) sample sites in the Abajo Mountains in southeastern Utah.

However, Worthington (1991) captured bats at five caves and four water sources in the Pryor Mountains, Montana. A total of 1,101 bats were captured including only two *E. maculatum* (<1%). Worthington did note that this species was observed throughout the southern portion of Bighorn Canyon National Recreation Area, including southern Montana and northern Wyoming. Similarly, Kuenzi et al. (1999) captured 299 bats of 11 species during a study in west central Nevada, including only three *E. maculatum* (1%).

Before 1990 the spotted bat was known in Wyoming from two records, a single specimen found dead near Byron in the northern Bighorn Basin (Mickey 1961), and a photograph taken of a live spotted bat near Lovell (Priday and Luce 1999). The first capture in Wyoming was of two live

specimens taken in mist nets in August 1990 on the Little Mountain plateau northeast of Lovell (Priday and Luce 1999). Between 1994 and 1997, 33 additional records of the spotted bat, including one capture, were documented in central and north-central Wyoming (Priday and Luce 1999).

Population Trend

Since this species is rarely captured during general bat surveys in Wyoming, and acoustic surveys have been only recently been used to record distribution locally, no regional, range-wide or statewide trend data are available. Likewise, no anecdotal information exists. Follow-up surveys have not been conducted at the locations where *E. maculatum* was documented in the past in Wyoming.

Habitat Requirements

General

E. maculatum has been reported from a wide variety of habitats from desert shrub to coniferous forest (Findley and Jones 1965). Early records seemed to indicate a preference for forested habitat (Vorhies 1935) or caves (Vorhies 1935, Hardy 1941, Parker 1952). Rocky cliffs (Figure 5) have been recognized as preferred roosting habitat in several studies (Easterla 1970, Watkins 1977, Ruffner et al.1979, Leonard and Fenton 1983). *E. maculatum* has also been observed and captured in dry, desert terrain at low elevations. *E. maculatum* were never observed more than 10 km from substantial cliff features during recent studies in California (Pierson and Rainey 1998) and British Columbia (Wai-Ping and Fenton 1989). Pierson and Rainey (1998) found *E. maculatum* in black oak, ponderosa pine, incense cedar, giant sequoia/red fir, lodgepole pine, and white fir habitats in California.

Foraging has been observed in forest openings (Woodsworth et al. 1981), pinyon juniper woodlands and large riverine/riparian habitat (Navo et al. 1992), riparian habitat associated with small to mid-sized streams in narrow canyons (Priday and Luce 1999), wetlands, meadows, old agricultural fields (Leonard and Fenton 1983, Wai-Ping and Fenton 1989, Worthington 1991, Pierson and Rainey 1998), and subalpine mountain meadows (Rabe et al. 1998).

E. maculatum has been reported in caves or cave-like situations (Vorhies 1935, Hardy 1941, Parker 1952, Priday and Luce 1999) but until recently use of these structures during any season of the year, other than incidental, had not been documented. Mead and Mikesic (2001) documented at least six to nine individual *E. maculatum* day roosting in a cave in northern Arizona between May 6 and early October, and captured 11 individuals (nine adult males, two adult females) on August 16-17.

Williams (2001) sampling from June through January, found *E.maculatum* using mesquite bosques up to 5 m tall consisting of native screwbean mesquite (*Prosopis pubescens*) and honey mesquite (*Prosopis glandulosa*). These areas were recovering floodplains where agriculture and grazing has ceased. Riparian marshes near the headwaters of the river were the second most commonly used habitat. These were up to .5 m tall and dominated by mixed sedges (*Carex, Eleocharis, Juncus*), cattail (*Typha*), and graminoids. Riparian shrublands habitat were used to a lesser extent, and consisted of monotypic stands of arrowweed (*Pluchea sericea*) and quailbush (*Atriplex lentiformis*) as tall as 2 m.

E. maculatum distribution is patchy over the known range of the species. The species is apparently confined to areas with specific geologic features due to its dependency on rock-faced

cliff roosting habitat occurring near suitable foraging areas. Roosting is apparently confined to small crevices or openings in rock walls.

The key resources required by all bat species are roosts, forage, and water. In arid regions, surface water for drinking may be a limiting factor for all bat species (Cross 1986). Numerous researchers have documented heavy use of natural and manmade water sources (Chung-MacCoubrey 1996, Cockrum et al. 1996, Szewczak et al. 1998), either for drinking or as foraging habitat.

Spring/Summer/Fall

This species uses similar habitats spring through at least early fall, although male and females may not use the same areas. Hoffmeister (1986) reports *E. maculatum* (sex unknown) at a low elevation desert site near the Colorado River in the vicinity of Yuma, Arizona in April. The habitat is in Lower Sonoran Desert, and vegetation association is creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*).

Hoffmeister (1986) also reports a record of a male *E. maculatum* captured in a ravine along the lower Colorado River (similar habitat as described above) in June, and a specimen (unknown sex) taken in the summer in the city of Tempe in the Salt River Valley where habitat was historically creosote-dominated Sonoran Desert, but which is now irrigated agriculture or urban area. Ruffner et al. (1979) captured six males at Ft. Pierce Wash 13 km SE of St George, Utah in June in riparian habitat consisting of creosote bush, mesquite (*Prosopis glandulosa*), tamarisk (*Tamarix chinensis*), desert willow (*Chilopsis linearis*), baccharis (*Baccharis glutinosa*) and arrowweed (*Pluchea sericea*).

Findley and Jones (1965) suggest that females of *E. maculatum* bear and rear young in ponderosa pine forest and perhaps other forest types in the Southwest, and after the breeding season, move to lower elevation winter range. Barbour and Davis (1969) also suggest that *E. maculatum* is a resident of the ponderosa pine zone in June and July, and wanders to lower elevations in autumn.

Kuenzi et al (1999) captured *E. maculatum* in Great Basin desert shrub (sagebrush (*Artemesia* spp.), saltbush (*Atriplex* spp), pinyon pine (*Pinus monophylla*) and juniper (*Juniperus osteosperma*) in June – August.

Rabe et al. (1998) found *E. maculatum* in subalpine meadows in July and August on the Kaibab National Forest in Arizona. Associated forest species included ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziezii*), white fir (*Abies concolor*), and patches of aspen (*Populus tremuloides*). The July temperature at this elevation averaged 23 degrees C. One *E. maculatum* was radio-tracked to its day roost. The roost was at an elevation of about 700m on a south-facing limestone cliff about 150 m above and 200 m from the Colorado River. The site was Sonoran Desert habitat with predominantly catclaw (*Acacia greggii*), and mesquite. Average July temperature at the closest weather station to the roost site, Phantom Ranch in Grand Canyon National Park, 748 m elevation, was 35 degrees C. After foraging in the subalpine meadows previously described, the female roosted in the same patch of aspen on the south face of a small ridge, 1 km east of the meadow, for several nights. Wai-Ping and Fenton (1989) radio-tracked four females, including one lactating female, to roosting sites on cliff faces in British Columbia.

Rabe et al. (1998) heard a number of *E. maculatum* echolocation calls along the rim of the Grand Canyon in the early evening in July and August, suggesting that the bats were roosting in

the canyon and traveling to foraging areas above the rim. The large elevation and temperature difference between the hot, low elevation desert cliff roosting sites and high, cool subalpine meadow foraging sites present an opportunity to forage in several habitat types (Rabe et al 1998). Racey (1982) speculated that the high-energy demands on lactating female bats in July and August probably force them to choose the most productive foraging habitat. Further research is needed to document whether selection of foraging areas is more a function of availability of suitable insect prey than other factors.

Leonard and Fenton (1983) found that *E. maculatum* preferred foraging sites in open areas associated with ponderosa pine forest in June, July and August. They also documented use of old fields consisting of knapweed (*Centaurea* spp), with bunchgrass (Agropyron *spp*) in moist depressions and ponderosa pine along the field margins. Irrigated hay fields planted to alfalfa (*Medicago sativa*) and bordered by ponderosa pine were also used as foraging sites. Woodsworth et al., (1981) observed *E. maculatum* along the Okanagan River in southern British Columbia in May, June and August at elevations ranging from 500 to 1500 m in habitat dominated by sagebrush (*Artemisia* spp.), low grasses, and open ponderosa pine montane forest. The habitat is described as more typical of semiarid habitats much further south.

Leonard and Fenton (1983) observed *E. maculatum* using burned-over ponderosa pine forest, but not foraging there. Wai-Ping and Fenton (1989) observed *E. maculatum* foraging in open areas six to 10 km from day roosts in cliffs. Foraging took place in a variety of habitats, but mostly over marshes and in open ponderosa pine woodland where foraging bats could fly 5-15 m above the ground in large elliptical paths with long axes of 200-300 m.

In Colorado, Storz (1995) documented *E. maculatum* at Echo Park Meadow (1548 m) and Pool Creek (1635 m) foraging in open meadows with dominant ground cover of cheatgrass (*Anisantha tectorum),* various bunchgrasses, and isolated boxelder stands. Echo Park is adjacent to the Green River and sandstone cliffs (150-230 m). *E. maculatum* was documented at Orchid Draw and Red Wash which are dry desert washes characterized by rabbitbrush (*Chrysothamnus nauseosus*) , sagebrush (*Seriphidium tridenta*), greasewood (*Sarcobatus vermiculatus*) and shadscale (*Atriplex confertifolia*).

Perry et al. (1997) captured lactating females foraging over a stock pond in open grazed meadows surrounded by mixed conifer forest 0.4 km from cliffs in the Sacramento Mountains of New Mexico.

Priday and Luce (1999) reported on the capture of two lactating female *E. maculatum* on August 27 and 28 at a small spring pond (Site #1) in open juniper *(Juniperus scopulorum*) grasslands on Little Mountain Plateau in extreme northern Wyoming. Calls were documented in nine additional locations: Site#2, Spring Creek Canyon, was a 4.8 km-long canyon with sheer limestone cliffs and a small perennial stream running through boxelder (*Acer negundo*) stands near the stream, and mountain mahogany (*Cercocarpus montanus*), big sagebrush (*Artemesia tridentata*), and juniper between the stream and the canyon rim. Site #3, Canyon Creek, is also a perennial stream in a canyon of rugged rock outcrops and steep canyon walls with juniper and big sagebrush.

Site #4, elevation 1890 m, was approximately 0.8 km from the Green River in a rugged canyon with bare rock walls containing numerous cracks and fissures, greasewood (*Sarcobatus vermiculatus*) between the river and cliffs, and big sagebrush on the plateau. Site#5, elevation

1920 m was a steep canyon with adjacent habitat including Douglas-fir interspersed with limber pine (*Pinus flexilis*) and aspen. Site#6 in Wind River Canyon was an area of limestone karst with several natural caves, and bare rock walls. Big sagebrush and juniper occur along the river, and sagebrush-grassland habitat occurs on the adjacent plateaus. Site #7 in Sheep Canyon along the Bighorn River has sheer rock walls immediately adjacent to the river, with mixed sagebrush-grassland on the plateau. Site #8 on the Middle Fork of the Powder River at elevation 1597 m was a karst area with bare rock walls of limestone. Vegetation along the river included narrowleaf cottonwood (*Populus augustifolia*) and boxelder near the streambank, and lodgepole pine (*Pinus contorta*), juniper, and big sagebrush between the river and the canyon walls. The adjacent plateaus are dominated by sagebrush-grassland with scattered lodgepole pine.

Site #9 was a karst area near Mayoworth at elevation 2530 m. The site is located in an area of mixed lodgepole pine and Douglas-fir interspersed with sagebrush-grassland parks. Rock outcrops and a canyon with bare rock walls occurs within 1.6 km of the site, and three man-made stock ponds occur within 3.2 km. Site #10 was on the shore of Boysen Reservoir near several high rock bluffs in sagebrush-grassland. Elevation is 1460 m.

In summary, all *E. maculatum* occurrences were associated with habitats containing canyons with cracks and fissures, high, bare rock walls, and rock ridges close to permanent water. Occurrence of *E. maculatum* in Wyoming may be more closely associated with habitat structure and roost availability in proximity to foraging areas than specific vegetation types (Priday and Luce, 1999).

Twelve sites surveyed for *E. maculatum* on the Shoshone National Forest were in habitats similar to Sites #2 - 10 described above. Elevations from 1460 to 2750 m were higher at eight of

the sites than where *E. maculatum* was documented elsewhere in Wyoming, leading the researchers to speculate that elevation may have been a limiting factor in this area (Priday and Laurion 1998).

Late Fall/Winter

Ruffner et al. (1979) reported capturing seven *E. maculatum*, three females and four males, in January and February at Ft. Pierce Wash near St George, Utah at an elevation of 880 m. Several stock tanks and the Virgin River are within a 10 km radius of the site. Captures were between 2.5 and 11 h after sunset. *E. maculatum* was not captured at this site during any other season of the year. Other winter records of *E. maculatum* are reported from roughly the same area in southwestern Utah (Hardy 1941, Poche 1981). The coldest temperature at which Poche (1981) captured an *E. maculatum* was –5 degrees C., and he speculated that this species may emerge from torpor to obtain water. The study site occasionally warms enough during some parts of the winter to produce emergence of insects, and provide the opportunity for bats to forage. Toone (1991) documented calls of *E. maculatum* at low elevations in several locations in Grand County in southeastern Utah in October, potentially supporting the theory of local migration to lowlands in winter.

Hibernation habitat has not been characterized. Hardy (1941) reported at least four hibernating *E. maculatum* near Kanab, Utah. Poche (1981) checked 17 caverns and caves near Ft. Pierce Wash, a well-documented *E. maculatum* use area, finding several bat species, but no *E. maculatum*.

There are no winter records for *E. maculatum* in Wyoming. Winter surveys of 161 caves and 137 abandoned mines in Wyoming between 1994 and 1997 documented no use by *E. maculatum*

(Priday and Luce 1998), suggesting either a seasonal migration or a hibernation strategy other than use of hypogeal roost sites. Since this bat is solitary except during breeding, solitary movement to hibernacula and solitary hibernation, are likely. Insects are unlikely to be active for a significant period at any outside location in the state during the winter in Wyoming.

Landscape Pattern

Rocky cliffs near forest foraging sites have been recognized as preferred habitat in a number of studies (Leonard and Fenton 1983, Watkins 1977, Easterla 1970; Ruffner et al.1979). Berna (1990) captured *E. maculatum* at Fracas Meadow Camp in Coconino County, AZ at elevation 2,507 m in subalpine grassland habitat surrounded by old growth (>20m tall) and secondary growth stands of ponderosa pine (4 to 12 m tall) and mixed-age aspen 2 to 10 m tall). An incline on the north side of the meadow bordered a large limestone sinkhole with exposed cliffs.

Toone (1991) documented *E. maculatum* using all habitat types, except pinyon-juniper which was used more than other habitats, proportionate to availability in the Abajo Mountains of southeastern Utah. *E. maculatum* used open forest areas (0-25% canopy cover) more than any other canopy class, foraged more often in areas 200-300 m from water, and less in areas 0-100 m from water, and used areas up to 2500-2600 m elevation. With respect to ponderosa pine DBH, distance to cliffs, and dominant overstory, *E. maculatum* activity was in proportion to availability.

Rabe et al. (1998) found that female *E. maculatum* with radio transmitters foraged in specific meadow systems for part of the night, and night roosted in trees bordering meadows. Wai-Ping and Fenton (1989) observed *E. maculatum* foraging in open areas six to 10 km from day roosts in cliffs, foraging continuously while away from cliff roosts, and flying about 19 km/h while foraging.

Movement and Activity Patterns

Migration by *E. maculatum* is not well understood or documented. Fenton (pers. comm. *in* Toone 1991) opines that it is unknown whether the species migrates locally, hibernates, or is a long distance migrant. Berna (1990) observed *E. maculatum* at higher elevations in conifer forests and then at lower elevations later in the summer, suggesting altitudinal migration. Poche (1981) observed *E. maculatum* primarily in low elevation xeric areas, but suggested they may wander to higher elevations to escape summer heat. Geluso (2000) noted that the cities of Reno and Las Vegas account for 35% (n=11) of the occurrences of *E. maculatum* in Nevada, and that eight of the 11 bats documented were found in late August and early September. He suggests that this may indicate that *E. maculatum* wanders to lower elevations after bearing and raising its young.

The Nevada Bat Conservation Plan (Nevada Bat Working Group 2002) states that *E. maculatum* hibernates in Nevada but periodically arouses during the winter to forage and drink. *E. maculatum* was documented in a ponderosa pine forest in New Mexico only during the period June 23 to July 1, leading to speculation that specimens taken in August and October may indicate post-breeding wandering (Handley 1959).

Findley and Jones (1965) suggest that *E. maculatum* bears and rears young in ponderosa pine forest and perhaps other forest types in the Southwest, and after the breeding season, moves to lower elevation winter range. Hoffmeister (1986) reports *E. maculatum* at low elevation sites in Arizona in April, near Yuma, and in December-January (near St George, Utah - the Arizona/Utah state-line). Barbour and Davis (1961) also suggest that *E. maculatum* is a resident of the ponderosa pine zone in June and July, and wanders to lower elevations in autumn.

Rabe et al. (1998) found *E. maculatum* in meadows in ponderosa pine habitat in July and August on the Kaibab National Forest in Arizona. Winter records for *E. maculatum* are rare (Hardy 1941, Ruffner et al. 1979) and are only from southwestern Utah. The locations of wintering sites in the northern part of its range, including Wyoming, are not known, if *E. maculatum* does indeed winter there. In no geographical area of Wyoming are November through March ambient temperatures, or insect prey availability, conducive to bat activity. Therefore *E. maculatum*, as well as other bat species, must either migrate southward to a more favorable climate where they can maintain at least some level of winter feeding activity, or hibernate. Ruffner et al. (1979) sampled over a desert wash in southwestern Utah at elevation 823 m during November 1974 through March 1975. They documented winter activity for *E. maculatum* only in January and February. Both free water and insects were available all winter. They speculated that winter activity may be a result of poor hibernacula in the area.

Negus (pers. comm. *in* Hoffmeister 1986) reported mist netting *E. maculatum* in November and June in the same area as Ruffner et al. (1979), indicating that the species may be present in the area all year. Since *E. maculatum* is not known to congregate at large maternity sites, documentation of movement activity related to maternity season is not known, but can to some extent, be inferred from breeding data. Depending upon latitude and elevation, the species breeds late February to April, and young are born May or June. Lactating females have been captured in late June and early July in New Mexico, mid-July in Wyoming, and mid-August in Utah, but no movements between breeding and immediate post-breeding areas have been tracked. Post-lactation females have been captured in Wyoming in late August (Priday and Luce 1999).

Daily Activity

Barbour and Davis (1969) and Easterla (1965) speculated that *E. maculatum* is a late flyer similar to Townsend's big-eared bat, *Corynorhinus townsendii*. Clark et al. (1993) reported emergence from the roost for *C. townsendii* to average 45.5 minutes after sunset. Most captures Barbour and Davis (1969) were familiar with took place after midnight, and they noted only one conflicting record in Constantine (1961) who reported one capture at 2038. Navo et al. (1992), using a bat detector and audible call recognition, documented early evening appearance of *E. maculatum*, and activity all night. Leonard and Fenton (1983) and Wai-Ping and Fenton (1989) found *E. maculatum* active throughout the night in southern British Columbia, with peak foraging activity from 0000 to 0300 (50% of the nightly activity). Poche and Bailie (1974) reported captures at 2215 and 2230 hs. Winter captures of seven *E. maculatum* in Utah were between 2.5 and 11 hours after sunset, indicating activity over the entire night (Ruffner et al. 1979).

Long distance movement to forage was documented by Rabe et al. (1998) who found one female *E. maculatum* making a daily one-way flight of 38.5 km, and one male a one-way flight of 32 km. Rabe et al. (1998) first detected *E. maculatum* at 2010 to 2030 h (2.8 h to 3.2 h after sunset), and believed that these times represented emergence from the roost. *E. maculatum* on Dinosaur National Monument first arrived at foraging areas at 2123 h (+-11 min) and remained active throughout the night. *E. maculatum* foraged within the study site for 6.22 min (+-24. min) out of every 15 min sampling period between 2100 and 0400. Foraging sessions lasted 5.48 min (+-2.74 min) (Storz 1995). Rabe et al. (1998) documented arrival of a female *E. maculatum* at a foraging site at 2130 h, foraging until 2400 h or 0100 h, night roosting between 0330 and 0350, and direct return flight to the day roost on a cliff.

At eight of 15 sample locations observed by Storz (1995), he documented only commuting *E. maculatum*, with a fairly constant number of passes/night, indicating movement to and from roost sites to foraging areas. Recent research indicates that activity peaks reported in early literature are likely artifacts related to proximity of sampling sites to diurnal roosts and/or drinking sites (Storz 1995).

Mead and Mikesic (2001) documented emergence from a cave roost in Arizona 15 to 30 minutes after sundown, and *E. maculatum* activity all night. Peak activity was from 2100 h to midnight and from 0400 to 0500 h.

Priday and Luce (1999) documented *E. maculatum* activity at 10 sites in Wyoming; the earliest nightly activity was at 1900 h. on October 16, 1995; 2112 h in July; and 2030 h in August. During August sampling, foraging activity was documented several times during the period 2030 h to 2330 h in a meadow in the vicinity of a spring pond.

Reproduction and Survivorship

Little is known about reproduction in *E. maculatum*. Easterla (1965) captured two pregnant females in early June in Texas, and Poche (1981) captured a pregnant female in Utah near the Utah-Arizona state line on June 20, about to give birth. Lactating females have been captured in June, July, and August (Jones 1961, Easterla 1965, 1970; Barbour and Davis 1969) so indication is strong that parturition occurs prior to mid-June (Watkins 1977). Post-partum females have been captured June 23 and July 1 in New Mexico (Jones 1961), June 30 in New Mexico ((Findley and Jones 1965), August 10-18 in Utah (Easterla 1965), August 3 – 9 in Texas (Easterla 1970), and August 27-29 in northern Wyoming (Priday and Luce 1999).

Easterla (1965, 1973) caught male *E. maculatum* in Texas during late summer which had enlarged testes, indicating that copulation probably occurred in the fall and parturition occurs during the spring after delayed implantation, similar to other vespertilionids. Poche (1981) however, found mature spermatozoa in one individual caught in the spring, potentially indicating breeding at that time.

E. maculatum apparently gives birth to one altricial young, weighing about four grams (Easterla 1965, 1971; Findley and Jones 1965). There is no evidence that *E. maculatum* congregates into maternity colonies (Poche 1975) as do other bat species that occur in Wyoming.

Population Demographics

Limiting Factors

Mead and Mikesic (2001) suggest that *E. maculatum* was unable to roost/live as far north as the Grand Canyon until summer temperatures and rainfall patterns had established the modern regime ca. 11,000 to 10,200 ca. year B.P.), based on a fossil specimen they dated at ca. 10,500 ca. Year B.P. This suggests that temperatures and rainfall may still limit the distribution of this species.

However, the primary limiting factor for *E. maculatum* appears to be either habitat related or food related. Cliffs or rock walls must be associated with meadow foraging areas. Moths present in foraging areas must be of a particular size and type. (Ross (196l, 1967; Easterla and Whitaker 1972) found stomach contents and fecal pellets to indicate that 97 to 100% of prey items were moths (probably noctuids) ranging in size from 5 to 11 mm. Structural features of the habitat

related to density of clutter may also be most predictive of habitat suitability and use of forging space (Storz 1995).

Historically *E. maculatum* has endured little impact from human disturbance due to the remoteness of its roosts. This condition probably continues to exist over most of the range, but impoundment of reservoirs and recreational rock climbing may impact the species in local situations (Snow 1974, Pierson and Rainey 1998).

Large-scale non-target pesticide spraying programs could impact *E. maculatum* by reducing availability of prey. Non-target insecticide sprays reduce the number of insects that are available to foraging bats in an area (Brown and Berry 1991) and have been identified as a factor contributing to the decline of bat populations in North America (Clark 1981). Non-target lepidopteran sprays used to control gypsy moth outbreaks may reduce local moth populations for several years, and even *Bacillus thuringiensis* sprays may suppress tussock and spruce budworm moths enough to impact bats (Perkins and Schommer 1991).

The insecticide difllubenzuron (Dimilin) is an insect growth regulator that may produce significant indirect impacts on bats by reducing the food available (Sample and Whitmore 1993). Malathion and carbaryl are insecticides widely used for large-scale range and agricultural spraying projects over thousands of acres, including control of Mormon crickets in Wyoming, and may have an impact on bats. Clark (1988) suggested that bats are at risk from direct poisoning by insecticides due to their diet, high metabolic rates, high rate of food intake, and high rates of fat mobilization. Fenton et al. (1983) stated that collection of specimens and use of pesticides that the bats may accumulate through their diet, and that kill their prey, are the biggest threats to *E. maculatum*.

Oil reserve pits associated with oil drilling operations can be a source of bat mortality (Flickinger and Bunck 1987). Various species of bats have been found drowned in these ponds in Wyoming (Esmoil and Anderson (1995), B. Weynand, Bureau of Land Management, Wyoming pers. comm.).

Livestock grazing has been responsible for large-scale conversion of mesic riparian habitats to xeric uplands throughout the West. The impact of this on foraging strategies of *E. maculatum* is unknown, however *E. maculatum* is known to prefer noctuid moths which are obligate users of lentic vascular hydrophytes such as *Thya*, *Salix*, *Pontederia*, and *Polygonum* (Lange 1979). It is possible that the noctuid prey base has been significantly reduced where these host plant species have been severely impacted or eliminated by livestock grazing.

Metapopulation Dynamics

The literature gives no data on metapopulation dynamics for *E. maculatum.*

Genetic Concerns

According to Williams et al. (1970) the karotype of *E. maculatum* is most similar to that of *Plecotus phyllotis* and the two are probably derived from the same ancestral stock. Small, scattered populations seem to be the norm for this species. No data exist on potential in-breeding.

Food Habits

Food Items

E. maculatum feeds primarily on flying moths (Easterla 1965, Ross 1967), but has been reported to pursue grasshoppers (Poche and Bailie 1974) or other insects (Findley 1987) on the ground. Leonard and Fenton (1983) discount these reports as instances in which *E. maculatum*

followed a typanate moth towards or onto the ground after the moth detected the bat's echolocation call.

Ross (196l, 1967; and Easterla and Whitaker 1972) found stomach contents and fecal pellets to indicate that 97 to 100% of prey items were moths (probably noctuids) ranging in size from 5 to 11 mm. Easterla and Whitaker (1972) found some evidence June beetles were taken. M. Painter, Northern Arizona University (pers. comm.) found *E. maculatum* feeding upon Noctuidae (83%), Lasiocamphidae, and Geometridae moths; and Coleoperta (<2% of bat digested material) on the Kaibab Plateau in Arizona in 2002.

E. maculatum may have a unique echlocation strategy in that its calls may not be detected by some moths until the bat is 0.1 to 2 m away. This provides a substantial advantage over such species as *Myotis lucifugus*, which can be detected by some moths at over 40 m. (Woodsworth et al. (1981).

Foraging Strategy

E. maculatum is a high-flying, fast foraging bat emitting a low frequency echolocation call of 8 to 15 kHz, with maximum energy at 10.9 kHz (Woodsworth et al. 1981). Woodsworth et al. (1981) observed an *E. maculatum* return to the same site, a one to two ha clearing in ponderosa pine forest at the same time of night (2100 h) on four subsequent nights. The bat always entered the clearing from the uphill side, made several circuits of the clearing for three to five min at a height of 10 to 15 m and within 20 m of the forest edge, then left the clearing on the downhill side. Another *E. maculatum* observed for five consecutive nights used a "trapline" forging strategy where it searched at least six clearings in ponderosa pine forest within an 8 km^2 area. The bat

always arrived at the first clearing about 20 min after dark and at each of the other clearings within three minutes of arrival on previous nights.

Storz (1995) documented *E.maculatum* arriving at foraging sites in Dinosaur National Monument, Echo Park Meadow, at 2123 h +-11 min MDT always after dark, and active throughout the night. *E. maculatum* foraged within the study site for 6.22+- 2.40 min out of every 15 min sampling period between 2100 and 0400 h.; and foraging sessions lasted 5.48 +-2.74 min. at Pool Creek, foraging took place in the study site for 6.82+-5.03 min out of every 15 min sampling period between 2100 and 0200 h, and foraging sessions lasted 8.97+-8.78 min. Foraging *E. maculatum* typically flew in large circular or elliptical orbits at heights of 10-30 m above the ground.

At Echo Park Meadow, 81.5% of activity occurred over open meadows, which constituted about 85% of the site, while 18.5% of activity occurred within 8 m of foliage of leafed boxelders at mid- to upper-canopy level. This activity involved *E. maculatum* circling closely above and around individual trees or isolated clumps of trees. *E. maculatum* was rarely observed within 0.5 m of the canopy, and no instances of hovering or foliage gleaning were noted. At Pool Creek, where canopies of boxelder and cottonwood comprised a larger percentage of the study site, all activity occurred over open meadows.

Leonard and Fenton (1983, 1984) estimated that *E. maculatum* in British Columbia maintained a distance of at least 50 m from other adjoining foraging *E. maculatum* through mutual avoidance, and actively monitored proximity to conspecifics using the same area. Storz (1995) observed similar behavior in Dinosaur National Monument. Foraging *E. maculatum* produced agonistic vocalizations when a 50-m buffer zone was breached by another *E. maculatum*. These

vocalizations were different than feeding buzzes and occurred only during close encounters between conspecifics. Of 247 feeding buzzes, there was never more than one per min from the same bat. During 37 foraging sessions, *E. maculatum* attacked an insect every 2.15 min on average (0.466+-0.294 attacks/min, range 0.16 – 0.94; n = 152 feeding buzzes). Woodsworth et al. (1981) observed two *E. maculatum* encountering each other and maintaining about 100 m distance from each other. These data generally agree with Leonard and Fenton (1983) and Wai-Ping and Fenton (1989).

Apparently *E. maculatum* attacks prey at a rate much lower than is typical of bats in general (Barclay 1985, Hickey and Fenton 1990). Woodsworth et al. (1981) observed only six feeding buzzes during 44 minutes of observation of an *E. maculatum*. The bat always flew 10 to 30 m above the ground, at or above treetop. *E. maculatum* is not restricted to particular vegetation associations (Wai-Ping and Fenton 1989, Navo et al. 1992), therefore structural features of the habitat related to density or clutter may be the biggest determining factor concerning habitat suitability and use of foraging space (Storz 1995).

Rabe et al. (1998) documented arrival of a female *E. maculatum* at a foraging site at 2130 h, foraging until 2400 h or 0100 h, night roosting between 0330 and 0350, and direct return flight to the day roost on a cliff. Female *E. maculatum* with radio transmitters foraged in specific meadow systems for part of the night, night roosted in trees bordering meadows for about three h, and abruptly departed for day roosts between 0300 and 0400. In contrast, Wai-Ping and Fenton (1989) observed *E. maculatum* foraging in open areas six to 10 km from day roosts in cliffs, foraging continuously while away from cliff roosts, and flying about 19 km/h while foraging. Rabe et al. (1998) speculated that the long foraging distances observed by him may be explained by a lack of

suitable high-cliff roost sites near preferred foraging sites in the meadow systems on the Kaibab National Forest, while the abundance of large (>10 mm) moths justifies the energy expenditure of such long flights. Woodsworth et al. (1981) observed up to nine *E. maculatum* passes during a 15 minute period as they flew from an area of high cliffs at dusk toward foraging areas in ponderosa pine forests.

Foraging Variation

Foraging patterns appear similar throughout the range. Seasonal foraging patterns may shift. Leonard and Fenton (1983) observed *E. maculatum* flying in elliptical orbits 10 m above the ground, 40 to 70 m in length, and 20 to 30 m in width in May, and a similar pattern persisted until July. The feeding pattern was less predictable later in the summer and fall, moving over larger areas and spending less time at any one site.

Community Ecology

Predation

E. maculatum is relatively predation free. American kestrel, peregrine falcon, and red-tailed hawk have been observed diving at released banded *E. maculatum* (Easterla 1973) and one instance of *E. maculatum* capture by a kestrel has been reported (Black 1976). Owls occasionally take bats and *E. maculatum* may be susceptible to this form of predation. However, predation by raptors is probably rare and has little effect on populations.

Competition

Due to the unique roosting and foraging strategies of *E.maculatum*, competition from other bat species, or insectivorous birds, does not appear to be a survival factor.

Parasites and Disease

Whitaker and Easterla (1975) reported the external parasites *Cryptonyssus* spp., *Basilia rondanii* and *Ornithodorus* spp. on *E. maculatum* from west Texas, and *Basilia forcipata* from *E. maculatum* in New Mexico. Poche and Keirans (1975) reported a larval tick, *Ornithodoros rossi* on *E. maculatum* in Utah. No internal parasites have been reported (Watkins 1977).

E. maculatum is susceptible to rabies and under some conditions this disease could impact local populations (Medeiros and Heckmann 1971, Constantine 1979). However, the solitary nature of the species limits opportunities for exposure.

Conservation

Conservation Status

Western Bat Working Group

The Western Bat Species: Regional Priority Matrix (Western Bat Working Group 1998) lists *E. maculatum* as a species of High Priority for management in three of the five eco-regions in which it occurs with regularity. The status of the *E. maculatum* in each of six ecoregions is shown in Table 1.

Federal Endangered Species Act

E. maculatum was listed as a "candidate species" by the U.S. Fish and Wildlife Service under a classification system used prior to the mid-1990s. The species currently has no status under the Endangered Species Act.

Bureau of Land Management

Bureau of Land Management Sensitive Species Lists are developed at the state level. Ten states list *E. maculatum* as a Sensitive Species: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Oregon, and Wyoming. BLM Wyoming included *E. maculatum* in the 2002 BLM Wyoming Sensitive Species Policy and List (USDI 2002).

U. S. Forest Service

Regions 1, 2, and 4 currently list *E. maculatum* as a Sensitive Species.

State Wildlife Agencies

State agency ranking are shown in Table 2. Seven states list *E. maculatum* as a Species of Concern (6) or Threatened (1).

Heritage Ranks

Heritage rankings are shown in Table 3. The Global Heritage Status Rank is G4.

Biological Conservation Issues

Abundance

E. maculatum has often been considered a rare species throughout its range (Snow 1974, Watkins 1977), but recent data are changing that perception (Nevada Bat Working Group 2002, Priday and Luce 1999). *E. maculatum* is apparently locally abundant in some situations. Rabe et al. (1998) found *E. maculatum* locally common north of Grand Canyon National Park in Arizona. Easterla (1973) found them locally abundant at sites in Texas, and data from British Columbia also suggest local abundance (Woodsworth et al. 1981, Leonard and Fenton 1983). Fenton et al. (1983) found *E. maculatum* in 10 of 80 areas surveyed, and detected *E. maculatum* at 34 of 142 sites

sampled (24%) within the 10 areas in which the species was present. Navo et al. (1992) found *E. maculatum* locally common, though not abundant, in Dinosaur National Monument.

Fenton et al. (1983) believed capture records to be a reliable indicator of abundance for this species. Berna (1990) supported this hypothesis. When conducting general bat surveys along the Kaibab Plateau in Arizona in August 1988, he captured 8 bats, three of which were *E. maculatum* (38%). Likewise, Doering and Keller (1998) documented *E. maculatum* at five of 11 (45%) of their sample sites in the Bruneau-Jarbidge River area of southwestern Idaho. Findley and Jones (1965) sampled ponderosa pine forests in New Mexico in 1961 and 1962. Of 107 bats captured, 7 (7%) were *E. maculatum*. Toone (1991) documented *E. maculatum* at 50 of 60 (83%) of sample sites in the Abajo Mountains in southeastern Utah.

There have been only a few efforts to document occurrence of *E. maculatum* in Wyoming. *E. maculatum* was known in Wyoming before 1990 from only two records, while the first capture in Wyoming was not until August 1990 (Priday and Luce 1999). Between 1994 and 1997, 33 additional records, including one capture, were documented in Wyoming, primarily by audible calls (Priday and Luce 1999). These data are an indicator that the species is more abundant than previously known. Although there is no reason to believe that the species is more common than it was historically, there are likewise no data to support a hypothesis that it is less abundant.

Trends

In the case of *E. maculatum*, the number of observations through time does not indicate either an upward or a downward trend and are likely an artifact of increased reporting and survey effort rather than an actual population increase. Figures contrasting documented locations per state in a

status report prepared for the U.S. Fish and Wildlife Service in 1981 (O'Farrell 1981), and recent literature are shown in Table 4.

There do not appear to have been any changes in geographic distribution or range of the species in the last 100 years.

Two habitat components are of importance to this species (roosting and foraging), for which it would be important to understand trends. The dependency on rock-faced cliff roosting habitat within 40 km of foraging areas limits the species to very small geographic areas with specific geologic features. Rabe et al. (1998) speculated that the long foraging distances observed by them may be explained by a lack of suitable high-cliff roost sites near preferred foraging sites in the meadow systems on the Kaibab National Forest, while the abundance of large (>10 mm) moths justifies the energy expenditure of such long flights.

Range Context

The species seems to be locally common in areas with suitable habitat and abundance of prey, but such local populations are often separated by large areas in which suitable combinations of roosting and foraging habitat do not exist. This makes the range wide population of *E. maculatum* highly fragmented in nature. True to this generality, the local populations in Wyoming are geographically separated from each other during at least the spring-fall period. At present, Wyoming populations appear to be very comparable to those found elsewhere in terms of the distribution and numbers (Table 4).

Extrinsic Threats

Decline has not been documented. The known potential threats such as invasive species, genetic factors, stochastic events, and natural predation have not been shown to be significant. Roosts are in remote rocky cliffs that are not highly impacted by human activity, nor likely to be in the future except in the local instances previously discussed.

Impoundment of reservoirs and recreational rock climbing may impact the species in local situations (Snow 1974, Pierson and Rainey 1998). Large-scale pesticide programs may impact *E. maculatum* by reducing availability of prey. Fenton et al. (1983) stated that collection of specimens and use of pesticides that the bats may accumulate through their diet and that kill their prey are the biggest threats to the species, however the magnitude of these threats is unknown.

Habitat on public lands is under considerable pressure due to exploration and development of mineral and fossil fuel resources including coal bed methane, oil, natural gas, and coal. Seismic surveys regularly occur over vast areas and may impact *E. maculatum* if they take place near roosts. O'Farrell (1981) addressed this threat, and the intensity of development has accelerated since that time. Power plants with the associated power lines and roads, and wind energy developments, invade remote sections of public lands and may bring human-disturbance impacts to roosting habitat. Blasting for roads, pipelines, etc. associated with energy development may impact roosting bats, however the level of disturbance has not been quantified.

Timber harvest in riparian areas may impact all bat species. Total bat activity averaged 4.1 to 7.7 times higher in wooded areas than adjacent logged areas in western Oregon (Hayes and Adam 1995), and more lepidopterans, a primary forage species for *E. maculatum*, were captured in wooded habitat than in logged areas. Edges of clear cuts are used as foraging areas, but foraging

rates of bats in British Columbia were greatest in habitats associated with lakes (Grindal 1996). Bat foraging habitat is enhanced by retaining natural, pre-harvest variability in stand structure and interspersion of natural openings, and size and shape of openings (Walker et al. 1995).

The rarity of *E. maculatum* makes it a sought-after museum specimen, and collection may impact local populations (O'Farrell 1981, Fenton et al.1987). O'Farrell (1981) considered the level of impact from scientific collecting to be significant. Several researchers (Easterla 1973, Poche and Bailie 1974, Poche 1975, 1981) documented lack of mark/recapture returns for *E. maculatum,* suggested that the species is sensitive to minimal human disturbance, and may abandon an area due to human activities, including scientific research.

State/provincial laws and regulations do not provide adequate regulatory authority and mechanisms for the protection of *E. maculatum*. The state wildlife agency classifications shown in Table 2 are not legally binding nor do they address habitat. *E. maculatum* is listed in Section 11 of the Wyoming Game and Fish Commission Nongame Wildlife Regulation. The regulation prohibits intentional take except for human health or safety concerns, or under a Scientific Collection Permit issued by the Wyoming Game and Fish Department. Neither incidental take nor habitat protection is addressed.

Intrinsic Vulnerability

E. maculatum characteristically occurs at a low population density and in disjunct sub-populations, factors that increase vulnerability. The species is a generalist in terms of foraging habitat, but specializes in prey selection. Bat rabies is endemic in North America, but primarily affects *Eptesicus*, *Myotis*, *Tadarida*, and *Lasiurus* species; and occurs at a very low rate of prevalence in those species Rupprecht (1990). *E. maculatum* is susceptible to rabies, but there is

no evidence that the disease impacts the species to a significant degree. *E. maculatum* was not represented in the sample of 1100 specimens turned in to the Wyoming State Veterinary Lab for rabies examination between 1981 and 1992 (Priday and Luce 1998, Bogan and Cryan 2000).

Protected Areas

From a national perspective, it appears that most local populations that have been studied occur on National Forests, National Parks or Monuments, or public lands administered by the Bureau of Land Management. In Wyoming, the 14 documented locations of *E. maculatum* are all on or adjacent to large blocks of public land, including Bureau of Land Management lands, Bighorn Canyon National Recreation Area, Flaming Gorge National Recreation Area, and Boysen State Park (Priday and Luce 1998; Figure 4). Although publicly owned, these areas are not necessarily managed for optimal habitat for wildlife, however, at the current time there is no evidence that *E. maculatum* is dependent upon public lands for maintenance of populations or habitat.

Population Viability Analysis

No Population Viability Analysis exists for this species.

Conservation Action

Existing or Future Conservation Plans

Bat Conservation International and the Western Bat Working Group are leading the effort to complete a North American Bat Conservation Plan that will include all bat species in Canada, the United States, and Mexico. Individual states in the range of *E. maculatum* are working on state bat conservation plans or will begin plans in the near future. Nevada recently completed the Nevada

Bat Conservation Plan (Nevada Bat Working Group 2002) that includes management recommendations for all bat species in the state, including *E. maculatum*.

Conservation Elements

Inventory and Monitoring

Conservation efforts for *E. maculatum* will be based to a significant degree on gathering more data on distribution and population ecology from throughout the range. At present, the two greatest needs are increased inventories in suitable habitat, and routine monitoring in known areas of occurrence. Inventories throughout the state, in a variety of habitats will offer further insight into the habitat specificity of *E. maculatum* in Wyoming. Thorough inventories will potentially identify additional foraging habitats similar to those found in other states, and identify roost locations, at least generally. Several areas with suitable habitat have received no inventory effort.

Areas of suitable habitat including habitat and elevation criteria should be identified from GAP land use/land cover maps or other GIS-level mapping and surveyed for *E. maculatum* in the future using acoustic detection methods. Intensive routine monitoring of known subpopulations using acoustic, mark/recapture, or telemetry techniques may provide insight into migration timing and routes, short and long-term fluctuations in roost fidelity, population changes, seasonal timing of sexual congregations, reproductive timing and habitat preferences.

Roosting and foraging habitat delineation is necessary to better identify critical habitat for *E. maculatum* and perhaps officially designate either crucial habitat or protected areas. Long-term monitoring should be established at priority sites, with special emphasis on riparian habitats and water sources, the most vulnerable of the habitats used by this species.

Habitat Preservation and Restoration

The following recommendations apply primarily to public land management, but should where possible be expanded to include valuable resources on private lands through land trades, private/federal agreements, use of federal programs for private land such as those administered by the Natural Resource Conservation Service, and funding of projects by private conservation organizations.

As suggested in the Nevada Bat Management Plan (Nevada Bat Working Group 2002), contact with climbing organizations, commercial guides, and caving clubs to disperse environmental educational information concerning bats may be valuable for protection of *E. maculatum* roosting areas on cliffs. All state and federal land management agencies with rock climbing resources should conduct these efforts. Large-scale vegetation conversion, particularly timber harvesting techniques that impact meadow foraging habitat; and conversion of riparian woodlands to open uplands through inappropriate livestock grazing practices and herbicide application, should be evaluated for negative impacts to *E. maculatum* during project planning by federal agencies.

Riparian areas in desert ecosystems must be managed to retain native vegetation and water regimes. Livestock grazing and human recreation impacts should be mitigated by managing a percentage of these habitats with an emphasis on native wildlife.

Pinyon-juniper and ponderosa pine, both valuable foraging and roosting habitat for *E. maculatum*, must be managed to retain the maximum potential of the habitat to support bats and other wildlife. Management should include maintaining openings and a mixture of second-growth and mature stands, since this combination creates preferred habitat for bats. All pinyon-juniper

management should ensure that a significant percentage of forest canopy be maintained in each watershed.

Timber harvest and human-created forest openings should be planned to enhance bat foraging habitat by retaining natural, pre-harvest variability in stand structure and interspersion of natural openings, and size and shape of openings. Regeneration openings may provide foraging areas, and in general, stand level changes that result in more open habitat may benefit *E. maculatum* (Schmidt 2002). Variation in harvest rotation ages, cutblock sizes, and cutblock residuals (green trees, snags, downed woody material) should approximate fire return intervals, fire sizes and post-fire residuals that occurred in a natural state. Modified type-cut logging strategies should be used to create a forest mosaic similar to pre-harvest (Walker et al. 1995). Livestock grazing of mountain meadows, spring areas, and riparian zones should be managed to retain native vegetation and adequate water flows, both to retain habitat for prey species and open water for drinking.

Establishment and maintenance of water sources such as wildlife or livestock/wildlife tanks near suitable *E. maculatum* foraging or roost sites will benefit the species (Mollhagen and Bogan 1997). Tanks (at least 8 feet in diameter or with 8 feet of run, and two feet deep) or ponds (at least 10 feet in diameter and three to six inches deep) will be beneficial to all bat species if constructed properly. For maximum habitat value for bats, fencing the primary water source, usually springs, to exclude livestock to maintain clean, clear water is recommended. Water should be piped to an off-site watering tank for livestock. The fence should be placed entirely around the water source being developed or managed for bats, with the top wire no higher than 42 inches, and at least 100 feet from the water so that bat flight access to the tank or pond is not impeded and bats are not impaled on the fence.

No livestock- or wildlife-excluding structures should be placed over the tank itself. Trees, shrubs and other vegetation within the fenced area should be managed to keep it low enough to allow bats on-the-wing access to the water (only low-growing vegetation less than six inches in height within 20 feet of the water, grading upward in height to no more than 42 inches at the fence. Bats can access water in manmade guzzlers, as long as they have room to maneuver in-flight (Schmidt 1999), so water developments should be planned to meet that need. However, pregnant females may be less maneuverable and require unobstructed in-flight access to water sources such as tanks and ponds during the spring-early summer period. Access to water is critical for lactating female bats (Kurta et al. 1989, Schmidt 1999), which may include the period in June through August.

Reconstruction of existing tanks and ponds to meet bat needs will also greatly benefit bats. Regular maintenance of water sources will be necessary to retain the area in the condition described above.

Non-target insecticide spraying projects that reduce the number of insects, particularly moths foraged upon by *E. maculatum*, should be thoroughly investigated by state and federal wildlife authorities before being allowed in areas used by bats, including *E. maculatum*. Pre- and post-project insect population monitoring is recommended for spraying projects conducted in areas occupied by *E. maculatum* to document impacts to non-target insect populations that comprise a substantial portion of their diet. If significant impacts are documented, alternative control programs should be instituted. Herbicide application should avoid riparian areas and meadows, and the practice of mechanical channelization of streams should be avoided since watering pools are lost and foraging habitat impacted.

Oil reserve pits, and other open impoundments of potentially contaminated water, should be covered with netting to prevent aerial access by bats, and regularly maintained. All bat research activities must be conducted responsibly and with the best interest of the bat populations in mind. State scientific research and collection permits should contain stringent requirements for protection of the bat resource during research projects, and collection of *E. maculatum* should be allowed only where justified for management/protection of the species, not merely to add to museum collections.

Prescribed fires that create open areas and maintain herbaceous plant cover, and therefore insect prey base, may benefit *E. maculatum*, especially if combined with silvicultural practices that open up or reduce stands of dog-hair ponderosa pine. Expansion of aspen may benefit *E. maculatum* if further research proves that this habitat provides night roosting habitat to a significant degree.

Captive Propagation and Reintroduction

Captive propagation and reintroduction are not needed or being considered for this species.

Information Needs

The following surveys, research, and data collection are needed:

1) All suitable habitat in the range should be surveyed to document presence/absence.
2) Site-specific surveys should be conducted on all proposed federal projects to document whether E. maculatum habitat is present in the project area. If suitable habitat exists, acoustic surveys should be conducted to determine whether or not the species occurs. If occurrence is documented, conservation measures should be implemented.

3) Research is needed on interspersion of forest habitat types, size and shape of openings, age of forest, etc. that constitute preferred foraging habitat.

4) Research is needed on quantification of foraging habitat – is it a function of prey availability, vegetation type or structure, size and number of openings or juxaposition of openings?

5) Research is needed to define what characteristics make a potential cliff roosting site suitable or unsuitable for E. maculatum use?

6) Research is needed to define seasonal movement patterns of E. maculatum, particularly in higher elevation range such as Wyoming?

7) Research is needed to identify the boundaries of sub-populations.

8) Research is needed to determine the age structure of metapopulations.

9) Research is needed to determine whether or not the presence of open water all year is critical for occurrence of E. maculatum in local areas, or is open water necessary only during lactation?

Tables and Figures

Table 1. Status of *E. maculatum* by ecoregions or groups of ecoregions (Western Bat Working Group 1998)

- [Region 1] Marine Regime Mountains (western Washington and Oregon): **Peripheral**
- [Region 2] Intermountain Semi-Desert Province (parts of eastern Washington and Oregon, Idaho, Montana, Wyoming, Colorado, Nevada and Utah): **High** Priority; Region 2 contains the known range in Wyoming: the inter-mountain basins adjoining the Bighorn Basin, south to the Laramie Plains, and the basins of southwestern Wyoming up to the lower elevations of the Wind River and Salt River Ranges.

- [Regions 3, 4, 9, and 10] Temperate Steppe Regime Mountains, Temperate Desert Regime Mountains, Temperate Steppe, Tropical/Subtropical Steppe (parts of Colorado, Idaho, Utah, and Texas: **Moderate** Priority

- [Region 5] Mediterranean (California): **High** Priority
- [Region 6] Inter-mountain Semi-Desert (parts of Colorado, Utah, Nevada and California): **High** Priority

- [Regions 7 and 8] Colorado Plateau/Arizona-New Mexico Mountains - Semi-Desert (parts of Arizona, New Mexico, Utah, and Colorado): **Moderate** Priority

Table 2. Classification of *E. maculatum* by state wildlife agencies; those states not listed either do not contain populations of *E. maculatum* or have provided it no special status.

Arizona	Candidate Species -Wildlife of Special Concern List (Habitat limited and potentially threatened, population declines seem imminent)
California	Species of Special Concern
Colorado	Nongame Species
Idaho	Species of Special Concern
Montana	Species of Concern (S1 Rank = Critically imperiled because of extreme rarity or biological factors that make it especially vulnerable to extinction)
New Mexico	Threatened
Nevada	Threatened
Oregon	Unclassified
Texas	Threatened
Utah	Species of Special Concern
Wyoming	Species of Special Concern - Native Species Status 2 (Restricted in numbers and distribution)

Table 3. Classification of *E. maculatum* by the Heritage Program

- Global Heritage Status Rank: G4
  - Global Heritage Status Rank Reasons: Widespread in North America; sparse, but more common than formerly believed. Abundance, population trend, and threats are essentially unknown.
- National Heritage Status Rank, United States: N3N4
- National Heritage Status Rank, Canada: N3
- U.S. and Canada State/Province Ranks: see below
  - AZ (S1S2), CA (S2S3), CO (S2), ID (S2), MT (S1), Navaho Nation (S3), NV (S1S2), NM (S3), OR (S1), TX (S2), UT (S2S3), WA (S3), WY (S1B, SZN), BC (S3)

Table 4. Comparison of location records of *E. maculatum* pre-1981, collected and reported by O'Farrell (1981), with a number of location records in 2003, reported by a variety of sources listed below.

	Pre-1981	2003
Arizona	6	no data
California	10	23 (Pierson and Rainey 1998)
Idaho	1	no data
Montana	1	no data
New Mexico	9	no data
Nevada	6	11 (Geluso 2000)
Oregon*	1	2 (Rodhouse pers. comm.)
Texas	3	no data
Utah	12	10 (Toone 1991)**
Wyoming	1	14 (Priday and Luce 1999)

* Not included in O'Farrell

**O'Farrell records were reevaluated

Figure 1. Photo of first *Euderma maculatum* captured in Wyoming (M.Bogan).

Figure 2. Photo of *Euderma maculatum* (M. Bogan)

Figure 3. *Euderma maculatum* North American Distribution Map (adapted from Bat Conservation International)

Figure 4. *Euderma maculatum* Wyoming Distribution Map (adapted from Priday and Luce 1999 and information from the Wyoming Natural Diversity Database)

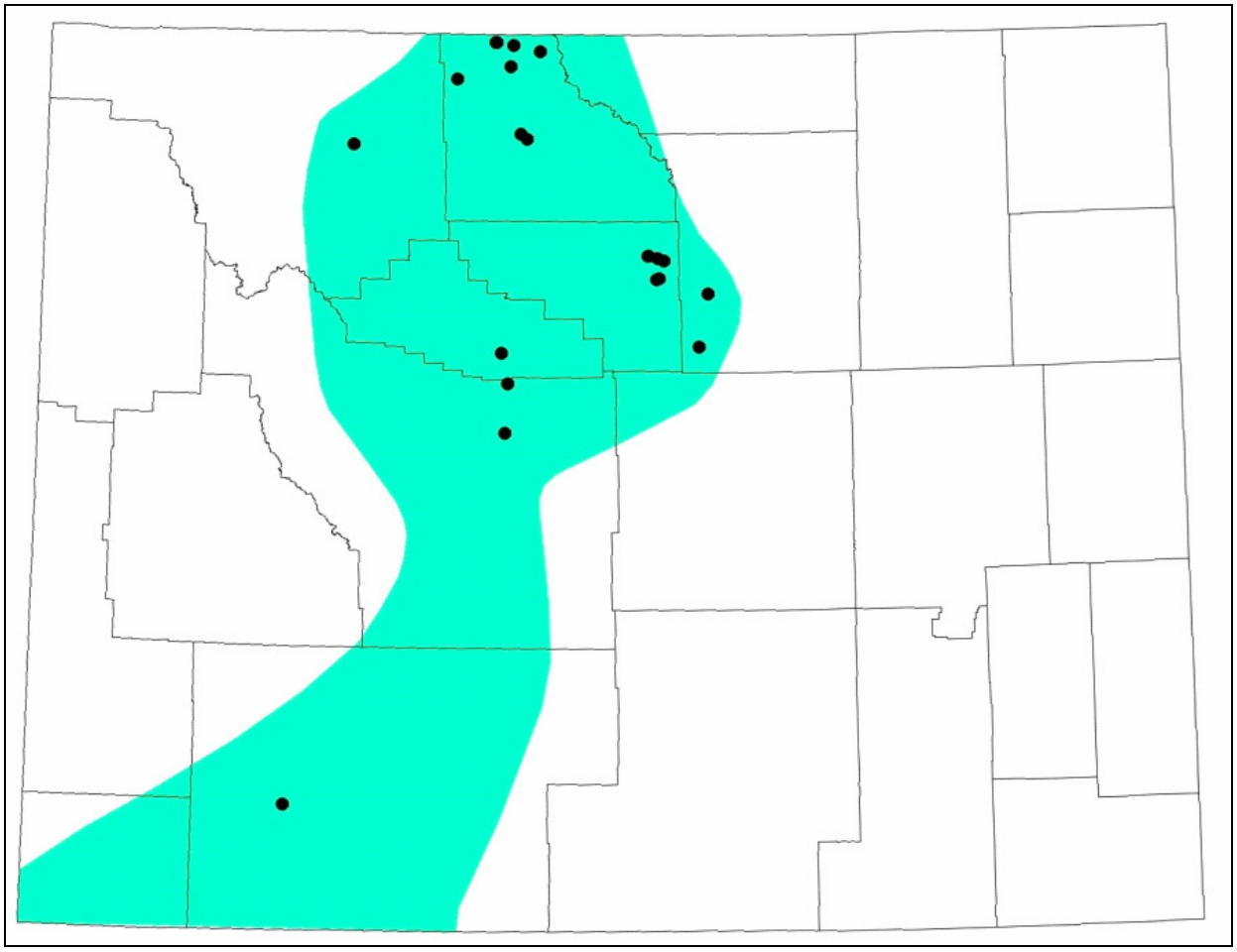

Figure 5. Typical *Euderma maculatum* habitat in Wyoming along the Bighorn River in Sheep Canyon near Greybull (B. Luce).

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