THE EFFECTS OF HUMAN DISTURBANCE ON

BIRDS IN BASTROP STATE PARK

A Dissertation

by

HEIDI ANN MARCUM

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Keith A. Arnold
Committee Members,	Nova J. Silvy
	William E. Grant
	David Scott
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ABSTRACT

The Effects of Human Disturbance on Birds

in Bastrop State Park. (August 2005)

Heidi Ann Marcum, B.S., Tarleton State University;

M.S., Baylor University

Chair of Advisory Committee: Dr. Keith A. Arnold

With rapidly disappearing natural areas due to development and fragmentation, public lands provide important habitat for birds. However, the increasing use of public lands for recreation may decrease the value of these areas for bird use. Human disturbance can damage birds in many ways, including disrupting foraging or social behavior, increasing nest predation, interfering with parent-offspring and pair bonds, increasing nesting failures, and reducing the viability of fledglings. Additionally, birds may perceive humans as predators and leave an area, and the resulting decline in species abundance resembles the effects of habitat loss. Increased human outdoor activity has created the need for information regarding the effects of human disturbance on birds. I investigated the effects of human disturbance on birds in Bastrop State Park (BSP) in central Texas in 1998 and 1999. A wide variety of people use much of BSP, and many areas within the park experience significant amounts of disturbance from people and vehicles, particularly in campgrounds. I evaluated the effects of various types of human disturbance on the presence of 20 avian species, including seven neotropical migratory species. Brown-headed Cowbird (*Molothrus ater*), Mourning Dove (*Zenaida* *macroura*), Carolina Wren (*Thryothorus ludovicianus*), and Summer Tanager (*Piranga rubra*), were sensitive to human presence, and Blue Jays (*Cyanocitta cristata*), and Downy Woodpeckers (*Picoides pubescens*) occurred in lower abundances in sites with higher numbers of vehicles. However, other species (e.g., American Crow [*Corvus brachyrhynchos*], Black-and-white Warbler [*Mniotilta varia*], Pileated Woodpecker [*Dryocopus pileatus*], Red-eyed Vireo [*Vireo olivaceus*], Ruby-throated Hummingbird [*Archilochus colubris*], White-eyed Vireo [*Vireo griseus*], and Yellow-billed Cuckoo [*Coccyzus americanus*]) tolerated humans, vehicles, or both. Neotropical migratory species did not show higher sensitivity to disturbance when compared to resident species, and forest interior species were not more sensitive than edge species. My results indicate that some species, including migrants, can become habituated to human presence in protected areas with low harassment and low-intensity, predictable disturbances. Management recommendations for BSP include protecting habitat, minimizing human disturbance in some areas, providing buffer zones between human-dominated zones and sites containing vulnerable species, and softening edges in campgrounds.

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INTRODUCTION

Many people of diverse cultures appreciate and regularly observe wildlife. Interest and participation in non-consumptive outdoor recreation have increased rapidly during the past 40 years, and recreational use of public lands has risen steadily. In 2001, more than 82 million U. S. residents participated in hunting, fishing, and wildlife viewing, and spent over $108 billion in activities involving wildlife (United States Department of the Interior 2002). Considerable evidence exists, however, that human-caused disturbance from these activities damages wildlife (Hume 1976, Boyle and Samson 1985), with clear links between disturbance and the survival and reproductive success of individuals (Schulz and Stock 1993). Human activities can affect wildlife by causing them to leave an area (McLellan and Shackleton 1988, Andersen et al. 1990), disrupting foraging or social behavior (Burger 1981, 1986, Edington and Edington 1986:41, Skagen et al. 1991), increasing nest predation (Strang 1980, Safina and Burger 1983, Piatt et al. 1990), and directly decreasing wildlife densities (Werschkul et al. 1976, Erwin 1980, Madsen 1985). However, in many cases disturbance acts in more subtle ways, by disrupting pair bonds (Tindle 1979), increasing nesting failures (Boeker and Ray 1971), and reducing the viability of fledglings (Korpimaki and Lagerstrom 1988). Such changes in reproductive activities (Stalmaster 1980, Safina and Burger 1983, Knight and Knight 1984, Giese 1996) and decreased breeding success (Wiley 1975,

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This dissertation follows the style and format of The Auk.

White and Thurow 1985) can threaten the future reproductive success of species in an area (Drent and Daan 1980).

Disturbance amplifies the problems caused by habitat fragmentation (Aleixo 1999), because it decreases available habitat (Hill et al. 1997). Where disturbed areas resemble fragmented habitats, some species of forest birds that avoid edges probably occur in lower numbers or are absent (Anderson et al. 1977, Ferris 1979, Whitcomb et al. 1981, Kroodsma 1984). Additionally, disturbance can mimic habitat loss without actual fragmentation of the original patch by reducing access to foraging, nesting, and shelter areas (Gill et al. 1996), decreasing the area's carrying capacity and suitable habitat, and triggering a decline in species richness and abundance (Fernández-Juricic 2000). Because some species are sensitive to human presence (Ollason and Dunnet 1980, Burger et al. 1995, Rodgers and Smith 1995), while others become habituated to humans (Jacob 1983), disturbance can influence the probability of occupation of an area by some species and change the composition of the entire avian community.

To protect wildlife in the face of decreasing habitat, many public lands have been designated as protected areas, such as parks. Many of these areas consist of protected vegetation types embedded in an urbanized matrix, making them islands of suitable habitat within a sea of unsuitable habitats (Fahrig and Paloheimo 1988). Although these public lands may contain habitat suitable for a variety of birds, the presence of humans may prevent some species from occupying the area. To properly manage protected public areas, planners and managers must balance providing recreational opportunities against providing species with appropriate habitat for survival and reproduction. To do this, they must obtain a better understanding of the relationship between recreational activities and wildlife. An improved understanding of species-specific responses to human disturbance can help predict, mitigate, and manage changes in distribution and abundance of species. Researchers can determine the degree and types of disturbance which impact wildlife most significantly (Ollason and Dunnet 1980), and this information can be used to minimize the effects of disturbance (Safina and Burger 1983), while allowing people to experience the benefits of outdoor recreation (Risser 1993).

The rapid increase in human outdoor activities has created an immediate need for information on the effects of human disturbance to wildlife in protected areas. In this study, I identified human disturbance factors that significantly influence distribution and abundance patterns for birds within Bastrop State Park (BSP), in central Texas. Specific objectives were to: (1) quantify the disturbance factors in BSP, (2) identify and estimate the potential impact of selected human activities on abundance of birds in the park, and (3) develop strategies for managing a state park for both conservation and recreational purposes. Specific hypotheses were: (1) species that avoid edge habitats will occur in lower numbers, or be absent, from disturbed areas in BSP, (2) neotropical migratory species will be more sensitive to human disturbance than resident species at BSP, and will occur in lower numbers in disturbed areas, (3) resident species tolerate higher indices of disturbance than migratory species; and (4) edge species tolerate higher indices of disturbance than forest interior species.

Review of the Literature

Over the past several decades, scientists, wildlife managers, and others have become increasingly concerned about the detrimental effects of human activities on birds (Burger 1981, Yalden 1992, Fox and Madsen 1997). This issue becomes even more important when coupled with the loss of natural habitats due to human encroachment, and increased use of the remaining undisturbed places for non-consumptive, leisure activities (Madsen 1994). Human disturbance can change avian behavior, and affect the temporal and spatial distribution of various species of birds. Depending on its frequency and severity, disturbance can result in short-term or long-lasting effects. Short-term effects are easier to observe and to quantify, but the long-lasting effects have the strongest impact on populations (Bell and Owen 1990).

Although ornithologists have long been aware of the problems caused by human disturbance (Stoddard 1932, Kalmbach 1938, Johnson 1938, Skutch 1966), more recent studies have actually evaluated the problem (Evans and Wolfe 1967, Grier 1969, Newton and Campbell 1975, Ellison and Cleary 1978, Gottfried and Thompson 1978, Westmoreland and Best 1985). Several reviews of the literature have examined hundreds of articles that show the effects of human disturbance on wildlife (Anderson and Keith 1980, Boyle and Samson 1983, 1985, Grier and Fyfe 1987, Götmark 1992). Boyle and Samson (1983) identified 536 references concerning the effects of non-consumptive outdoor recreation on wildlife, and Götmark (1992) identified 225 studies that addressed the effects of observer disturbance on nesting birds. In 166 articles, Boyle and Samson (1985) determined birds and mammals as the most commonly reported subjects, and the most widely reported effects on wildlife came from hiking, camping, boating and wildlife observation.

Human intrusion. Interest and participation in outdoor recreation, particularly of a non-consumptive type, have increased rapidly (Brockman and Merriam 1973, United States Department of the Interior 2002). As more people use public areas for recreation (Batten 1977, Yalden 1992), managers and others have become concerned about the adverse effects on wildlife using these areas (Stalmaster and Newman 1978, Kaiser and Fritzell 1984, Hockin et al. 1992).

Many forms of outdoor recreation, such as shore recreation (Pfister et al. 1992), boating (Kahl 1991), and the use of off-road vehicles (ORVs) (Webb and Wilshire 1983) can be blatantly intrusive. Other disturbances may develop in the absence of any detectable ecological changes (Purdy et al. 1987: 21), and simply involve human presence in an area. The mere presence of people in the environment, termed intrusion, does not damage vegetation or cause other obvious community changes, but is a pervasive form of environmental disturbance (Gutzwiller et al. 1994). Bird colonies, and large, showy species such as herons (family Ardeidae), flamingoes (family Phoenicopteridae) and ibises (family Threskiornithidae), show particularly severe effects from intrusion disturbances (Burger et al. 1995). These activities, including hiking, fishing, and nature viewing, may seem innocuous, but they can significantly affect birds by disturbing resting and foraging activities (Burger 1981, 1986, Edington and Edington 1986:41, Skagen et al. 1991), causing them to leave the area (McLellan and Shackleton 1988, Andersen et al. 1990), disrupting pair bonds (Tindle 1979), and decreasing flock sizes and densities (Werschkul et al. 1976, Erwin 1980, Madsen 1985, Burger et al. 1995). As intrusion displaces individuals, it reduces reproduction and survival (Boyle and Samson 1985, Knight and Gutzwiller 1995, Riffell et al. 1996) and changes the quality of habitats for reproduction and survival of the remaining individuals (Gutzwiller et al. 1997).

Humans as disturbance. People on foot can have a particularly strong impact on birds within an area. In many areas, pedestrians are one of the most frequent forms of human disturbance to nesting waterbirds (Rodgers and Smith 1995). Birds may avoid trails, beaches, and even protected fields when humans are present, but use them when humans are absent (Clark and Niles 1986, Burger et al. 1995). Observers such as birdwatchers and field researchers may, themselves, disturb birds, and the effects of this disturbance may range from negligible to significant. Some studies have reported little effect (Gottfried and Thompson 1978, Gailbraith 1987, Vickery et al. 1992), while others have demonstrated drastic effects, particularly on nesting success (Evans and Wolfe 1967, Ellison and Cleary 1978, Livezey 1980, Ollason and Dunnet 1980). Although birdwatchers may not mean to harm the birds they watch, they habitually approach their subjects, and Burger et al. (1995) found many dead chicks, from pecking by adults, starvation, or cold stress, after people had visited the nesting area. The speed at which people pass through an area also may affect the impact on birds: slow-moving birdwatchers may have less of an impact than joggers or other fast-moving people (Burger 1991).

Researchers studying avian behavior and fecundity require unbiased data, but their mere presence can influence behavior and nesting success. When people observe birds, they may change the conditions surrounding the birds, which may reduce the validity of their conclusions drawn from the investigation, a phenomenon called the "uncertainty principle" (Lenington 1979).

Roads as disturbance. In the past few decades, road construction has drastically changed landscapes and modified animal communities. Roads affect wildlife populations by causing direct mortality (Hodson 1966, Case 1978), especially for juvenile dispersers (Wegner and Merriam 1979). Roads also increase habitat fragmentation (Mader 1984, Andrews 1990), and intensify toxic contamination among roadside populations (Jefferies and French 1972, Muskett and Johnes 1980). Other studies have examined the effects of roads and traffic on breeding success (Harmata et al. 1978, Van der Zande et al. 1980), and Boyce (1981) found the nesting success of Prairie Falcons (*Falco mexicanus*) increased with distance to roads. Roads serve as corridors for predators; both mammalian and avian predators take advantage of the lack of barriers along roadways to reach their prey (Anglestam 1986, Dreschel et al. 1991, Varland et al. 1993, Breininger et al. 1995). The constant noise from traffic along a larger road also may inhibit vocal communication for birds during social hunting (Varland and Loughin 1992). As traffic increases, this volume, along with increased speeds of traffic, greatly increases avian mortality along roadways (Village 1990). Finally, roads influence community structure, because busy roadways displace some species away from roadways, equivalent to a 'loss' of habitat (McLellan and Shackleton

1988), and also function as edges (Boag et al. 1984), allowing an increase in edge-related passerines (Wunderle et al. 1987).

Responses to vehicles and traffic may be species specific. Even a little traffic can displace some sensitive species. Breeding Trumpeter Swans (*Cygnus buccinator*) reacted to traffic when the vehicles stopped along roadways or sounded their horns (Henson and Grant 1991). Other species, however, may habituate to traffic. Nesting Least Terns (*Sterna antillarum*), and Black Skimmers (*Rhynchops niger*) rarely flushed from nearby traffic such as large, noisy tractor-trailers (Rodgers and Smith 1995). In fact, some species tolerate roadways and vehicle movement better than disturbance from people (Vaske et al. 1983, Vos et al. 1985, Freddy et al. 1986, Hill et al. 1997).

Vulnerability to disturbance. In the wild, birds must maintain constant vigilance to detect predators, search for food, find mates, and watch for competitors. In areas that experience human disturbance, birds must increase their vigilance to avoid unwanted human interactions, since humans prey on birds, harass them, or disturb them inadvertently (Burger and Gochfeld 1991).

Avian vulnerability to disturbance is a function of the type and frequency of disturbance and the species involved, which influences whether a disturbance generates any responses from birds (Sousa 1984, Rapport et al. 1985, Petraitis et al. 1989). Disturbances in various forms can occur throughout the year, and may, at times, last all day. For example, an area may be used for hunting during the fall months, and for leisure activities (e.g., walking, sailing, and wind surfing) during the rest of the year (Madsen 1994). Factors contributing to species responses include timing of the disturbance (breeding season or not), group size (solitary or flocks), activity (foraging, resting, nesting), habitat used (edge species or forest interior species), degree of wariness, species size, feeding behavior, and location (ground, perched in trees, or on water). Rare birds attract more humans, and are often surrounded by birdwatchers or photographers, which makes it hard for them to forage, rest, or take care of their young (Burger et al. 1995).

Differences may exist in the responses between migratory and resident species to disturbance. Flather and Sauer (1996) found human-dominated landscapes (i.e., agricultural and urban land) contained fewer neotropical migrants than more natural landscapes. The amount of edge in a habitat may influence whether neotropical migrants use an area. Lower relative abundance of neotropical migrants occurred in landscapes with higher forest edges, while permanent residents showed little sensitivity to variation in landscape structure (Flather and Sauer 1996). On the other hand, many migratory species are habitat generalists (Petit et al. 1993), since resident species that inhabit an area year-round occupy the specialized niches, leaving suboptimal habitats for the migrants (Rappole et al. 1989, Askins et al. 1990).

Disturbance effects on bird behavior. Disturbance may directly change the behavior of birds in all life stages, as adults, juveniles, and chicks. This altered behavior may change foraging patterns (Skagen et al. 1991), increase distraction displays, or cause birds to leave, or completely avoid, the disturbed areas (Burger et al. 1995). Additionally, the higher level of vigilance required reduces the time available for foraging, which places increased stress on adults trying to find food for themselves and their young, and young learning to forage (Burger 1991). Reduced foraging time may affect survival of the adults or young if they do not obtain enough food reserves (Burger et al. 1995)

Disturbance also may affect breeding behavior, resulting in detrimental effects on reproduction in those species that use recreational areas for nesting and breeding (Gillet et al. 1975, Tremblay and Ellison 1979, Cairns 1980, Safina and Burger 1983, Keller 1989). Several studies have shown qualitative (Johnson and Sloan 1976, Ellison and Cleary 1978, Anderson and Keith 1980) and quantitative (Jenni 1969, Tremblay and Ellison 1979, Parsons and Burger 1982, Kaiser and Fritzell 1984) human impacts on bird species (Rodgers and Smith 1995). Any disturbance that causes adults to leave their nest can cause losses of either eggs or young (Hunt 1972, Kury and Gochfeld 1975, Anderson and Keith 1980, Hand 1980, Titus and van Druff 1981) or total abandonment of nests (Tremblay and Ellison 1979, Livezey 1980, Safina and Burger 1983). Adverse effects on the young include nestling mortality (Teal 1965, Jeffrey 1984), premature fledging or nest evacuation (Veen 1977) and reduced body mass or slower growth of nestlings (Kury and Gochfeld 1975, Pierce and Simons 1986). Species often have fewer individuals nesting and lower reproductive success at colonies visited by humans (Burger et al. 1995). These negative effects on reproduction can ultimately result in low breeding success and a decline in the breeding population.

The impact of nest visitation on nesting success may be influenced by the visitation schedule (number and timing of visits), observation methods, predators present, and habitat characteristics (Rotellam et al. 2000). The number of visits to a nest may influence mortality rates, with highest mortality the first day after a nest visit than on subsequent days for American Robins (*Turdus migratorius*), Eastern Bluebirds (*Sialia sialis*), and Mourning Doves (*Zenaida macroura*) (Bart 1977). Renesting or courting Black-crowned Night Herons (*Nycticorax nycticorax)* abandoned their nests and avoided the colony when researchers visited their colonies during the early nesting period, but did not respond as strongly during late incubation (Tremblay and Ellison 1979).

Although bird species that nest near or on the ground may be particularly vulnerable to disturbance (Yalden 1992), many species position their nests in an attempt to maximize nesting success and minimize the effects of human disturbance. Black-billed Magpies (*Pica hudsonia*) (Brown 1957, Ratcliffe 1962, Knight and Fitzner 1985) and Northwestern Crows (*Corvus caurinus*) (Stoner 1937), increase their nest height in disturbed areas, and American Robins nest higher in trees in urban areas (Preston and Norris 1947, Weber 1975). Finally, birds may learn from past experience with human disturbance and respond by placing their nests in higher, less vulnerable locations (Dhindsa et al. 1989).

Disturbance effects on nest predation. Another serious effect of disturbance may be the increased rates of predation on nests by local predators (Lack 1954). In fact, nestling predation may be as significant as deforestation in wintering grounds in the decline of some avian species (Bohning-Gaese et al. 1993). Nest visits by humans may provide predators and/or brood parasites with cues for finding nests (Nichols et al. 1984, Westmoreland and Best 1985), which can increase nest predation rates (Strang 1980, Wilcove 1985, Sieving 1992), particularly in open-nesting species, where avian predators could easily follow people searching for nests (Götmark and Ahlund 1984, Westmoreland and Best 1985). Increased nestling and egg predation can result from disturbing the vegetation around nests (Morton et al. 1993) or using an experimental apparatus that attracts predators (Nol and Brooks 1982). Disturbance also may cause birds to discontinue nest defense, or leave the area long enough for predators to steal eggs (Götmark 1992). Conversely, investigator disturbance can increase nest success by repelling predators that avoid contact with humans (MacIvor et al. 1990, Morton et al. 1993). Ultimately, predation affects population dynamics, population growth and structure of the community (Martin 1993).

Humans as predators. Animals often perceive humans as potential predators, and the effects of disturbance on animal behavior mirror those of predation risk. A conflict results from the choices a bird must make: to avoid the disturbance or to continue its normal foraging, roosting or nesting behavior in spite of the disturbance (Gill et al. 1996). In a disturbed area, animals have several options to avoid humans. Depending on the species, stage of life and type and degree of disturbance, an animal may leave the area, become more nocturnal, or avoid using trails or areas where humans travel (Griffiths and van Schaik 1993). Finally, if birds avoid highly disturbed resource patches, then, as with the response to the risk of predation, that resource becomes, in essence, unavailable and the total carrying capacity for that area declines (Gill et al. 1996).

Habituation. Some species of birds have adapted to disturbance by becoming habituated to humans (Robert and Ralph 1975, Burger 1981, Burger and Gochfeld 1981, Knight and Fitzner 1985, Dhindsa et al. 1989, Keller 1989, Conomy 1993, Conomy et al. 1998). Habituation is an adaptive mechanism in which organisms minimize their response or cease to respond to stimuli, which prevents needless expenditures of energy (Boudreau 1968). An organism that becomes habituated can maximize maintenance, energy intake, and energy-conservation activities. The process of habituation involves learning (Petrinovich 1973, Petrinovich and Patterson 1982) and relates to the experiences which the birds have had with people (Burger and Gochfeld 1983).

Habituation may be a species-specific phenomenon that reflects the capabilities of various species to become accustomed to the presence of humans (Belanger and Bedard 1990), and depends on the species, social organization, environment, and season (Barry and Spencer 1976, Busnel 1978, Burger 1981, Tuite et al. 1984). Birds protected in parks or nature reserves often habituate to the activities of people, and allow them to approach closely without responding or showing negative effects (Humphrey et al. 1987); for example, passerine species in suburban areas are more approachable than those in rural areas (Cooke 1980), and other species such as Great Crested Grebes (*Podiceps cristatus*) readily breed in suburban parks (Jacob 1983), reproducing successfully in areas close to human activities (Keller 1989). Still other species may even become more aggressive towards people (Burger and Gochfeld 1991).

The time of year may influence whether birds tolerate human disturbance: species may become accustomed to visitors during summer months, but in the winter, with fewer visitors present, wintering species may not habituate to humans (Buehler et al. 1991). However, in winter ski resorts, a species can become habituated to skiers, ignoring the people unless the skiers stopped too close to them (Watson 1979). Species that habituate may have a historic association with humans. For example, Brown Pelicans *(Pelecanus occidentalis)* frequently associate with fishing activities, while Cattle Egrets (*Bubulcus ibis*) often follow farm machinery; both species habituate well to humans (Rodgers and Smith 1995). Other species may habituate to regular and predictable disturbances, rather than erratic and startling disturbances (Hockin et al. 1992, Fox and Madsen 1997). In protected areas, with regular exposure to people who pose no threat, individual birds may become habituated to disturbance (Petrinovich 1973, Burger and Gochfeld 1991), since they have learned that humans are not predators.

Despite habituation, however, excessive closeness or persistant disturbance can still affect birds. Although some species of gulls habituated to the presence of humans after repeated exposure, people still interrupted their foraging activities (Burger and Galli 1987). Even if birds do habituate to humans and tolerate close approach, they must constantly move out of the path of strollers, joggers and vehicles in areas with humans, and may fly away when frightened (Burger et al. 1995).

The role of state parks in species protection. State parks provide a wide range of resource protection; some are managed mostly for preservation, while others are intensively developed for public recreation. Parks may be developed in ways that provide opportunities for compatible types of resource-based recreation (Texas Parks and Wildlife Department 1975), but many have increasingly undergone changes to make them more amenable for recreation: roads, electrical lines, and cabins are built for recreation convenience, vegetation is cleared and mowed to provide more open space, and bird feeders are used to attract species to an area for birdwatching. While these activities may be desirable from a recreational standpoint, the disturbance to wildlife, including birds, can be significant.

Even in habitats set aside for conservation purposes, recreational activities can severely degrade the value to wildlife (Garton et al. 1977, Madsen 1985, Blakesley and Reese 1988). Although managers may be highly committed to resource protection in state parks, mounting pressure from the public can affect any species sensitive to disturbance and negatively influence their population trends (Goethe et al. 1981). As recreation expands, the impacts on wildlife mount (Purdy et al. 1987, Whelan 1991, Holecek 1993). With these long-term, widespread and increasing recreational impacts, agencies charged to preserve wildlife populations and communities find it difficult to meet their goals (Purdy et al. 1987), and maintain the balance between wildlife protection and human enjoyment.

METHODS

Bastrop State Park

Study site. I conducted this study at BSP, 48.3 km southeast of Austin in Bastrop County, Texas. Bastrop State Park is located in Region 2, the prairies and lakes region, of Texas (Fig. 1), which extends from the northern border of Texas, through Fort Worth, Dallas, and Waco, and continues south to Interstate 10. Region 2 includes the Oak Woods and Prairies and Blackland Prairie ecoregions, and contains more than 20 state parks. Bastrop State Park occurs in the area of Texas that serves as a transition zone between the east Texas pine woodlands and the western Great Plains. This highly fragmented part of Texas has over 75% of the natural vegetation converted to agriculture, and only 1% of the intact vegetation remains, which has severely limited natural ecological processes (Ricketts et al. 1999).

Opened in 1937, BSP (30:06:00 N, 097:20:00 W) encompasses 1,418 ha, and is the site of the famous “Lost Pines” forests of Texas. This unique area contains loblolly pine (*Pinus taeda*) woodlands that are separated from east Texas pines by 161 km of post oak (*Quercus stellata*) woodlands. Bastrop’s elevation ranges from 114 to 183 m above sea level, and consists of gently rolling and hilly terrain. Annual precipitation averages 92.7 cm, with cool winters (January average = 3.3° C) and hot summers (July average = 35.6° C). Forested land covers the majority of the park, with scattered campgrounds and a 4-ha lake, stocked annually with channel catfish (*Ictalurus*

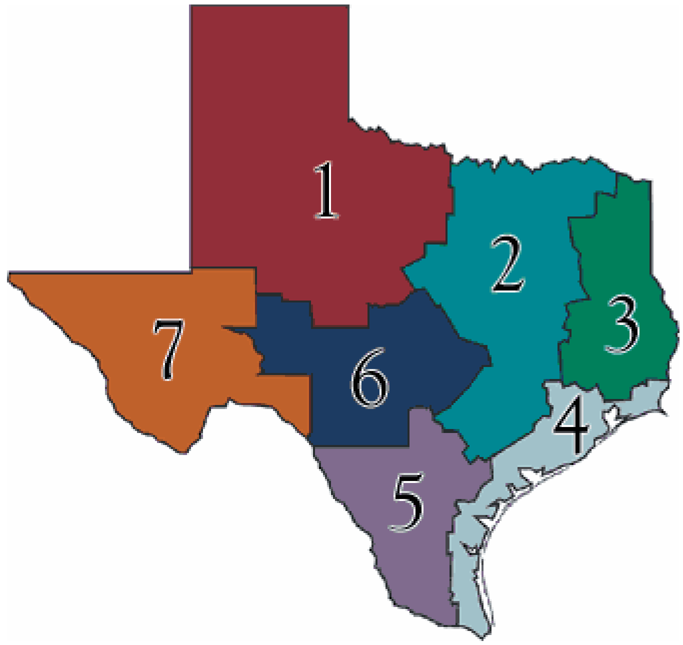

Fig. 1. Texas regions (1 = Panhandle Plains, 2 = Prairies and Lakes, 3 = Pineywoods, 4 = Gulf Coast, 5 = South Texas Plains, 6 = Hill country, 7 = Big Bend Country). (Source: Texas Parks and Wildlife Department, http://www.tpwd.state.tx.us/park/clicpark.htm).

punctatus), bass (*Micropterus* spp.) and sunfish (*Lepomis* spp.). Most of this heavily wooded park contains large (woody stems > 2.5 m tall) deciduous and coniferous trees, snags and a high percent of canopy cover. Ground cover consists of woody and nonwoody vegetation, and ranges from sparse to very dense. Litter covers much of the ground within BSP, but campgrounds have large areas of bare ground (Marcum, unpublished data). BSP also has extensive areas of watered grass, and a well-maintained golf course.

Dominant canopy trees include pecan (*Carya illinoinensis*), walnut (*Jugans* spp.), black hickory (*Carya texana*), American sycamore (*Platanus occidentalis*), burr oak (*Quercus macrocarpa*), eastern cottonwood (*Populus deltoides*), post oak, buckeye (*Aesculus* spp.), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), red oak (*Quercus texana*), bald cypress (*Taxodium distichum*). Subcanopy/shrub trees include Texas persimmon (*Diospyros texana*), wax myrtle (*Morella cerifera*), Mexican plum (*Prunus mexicana*), flameleaf sumac (*Rhus copallinum*), green hawthorn (*Crataegus viridis*), escarpment black cherry (*Prunus serotina*), American elderberry (*Sambucus* spp.), and buttonbush (*Cephalanthus* spp.).

Open 7 days a week, BSP is used year-round by approximately 580,000 people/year. Visitors to BSP can participate in a wide variety of recreational activities, including canoeing, swimming, backpacking, camping, picnicking, golfing, wildlife viewing and hiking. Campers can rent cabins (13 in the park), use their own recreational vehicles in developed campsites, or pitch tents in primitive campsites. BSP contains 35 sites with full water, electricity and sewer facilities, 19 campsites with water and electricity (for recreational vehicle or tent users), and 24 tent sites (water only). Primitive camping, where people backpack in, is allowed in virtually all parts of the park. BSP also contains a group barracks and a dining hall for day use. Bastrop State Park is bordered on one side by a major highway less than 100 m from its perimeter. Traffic on this road increases during weekday rush hours and holidays. A two-lane, paved road runs through the center of the park, allowing for "drive-through" visitors.

Because of its close proximity to Austin, day users also visit BSP. In addition to its 18 hole golf course and outdoor swimming pool, people have access to more than 40 km of hiking trails, ranging from well-marked to obscure, barely used trails. Fishermen, birdwatchers, joggers, and hikers often use these trails to reach various spots throughout the park. Several areas of the park are heavily used (e.g., campgrounds, the lake), while other areas have no trail access and receive little human traffic. Park visitation is typically highest on weekends, holidays and the summer months.

Vegetative and trail characteristics of BSP. Bastrop State Park has trails located throughout the park. Some wide, accessible trails leave the campgrounds or are easily entered from parking lots near the roads. Several well-marked trails wind through the forested areas; park staff maintain these and keep them free of obstacles. Other relatively hidden and inaccessible trails occur in more remote areas. Compared to other Texas state parks, BSP does not have paved trails or trails composed of rocks; trails are either gravel-based or bare ground. Since many trails wind through heavily forested areas, canopy cover is not reduced in point counts with trails. Given the large number of trees of many different class sizes, litter is the major cover for many trails.

Field Techniques

Point count placement. With the help of K. Blair, of the Texas Parks and Wildlife Department, I located 45 census sites on a digitalized map of BSP (Fig. 2). To minimize the likelihood of encountering the same individual bird on adjacent point counts, the distance between plots is usually at least 150 m (Annand and Thompson 1997), or 200 m (DeSante 1986, Blake and Loiselle 2001). Because 150 m is not sufficiently far apart to prevent counting birds on more than one point count (Willson and Comet 1996), and since larger forest birds may forage more than 250 m from their nest site (Bull and Holthausen 1993), I set all point counts in this project at least 500 m apart. This distance, while not as great as Riffel et al.'s (1996) 700 m, or Burdick et al.'s (1989) 800 m distances, is a compromise between minimizing recording the same individual in two point counts and providing representative samples of the available habitat contained with the park. I first located count sites on the digitalized map to avoid bias in selecting habitats within the park, and ensure that all portions of the park were censused. Additionally, by first using the map to locate the census sites, I could place these plots near a wide variety of areas, such as roads, campgrounds, remote locations, water, and trails. After selecting the sites on the map, I used easily recognizable landmarks on the map to locate the plots in the park.

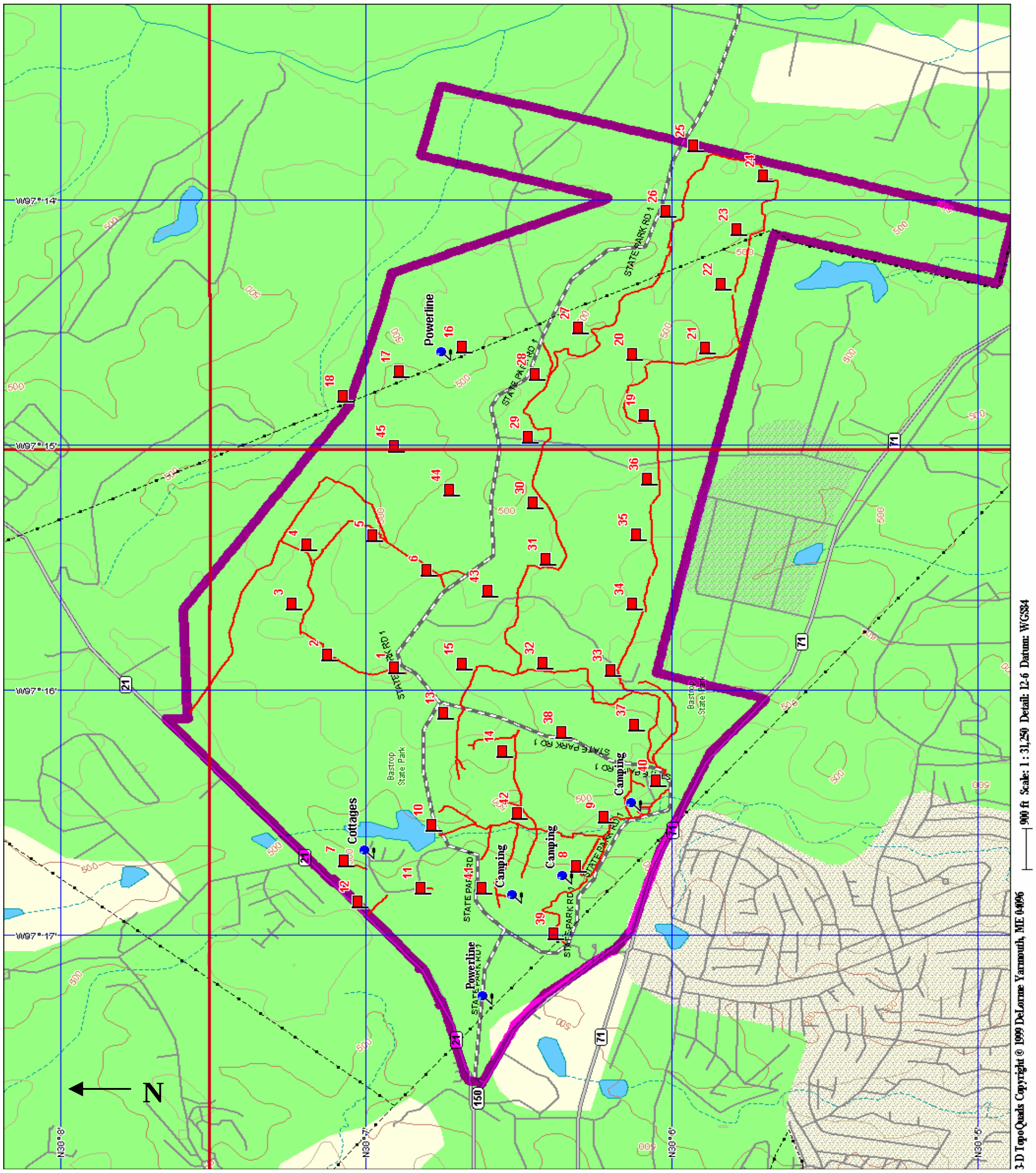

Fig. 2. Location of the 45 point counts at BSP.

I used fixed radius (50 m) point counts (Ralph 1981, Hutto et al. 1986, Koford et al. 1994, Ralph et al. 1995, Smith et al. 1995) to survey birds during the field season. This technique provides a rapid method for determining relative density estimations of bird populations and abundances efficiently (Reynolds et al. 1980). Using the same procedures at each point count gave comparable density estimates and legitimized statistical comparisons between plots (Strong and Bock 1990, Greenberg et al. 1999). At each point count, I drove a 0.5 m metal bar into the ground, and marked the nearest tree with colored tape containing the number of the point count. I also recorded the GPS position of each point count. For point counts located on a trail, I placed the metal bar 1 m off the trail, to prevent vandalism and injury to people.

Bird census. The field season lasted from mid-May until mid-July, in 1998 (8 weeks) and 1999 (9 weeks). This period corresponds to nest building and incubation periods for birds, as well as recreational use of BSP. I used the same 45 sites and census methods both years. Censusing occurred on Saturdays, Sundays, Mondays, Wednesdays, and Fridays, since weekends and summer holidays have the heaviest recreational activity, which is often seven or eight times higher than weekday park usage (Kaiser and Fritzell 1984). One field technician censused all point counts, to avoid observer bias (Scott et al. 1981, Verner and Milne 1989, Jokimäki and Huhta 2000); however, different technicians worked each year. To avoid censusing the same point count at the same time throughout the field season (Robbins 1981), the field technician visited each point count at various times, and in a different order, during the field season. The order of plot visits and entrance points also varied as much as possible. Because of my interest in observing birds when people were most likely to be in the area, the technician conducted point counts from 0800 to 1200 hours (CST). Afternoon counts were not conducted because summer days in Texas often exceed 37.8° C, and people restrict their time outdoors during the hottest parts of the day. Also, bird activities tend to decrease during the middle part of the day (Strong and Bock 1990). By spreading observation periods throughout the morning and the breeding season, the likelihood of detecting rare or less conspicuous species increased (Wagner 1981, Morrison 1984, Bradley 1985, Morrison et al. 1992). Visits to point counts were not made during rain or high winds (Robbins 1981, Ralph et al. 1995, Aigner et al. 1998, Catterall et al. 1998), because birds are less detectable under these conditions (O'Connor and Hicks 1980, Robbins 1981); however, these conditions occur rarely during summer mornings in Texas.

To avoid problems with naïve observers (O'Connor 1981), I used investigators experienced in identifying Texas bird species by sight and sound. Observers avoided disrupting vegetation and ground cover (logs, rocks, etc.). In areas with no trails, the investigator entered the plot from different directions during each census to prevent creation of trails and minimize vegetation disturbance (Gutzwiller et al. 1994). For points on trails, the investigator simply approached the point count using the trail. Observers wore drab gray or brown clothing, since some species may be sensitive to clothing color (Gutzwiller and Marcum 1993), counted alone (no other people or pets), and remained quiet (Gutzwiller et al. 1994).

At each point count, the census period lasted for 8 minutes (Willson and Comet 1996), a compromise between detecting all individuals within the point count and visiting as many point counts as possible. During each census, the investigator began recording individual birds upon reaching the perimeter of the plot, to include species that might fly away or become silenced as the technician approached (Hutto et al. 1986). After reaching the center of the plot, the researcher stayed there for the rest of the count, moving only to detect birds in other sections of the plot. Counts conducted as described are non-intrusive, and observer presence during censuses does not cause behavioral responses (Riffell et al. 1996, Gutzwiller et al. 1997). All birds seen or heard (song, call note, wing drumming) during the census period were recorded (Annand and Thompson 1997, Blake and Loiselle 2001), but not birds flying over the site (Ralph et al. 1995, White et al. 1996). Birds estimated as outside the 50-m radius were recorded, but were not included in subsequent analysis, because of reduced reliability of location and identification. If the technician could not confidently identify the species of an individual, that individual was identified to the family level. The design of the data sheet allowed the observer to record most information with a check mark, identifying species with a four letter code and recording the date, time, temperature, and each bird's position within the plot, as well as any vocalizations, wing noises or drumming.

Human disturbance. One of my goals in locating the point counts throughout BSP included obtaining data from areas that were exposed to substantial human activity and others that were not. The disturbed sites included campgrounds, parking lots, and hiking trails. Human activity is concentrated around these areas and along the shores of the lake. In addition to recording the number of birds observed at each point count, the field technician recorded the number and species of any animals and humans encountered.

During each visit, the technician recorded the number of potential avian predators (dogs, cats, and foxes) observed (Table 1). Disturbances to wildlife can result from anglers, hikers, picnickers, birdwatchers, nature viewers, photographers, researchers, or anyone else who approaches an animal (Boyle and Samson 1985), so the technician recorded the activity of any person encountered. To provide additional information, people were divided into categories: hikers seen but not heard, seen and heard within the 50-m point count, or heard outside of the 50-m radius of the point count. The technician recorded the number of joggers if they appeared during the census period. The number of bicycle riders were recorded as seen, but not heard; heard within the 50-m radius of the point count; or heard outside of the 50-m point count. The technician also recorded other people present during any census periods as campers, fishermen, or state park employees.

In point counts located within campgrounds, or near parking lots, the technician recorded the number of vehicles observed (McLellan and Shackleton 1988). For point counts near, but not on, roads, however, it was not possible to count the number of cars driving by, but the technician recorded if audible traffic occurred.

After the field season, and for each point count separately, I calculated disturbance data in one of two ways. For most variables, I divided the number of

Table 1. Human disturbance variables and their definitions for BSP.

Variable	Description	Variable Type
Number of visits to the point count	# visits (7 or 8 in 1998; 8 or 9 in 1999) to a point count during the field period	Continuous variable
Dog	Mean # dogs seen/visit (# dogs/# visits)	Occurrence frequency
Cat	Mean # cats seen/visit (# cats/# visits)	Occurrence frequency
Fox	Mean # fox seen/visit (# fox/# visits)	Occurrence frequency
Quiet hiker	Mean # hikers not heard but seen/visit (# hikers/# visits)	Occurrence frequency
Hiker heard in the point count	Mean # hikers heard within the 50 m pc/visit (# hikers/# visits)	Occurrence frequency
Hiker heard outside of the point count	Mean # hikers outside of the 50 m pc heard/visit (# hikers/# visits)	Occurrence frequency
Total number of hikers	Mean # all hikers heard/visit (# hikers/# visits)	Occurrence frequency
Jogger	Mean # joggers within the 50 m pc seen/visit (# joggers/# visits)	Occurrence frequency
Total number of pedestrians	Mean # all hikers and joggers seen/visit (# all people/# visits)	Occurrence frequency
Quiet bicyclist	Mean # bikers not heard but seen/visit (# bikers/# visits)	Occurrence frequency
Bicyclist heard in the point count	Mean # hikers heard within the 50 m pc/visit (# bikers/# visits)	Occurrence frequency
Bicyclist heard outside of the point count	Mean # hikers heard outside of the 50 m pc/visit (# bikers/# visits)	Occurrence frequency
Total number of bicyclists	Mean # all bikers heard and seen/visit (# bikers/# visits)	Occurrence frequency
Camper	Mean # campers seen/visit (# campers/# visits)	Occurrence frequency
Angler	Mean # fishermen seen/visit (# fishermen/# visits)	Occurrence frequency
Park employee	Mean # workers seen/visit (# workers/# visits)	Occurrence frequency
Total number of people at a point count	Mean # people seen and heard/visit to the pc (# total people/# visits)	Occurrence frequency
Number of cars seen	Mean # cars seen/visit (# cars/# visits)	Occurrence frequency
Number of times a car was observed	Mean # times saw a car(s)/visit (# times saw a car/# visits)	Detection frequency
Traffic heard outside of the point count	Mean # times traffic was heard/visit (# times traffic heard/# visits)	Detection frequency
Index of disturbance caused by people	Mean # times saw a person(s)/visit (# times saw a person(s)/# visits)	Detection frequency
Index of disturbance caused by vehicles	Mean # of times vehicles are heard or seen/visit (# times heard or saw cars/# visits)	Detection frequency
Total index of disturbance	Mean total disturbance heard at that point count	Detection frequency

individual people, cars, etc. by the number of visits to that point count, to obtain a mean frequency, called the *occurrence frequency*. For a few other variables, however, it was not possible to count the number of individuals; in these cases, the number of times a particular event was observed, divided by the number of visits, resulted in a *detection frequency*. For example, if a technician visited a particular site eight times during the field season and saw four hikers during one census period, but no other hikers were seen during the rest of the field season, the occurrence frequency is 0.50 (four people/eight visits), whereas the detection frequency is 0.13 (people observed one time/eight visits). Detection frequencies are important for variables such as traffic, where individual cars could not be counted, but the technician heard cars going by the point count.

I calculated the occurrence frequencies for the non-avian animals separately. I also calculated the occurrence frequencies for each group of people separately, and for the total number of people encountered at each point count. In addition to the occurrence frequency for the number of cars during the field season, the number of times cars were observed at a point count divided by the number of visits to the point count provided a detection frequency for cars.

To estimate and compare the amount of disturbance at each point count, I used detection frequencies to calculate three indices of disturbance: an index of disturbance caused by people, an index of vehicle disturbance, and an index of total disturbance. To estimate the index of disturbance caused by people at each point count, I calculated its detection frequency by dividing the number of census periods that any people were detected by the number of visits to that point count. I added the two detection frequencies for vehicles (cars and traffic), which resulted in an index of disturbance from vehicles at each point count during the field season. To quantify a point count's total exposure to human disturbance, I summed the indices of disturbance caused by people and vehicles to calculate an index of total disturbance for each point count. Those point counts experiencing more and different forms of disturbance received a higher rating than point counts with fewer disturbances. These disturbance indices do not give an index of absolute levels of human use, because use of the park varies seasonally, but they can provide relative levels of disturbance between the point counts during the field season.

Statistical Analysis

Data description. For each point count, and each species separately, I determined the mean number of birds per visit, as well as total abundance and species richness. I used the simple measure of abundance instead of indices of community diversity that combine richness and evenness into a single measure (e.g., Shannon-Weaver index) because such indices often do not indicate the relative contributions of richness and evenness to diversity, and can lose statistical information (James and Rathbun 1981, Weller 1988). Additionally, richness and abundance can be readily estimated and easily interpreted (Verner and Larson 1989). I based my statistical analysis on a minimum of 360 comparisons (45 point counts surveyed at least 8 weeks) each year, with each day being a separate observation containing any species observed and any disturbance event at each point count. In this way, I could relate the effect of a disturbance to species observed at that point in time, whereas if I had compared means for a species' presence and disturbance over the entire field season for each point count, the relationship between a species occurring at the same time as disturbance would not have been apparent.

I applied two-tailed tests in all cases of my analysis, with a Type 1 error rate of $\alpha = 0.10$. To improve statistical power, I used an *a priori* α level for all tests of 0.10 instead of 0.05 (Nichols et al. 1984, Westmoreland and Best 1985). The tradition of setting $\alpha = 0.05$ developed in relatively controlled experimental circumstances compared to ecological field studies (Hinds 1984). Also, setting $\alpha = 0.05$ ignores information provided by test statistics when $P > 0.05$ (Salsburg 1985, Toft and Shea 1983), and using $\alpha = 0.10$ instead of 0.05 allowed me to detect not only substantial differences, but slight differences between variables (Gutzwiller et al. 1994). Because the data were non-normally distributed, I used nonparametric statistics for all my statistical analyses. I used the SAS statistical package (SAS Institute 1985) for all my analyses.

Species presence vs. absence. To determine which disturbance variables, if any, differed significantly between areas where a species occurred and where it did not occur, I created two categories for each species: the areas where a species was present (a used site), and where it was absent (an unused site) (Frederick and Gutierrez 1992). For each species, any point count with an abundance > 0 went into the "present" category. Any point count with an abundance = 0 belonged to the "absent" category. For each species, I compared occupied sites to unoccupied sites to determine whether disturbance events influenced that species' occurrence in point counts in BSP.

Many species, although present, were detected only rarely during the census. I identified a set of common species for each year (sensu Riffell et al. 1996), which represented the primary avian community structure across BSP during the field season. I analyzed only those species present on at least 20% (8 sites), but not more than 89% (40 sites) of the point counts in a state park. I also excluded from the analysis any disturbance variables that occurred on < 4 point counts. To determine if a disturbance variable differed significantly between used and unused sites for each species, I used the Wilcoxon rank-sum test (Zar 1984) for two sample data, which is the non-parametric equivalent of the Student's *t*-test. This procedure computes exact *P*-values when the data are classified into two levels (two-sample tests). Two-sample tests are based on simple linear rank statistics, and do not assume a normal population distribution or equal variances. The null hypothesis states that both populations have identical distributions, while the alternative hypothesis states that one population has larger or smaller values (Ott 1988:423). I assumed that disturbance variables that differed significantly ($P \leq 0.10$) between used and unused sites influenced the presence of the species in question.

After determining which disturbance variables differed significantly between the two groups, I examined the variables to determine if any correlated significantly, since highly correlated variables could confound an interpretation of the effects of disturbance on a species' use of sites within BSP. I calculated Spearman rank correlation coefficients (Nie et al. 1975) for all pair-wise comparisons of disturbance variables, eliminating one of a pair of variables which was highly correlated ($n = 45$, $r = 0.40$, $P < 0.05$) with another measure of disturbance (Green 1979). I retained the variable which was most interpretable in a biological sense in relation to the particular species I examined.

Species presence in control, trail, road, and campground sites. To determine whether species occupied some areas within BSP and did not occur in other areas, I divided the 45 point counts into four categories: control, trail, road and campground. A control site contained no trails and was located in the remotest areas of BSP. In many recreational areas, trails allow people to explore the various areas of the park and leave behind crowded campgrounds and picnic areas (Bright 1986). A trail site contained some form of trail, which I defined as any worn pathway, regardless of width, type or surface composition. I considered a road-associated point count one that was located on or near a road (within 50 m of the perimeter of the point count), and in a campground site, the point count was either partially or completely contained within a developed camping facility (i.e., with electric hook-up availability). To determine if the location of a point count influenced a species' presence, I compared the species' abundance in each of the four site categories using the Kruskal-Wallis statistic (Zar 1984), which measures heterogeneity among samples. The null hypothesis states that no difference exists between groups, while the alternative hypothesis states that differences exist between groups. I analyzed any species that occurred in > 7 point counts, and also abundance and species richness for each year separately. I did not include any disturbance variables that occurred on < 4 point counts in the analysis.

RESULTS

Disturbance at BSP

Disturbance, 1998. In 1998, the field technician visited 19 point counts 7 times and 26 point counts a total of 8 times. He encountered several non-avian species (dogs and foxes) while in the field, although not with great frequency (Table 2) nor in high numbers (Table 3). The technician saw dogs on only four of the point counts, and observed no cats at all during the field season, despite the fact that some point counts were associated with campgrounds or other areas where feral cats could survive.

Almost half of the point counts (48.9%, 22 point counts) had people present (hiker, biker, camper, etc.) at the site during the field season (Table 2). Twelve point counts (26.7%) had hikers that were heard within the 50-m radius of the point count, and some point counts also had hikers that were not heard, or were heard outside the point count's radius. Not only were hikers that were heard within the point count radius observed on the most point counts, they also were present in the highest numbers (Table 3). The technician encountered fewer joggers during the field season than hikers. The total number of all hikers plus joggers averaged 0.4 individuals per visit. The field technician observed bicyclists on relatively few point counts (all bikers = 8 point counts), and averaged 0.1 people per visit, with most heard when the bicyclist was within the point count's 50-m radius. He found other people (e.g., campers, workers) on far fewer point counts, and no birdwatchers were seen. The mean number of total people per point count per visit equaled 0.6 people, with a range of 0.0 to 4.5 (Tables 2 and 3).

Table 2. The percent of disturbed point counts BSP, 1998 and 1999.

Variable	1998 % point counts (number of point counts)		1999 % point counts (number of point counts)	
	Present	Absent	Present	Absent
Dog	8.8 (4)	91.1 (41)	17.8 (8)	82.2 (37)
Cat	0.0 (0)	100.0 (45)	0.0 (0)	100.0 (45)
Fox	4.4 (2)	95.6 (43)	0.0 (0)	100.0 (45)
Quiet hiker	11.1 (5)	88.9 (40)	0.0 (0)	100.0 (45)
Hiker heard in the point count	26.7 (12)	73.3 (33)	31.1 (14)	68.9 (31)
Hiker heard outside of the point count	17.8 (8)	82.2 (37)	6.7 (3)	93.3 (42)
Total number of hikers	44.4 (20)	55.6 (25)	31.1 (14)	68.9 (31)
Jogger	8.9 (4)	91.1 (41)	11.1 (5)	88.9 (40)
Total number of hikers + joggers	46.7 (21)	53.3 (24)	37.8 (17)	62.2 (28)
Quiet bicyclist	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Bicyclist heard in the point count	13.3 (6)	86.7 (39)	0.0 (0)	100.0 (45)
Bicyclist heard outside of the point count	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Total number of bicyclists	17.8 (8)	82.2 (37)	0.0 (0)	100.0 (45)
Camper	8.9 (4)	91.1 (41)	4.4 (2)	95.6 (43)
Angler	2.2 (1)	97.8 (44)	2.2 (1)	97.8 (44)
Birdwatcher	0.0 (0)	100.0 (45)	4.4 (2)	95.6 (43)
Park employee	2.2 (1)	97.8 (44)	2.2 (1)	97.8 (44)
Total number of people at a point count	48.9 (22)	51.1 (23)	44.4 (20)	55.6 (25)
Number of cars seen	20.0 (9)	80.0 (36)	35.6 (16)	64.4 (29)
Number of times a car was observed	20.0 (9)	80.0 (36)	35.6 (16)	64.4 (29)
Traffic heard outside of the point count	22.2 (10)	77.8 (35)	84.4 (38)	15.6 (7)
Index of disturbance caused by people	48.9 (22)	51.1 (23)	44.4 (20)	55.6 (25)
Index of disturbance caused by vehicles	31.1 (14)	68.9 (31)	86.7 (39)	13.3 (6)
Total index of disturbance	62.2 (28)	37.8 (17)	91.1 (41)	8.9 (4)

Table 3. Mean disturbance variables encountered during each visit to the point counts at BSP (1998 and 1999), *n* = 45 point counts.

	1998				1999			
Variable	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Dog	<0.1	0.1	0.0	0.3	<0.1	0.1	0.0	0.4
Cat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fox	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Quiet hiker	<0.1	0.1	0.0	0.4	0.0	0.0	0.0	0.0
Hiker heard in the point count	0.2	0.5	0.0	2.8	0.2	0.4	0.0	2.1
Hiker heard outside of the point count	0.1	0.4	0.0	2.0	<0.1	0.2	0.0	1.3
Total number of hikers	0.4	0.6	0.0	2.8	0.2	0.4	0.0	2.3
Jogger	<0.1	0.1	0.0	0.6	<0.1	0.1	0.0	0.2
Total number of hikers + joggers	0.4	0.6	0.0	2.8	0.2	0.5	0.0	2.3
Quiet bicyclist	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Bicyclist heard in the point count	0.1	0.2	0.0	1.0	0.0	0.0	0.0	0.0
Bicyclist heard outside of the point count	<0.1	0.2	0.0	1.3	0.0	0.0	0.0	0.0
Total number of bicyclists	0.1	0.3	0.0	1.3	0.0	0.0	0.0	0.0
Camper	0.1	0.3	0.0	1.4	0.1	0.5	0.0	3.6
Angler	<0.1	0.1	0.0	0.5	0.0	<0.1	0.0	0.2
Birdwatcher	0.0	0.0	0.0	0.0	<0.1	0.1	0.0	0.3
Park employee	<0.1	0.1	0.0	0.4	<0.1	0.3	0.0	2.0
Total number of people at a point count	0.6	0.9	0.0	4.5	0.4	0.9	0.0	5.1
Number of cars seen	0.1	0.2	0.0	0.6	0.1	0.2	0.0	0.9
Number of times a car was observed	0.1	0.3	0.0	1.4	0.2	0.5	0.0	2.0
Traffic heard outside of the point count	0.1	0.2	0.0	1.0	0.3	0.27	0.0	1.0
Index of disturbance caused by people	0.2	0.3	0.0	1.5	0.1	0.2	0.0	1.2
Index of disturbance caused by vehicles	0.2	0.3	0.0	1.4	0.5	0.4	0.0	1.6
Total index of disturbance	0.4	0.5	0.0	2.1	0.8	0.6	0.0	2.4

Only a few point counts (20%, 9 point counts) had cars parked at or near the point count (Table 2), averaging 0.1 cars/visit (Table 3), while 22.2% (10) point counts had traffic (e.g., moving cars heard or seen) within a short distance of the point count, with an average of 0.1 occurrences/visit. The presence of cars and traffic was not mutually exclusive; a point count could have either cars or traffic, or both.

Twenty-two point counts (48.9%) experienced some degree of disturbance from humans, while 14 point counts (31.1%) had some degree of machine disturbance (Table 2). Seventeen point counts experienced no disturbance, while the rest had some degree of disturbance. However, the amount of disturbance between point counts varied greatly. While the human-caused index of disturbance at a point count averaged 0.2, the highest disturbance at one point count was 1.5 (Table 3). Similarly, although the point counts experienced a fairly low average index of machine disturbance (0.2), the most disturbed point count had an index of 1.4. Finally, although the mean index of total disturbance experienced by a point count was 0.4, this number hides the fact that some point counts were extremely disturbed; the most disturbed point count had a total disturbance index of 2.1.

Disturbance, 1999. During 1999, a field technician visited 14 point counts a total of 8 times, 30 point counts 9 times and one point count 10 times. The only potential avian predators observed were dogs: more point counts (8) had dogs present than in 1998 (Table 2). Slightly fewer point counts (20) had people present (hiker, birdwatcher, etc.) at that site during 1999 than in 1998. Again, most of the point counts with people had either hikers or joggers (Table 2), but they occurred on fewer point counts (1998 = 21, 1999 = 17 point counts). Although the point counts had similar numbers of people as in 1998, in 1999 fewer point counts had total hikers and campers, but had more joggers and birdwatchers. No bicyclists were recorded in 1999. The mean total number of hikers per visit was lower in 1999 (1998 = 0.4/visit, 1999 = 0.2/visit), and the mean of total number of people was also smaller in 1999 (1998 = 0.6/visit, 1999 = 0.4/visit) (Table 3). Overall, 1999 had a lower (1998 = 0.2, 1999 = 0.1) index of human disturbance than in 1998.

In 1999, vehicular traffic occurred at much higher levels than in 1998, both in the number of point counts where cars and vehicles were detected (Table 2) and in the number of vehicles seen or heard (Table 3). Although the number of cars per visit equaled 1998 (0.1/visit), cars were observed twice as often in 1999 as in 1998 (1989 = 0.1 times/visit, 1999 = 0.2 times/visit), and traffic more than tripled over 1998 (1998 = 0.1, 1999 = 0.3). Traffic was heard on most point counts (38) in 1999, almost four times as many point counts as 1998. Once again, the presence of cars and traffic was not mutually exclusive; a point count could have either cars or traffic, or both.

The total index of disturbance for 1999 was much greater than in 1998, because more point counts experienced vehicular noise. In 1999, fewer (20) point counts experienced some degree of disturbance from people, but 39 point counts had some degree of machine disturbance (Table 2). In 1998, 17 point counts had no form of disturbance during the field season, while in 1999 only four point counts had no form of disturbance, due to the increased machine disturbance recorded. Once again, the amount of disturbance between point counts varied greatly. While the mean index of human disturbance at a point count was 0.1 (lower than 1998), the highest degree of disturbance at one point count was 1.2 (similar to 1998). However, the average index of machine disturbance (0.5) had almost tripled from 1998 (0.2), but the most disturbed point count experienced an index of machine disturbance of 1.6, not much higher than 1998 (1.4). Finally, the index of total disturbance experienced by a point count was 0.8, about two times more than 1998, with an index of 2.4 at the most disturbed point count.

Spearman rank correlation coefficients. Spearman rank correlations showed several associations between disturbance variables (Table 4). Correlations between variables resulted from two sources: a true correlation between variables, or because a variable was created from another variable. Variables created from other variables, such as the total number of hikers, strongly correlate with the variables that created them (e.g., hikers heard within the 50-m radius point count, hikers heard outside of the 50-m point count), and are not listed in Table 4. On the other hand, many variables correlate because they occurred at the same point counts. Campers correlated with bicyclists (n = 45, r = 0.6, P < 0.0001) and the number of cars observed (n = 45, r = 0.4, P < 0.0022) (Table 4). People correlated strongly with cars (1998: n = 45, r = 0.4, P < 0.0022, 1999: n = 45, r = 0.7, P < 0.0001). The index of disturbance caused by vehicles correlated strongly with the presence of bicyclists (n = 45, r = 0.6, P < 0.0001), total number of hikers (n = 45, r = 0.4, P = 0.0063), and total number of people (n = 45, r = 0.5 P < 0.0002).

Table 4. Spearman rank correlation coefficient analysis showing significant relationships between disturbance variables (r > 0.40) in BSP (1998 and 1999).

		1998		1999	
variable 1	variable 2	*r*	*P*	*r*	*P*
Camper	Bicyclist heard in the point count	0.6	<0.0001		
Camper	Number of cars seen	0.4	0.0022		
Bicyclist heard in the point count	Number of cars seen	0.8	<0.0001		
Total number of people at a point count	Number of cars seen	0.4	0.0022	0.7	<0.0001
Number of cars seen	Hiker heard in the point count	0.4	0.0029	0.5	0.0016
Index of disturbance caused by vehicles	Total number of hikers			0.4	0.0063
Index of disturbance caused by vehicles	Bicyclist heard in the point count	0.6	<0.0001		
Index of disturbance caused by vehicles	Total number of people at a point count			0.5	0.0002

Differences in disturbance between control, trail, road, and campground sites. When I placed the point counts into four categories (control, trail, road, and campground), several significant differences became apparent. Similar results for disturbance components existed between 1998 and 1999 (Table 5, Figs. 3 and 4). Hikers, campers, the total number of people encountered, and the number of cars all differed between control point counts and those associated with trails, roads, and campgrounds. Although hikers of all types were encountered in 1998 and 1999, only those hikers heard within the radius of the point count occurred in significantly different numbers between the categories: most occurred in campgrounds (1998 = 1.4/visit, 1999 = 0.4/visit), some occurred in trail (1998 = 0.1/visit, 1999 = 0.2/visit) and road point counts (1998 = 0.3/visit, 1999 = 0.1/visit), while none were encountered in the control sites in either year (Figs. 3 and 4). Bicyclists in 1998 reflected a similar pattern: none occurred in control sites, a few occurred in point counts on a trail (0.1 bicyclists/visit) or near a road (0.2 bicyclists/visit) and the most occurred in campgrounds (0.7 people/visit). Campers (identified either by their camping equipment, occupation of a campsite or by being asked) occurred in the highest numbers in campgrounds (1.1/visit), while a few were seen in trail sites (i.e., backpacking to their campsite; <0.1/visit). In both years, the total number of people seen reflected the same patterns. Most people occurred in the campgrounds (1998 = 3.3/visit, 1999 = 3.6/visit), some occurred on trails (1998 = 0.5/visit, 1999 = 0.3/visit) or alongside roads (1998 = 0.8/visit, 1999 = 0.5/visit), and almost none were observed in control sites (1998 = 0.0/visit, 1999 = <0.1/visit).

Table 5. Kruskall-Wallace analysis showing significant differences in disturbance variables between control, trail, road, and campground point counts in BSP.

Variable	No trail (Control) (*n* = 7)	Trail Present (*n* = 32)	Road (*n* = 4)	Campground (*n* = 2)	X^2	*P*-value* (*df* = 3)
1998						
Hikers heard in the point count	0.0	0.1	0.3	1.4	11.0	0.0019
Bicyclists heard in the point count	0.0	0.1	0.2	0.7	50.5	<0.0001
Camper	0.0	<0.1	0.0	1.1	71.3	<0.0001
Total number of people at a point count	0.0	0.5	0.8	3.3	39.9	<0.0001
Number of cars seen	0.0	0.1	0.6	0.4	84.4	<0.0001
Traffic heard outside of the point count	0.2	0.1	0.1	0.1	8.3	0.0410
Index of disturbance caused by people	0.0	0.1	0.4	0.8	41.1	<0.0001
Index of disturbance caused by vehicles	0.2	0.1	0.5	0.3	54.3	<0.0001
Total index of disturbance	0.2	0.2	0.9	1.1	57.3	<0.0001
1999						
Hiker heard in the point count	0.0	0.2	0.1	0.4	8.1	0.0443
Total number of people at a point count	<0.1	0.3	0.5	3.6	76.7	<0.0001
Number of cars seen	0.1	0.1	0.7	1.4	87.3	<0.0001
Index of disturbance caused by people	<0.1	0.1	0.2	0.8	71.9	<0.0001
Index of disturbance caused by vehicles	0.4	0.4	1.2	1.8	46.6	<0.0001
Total index of disturbance	0.4	0.5	1.4	2.7	56.4	<0.0001

*Significant at $P \leq 0.10$

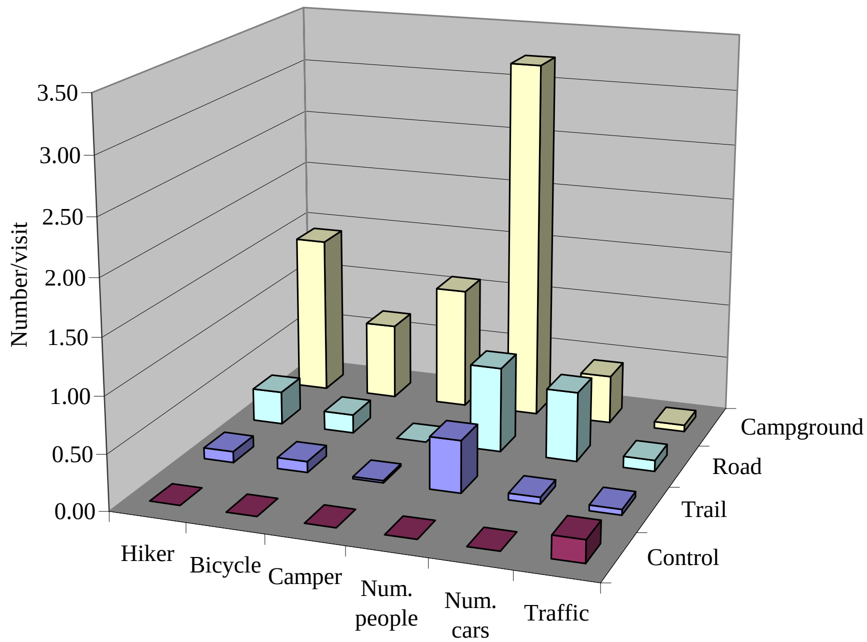

Fig. 3. Comparisons between 1998 disturbance components in four point count categories (control, trail, road, and campground) in BSP. (Hiker = people heard within the 50-m radius point count; Bicycle = bicyclists heard within the 50-m point count).

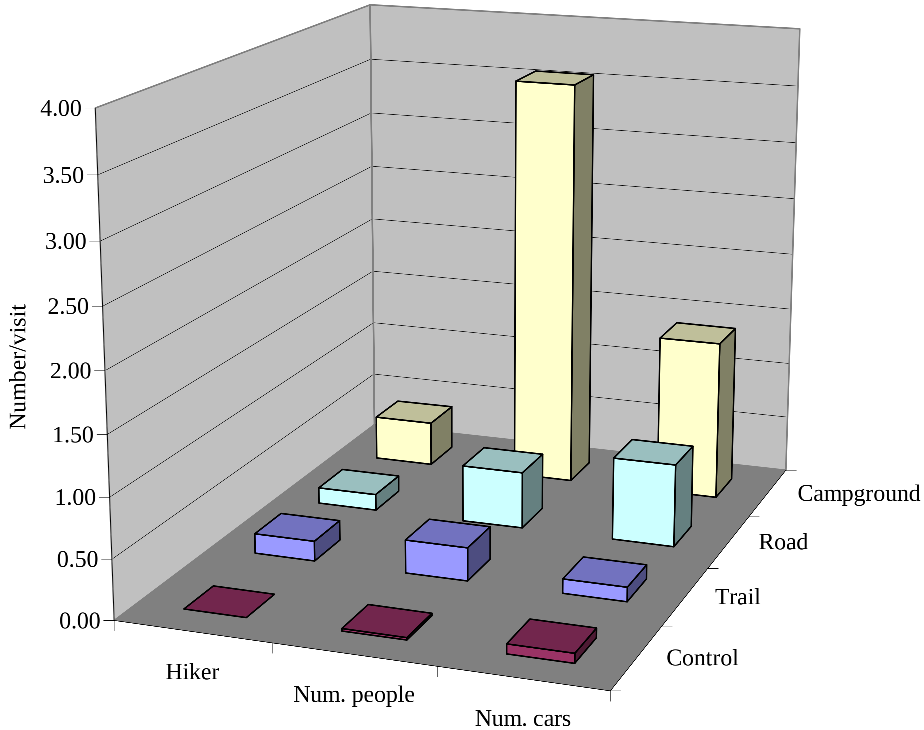

Fig. 4. Comparisons between 1999 disturbance components in four point count categories (control, trail, road, and campground) in BSP.

Cars also occurred in higher numbers at the campground point counts in both years (1998 = 0.4/visit, 1999 = 1.4/visit), and at road-associated point counts (1998 = 0.6/visit, 1999 = 0.7/visit). Traffic heard (but not necessarily seen) was heaviest in control (0.2 times/visit) sites in 1998, but did not differ in 1999 between the categories of point counts (Table 5, Figs. 3 and 4).

Campgrounds showed the highest disturbance index involving people in both years (1998 index = 0.8, 1999 index = 0.8), followed by roads (1998 index = 0.4, 1999 index = 0.2), and trail point counts (1998 index = 0.1, 1999 index = 0.1); control sites showed no disturbance in 1998, and a low index (<0.1) in 1999. The highest index of disturbance for vehicles occurred at point counts associated with roads in 1998 (1998 index = 0.5, 1999 index = 1.2), but in campgrounds in 1999 (1998 index = 0.3, 1999 index = 1.8). The highest total index of disturbance in BSP for both years occurred at campgrounds (1998 index = 1.1, 1999 index = 2.7), and the lowest occurred at the control point counts (1998 index = 0.2, 1999 index = 0.4) (Table 5, Fig. 5).

Bird Species at BSP

Avian species, 1998. In 1998, only one species – American Crow (*Corvus brachyrhynchos)* - was observed on all 45 point counts (Table 6). However, the technician observed six other species on more than 80% (36) of the sites, including Black-crested Titmouse (*Baeolophus bicolor*), Carolina Chickadee (*Poecile carolinensis),* Carolina Wren (*Thryothorus ludovicianus*), Mourning Dove, Northern Cardinal (*Cardinalis cardinalis*), Pine Warbler (*Dendroica pinus*), and Summer Tanager (*Piranga rubra*).

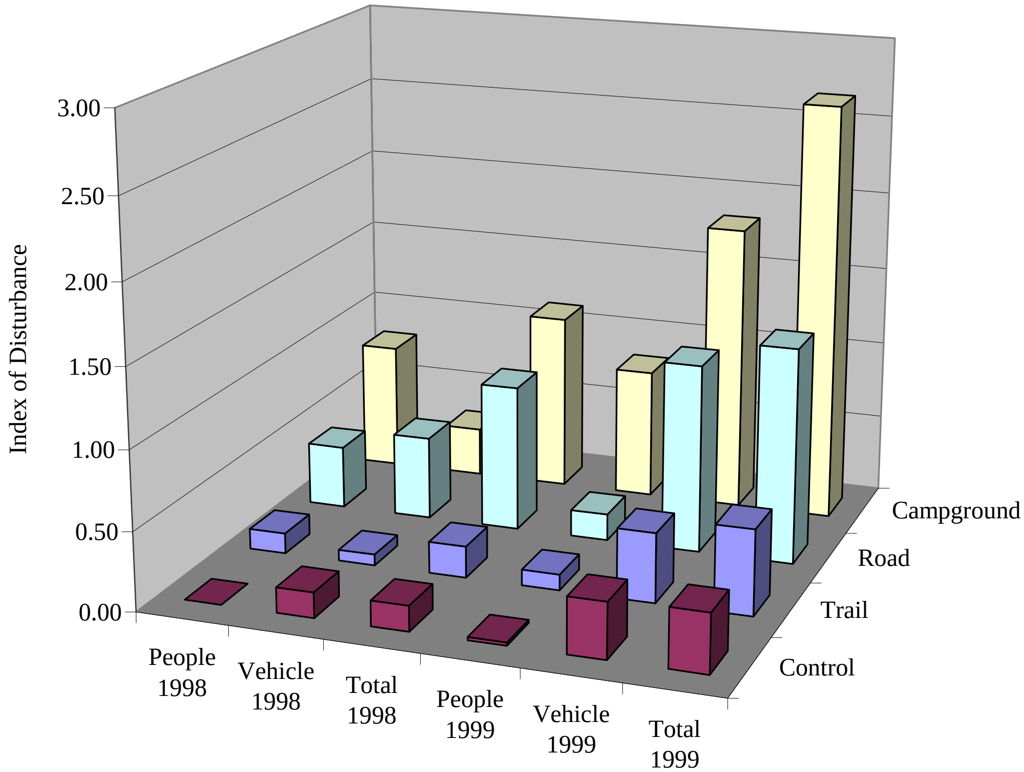

Fig. 5. Indices of disturbance for 1998 and 1999 in four point count categories (control, trail, road, and campground) in BSP.

Table 6. Avian species present in BSP, 1998 and 1999.

	1998 percent point counts (number of point counts)		1999 percent point counts (number of point counts)	
Species	Present	Absent	Present	Absent
American Crow	100.0 (45)	0.0 (0)	100.0 (45)	0.0 (0)
Belted Kingfisher	4.4 (2)	95.6 (43)	0.0 (0)	100.0 (45)
Black-and-white Warbler	35.6 (16)	64.4 (29)	4.4 (2)	95.6 (43)
Black-crested Titmouse	97.8 (44)	2.2 (1)	75.6 (34)	24.4 (11)
Blue-gray Gnatcatcher	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Blue Jay	62.2 (28)	37.8 (17)	80.0 (36)	20.0 (9)
Black Vulture	0.0 (0)	100.0 (45)	28.9 (13)	71.1 (32)
Brown-headed Cowbird	66.7 (30)	33.3 (15)	6.7 (3)	93.3 (42)
Canada Goose	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Carolina Chickadee	97.8 (44)	2.2 (1)	97.8 (44)	2.2 (1)
Carolina Wren	91.1 (41)	8.9 (4)	84.4 (38)	15.6 (7)
Cattle Egret	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Downy Woodpecker	77.8 (35)	22.2 (10)	4.4 (2)	95.6 (43)
Eastern Bluebird	4.4 (2)	95.6 (43)	0.0 (0)	100.0 (45)
Eastern Phoebe	4.4 (2)	95.6 (43)	17.8 (8)	82.2 (37)
Eastern Wood-Pewee	4.4 (2)	95.6 (43)	2.2 (1)	97.8 (44)
Great Crested Flycatcher	26.7 (12)	73.3 (33)	0.0 (0)	100.0 (45)
Greater Roadrunner	6.7 (3)	93.3 (42)	0.0 (0)	100.0 (45)
Great-tailed Grackle	0.0 (0)	100.0 (45)	2.2 (1)	97.8 (44)
Hairy Woodpecker	37.8 (17)	62.2 (28)	0.0 (0)	100.0 (45)
Killdeer	4.4 (2)	95.6 (43)	0.0 (0)	100.0 (45)
Mourning Dove	82.2 (37)	17.8 (8)	97.8 (44)	2.2 (1)
Northern Cardinal	97.8 (44)	2.2 (1)	97.8 (44)	2.2 (1)
Northern Mockingbird	15.6 (7)	84.4 (38)	64.4 (29)	35.6 (16)
Painted Bunting	2.2 (1)	97.8 (44)	15.6 (7)	84.4 (38)
Pileated Woodpecker	44.4 (20)	55.6 (25)	42.2 (19)	57.8 (26)
Pine Warbler	97.8 (44)	2.2 (1)	100.0 (45)	0.0 (0)
Red-bellied Woodpecker	48.9 (22)	51.1 (23)	8.9 (4)	91.1 (41)
Red-eyed Vireo	20.0 (9)	80.0 (36)	2.2 (1)	97.8 (44)
Red-headed Woodpecker	2.2 (1)	97.8 (44)	2.2 (1)	97.8 (44)
Red-shouldered Hawk	40.0 (18)	60.0 (27)	0.0 (0)	100.0 (45)
Red-tailed Hawk	4.4 (2)	95.6 (43)	0.0 (0)	100.0 (45)
Ruby-throated Hummingbird	20.0 (9)	80.0 (36)	2.2 (1)	97.8 (44)
Scissor-tailed Flycatcher	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Summer Tanager	95.6 (43)	4.4 (2)	33.3 (15)	66.7 (30)
Turkey Vulture	2.2 (1)	97.8 (44)	0.0 (0)	100.0 (45)
Western Kingbird	2.2 (1)	97.8 (44)	2.2 (1)	97.8 (44)
White-eyed Vireo	57.8 (26)	42.2 (19)	0.0 (0)	100.0 (45)
Whip-poor-will	0.0 (0)	100.0 (45)	2.2 (1)	97.8 (44)
Winter Wren	8.9 (4)	91.1 (41)	6.7 (3)	93.3 (42)
Yellow-billed Cuckoo	28.9 (13)	71.1 (32)	22.2 (10)	77.8 (35)

Conversely, many species occurred on only one or two point counts during the entire field season, including Belted Kingfisher (*Ceryle alcyon)*, Blue-gray Gnatcatcher (*Polioptila caerulea*), Canada Goose (*Branta canadensis*), Cattle Egret, and Painted Bunting (*Passerina ciris*). Several other species occurred in BSP during 1998, but not in 1999, such as Eastern Bluebird, Great Crested Flycatcher (*Myiarchus crinitus*), Greater Roadrunner (*Geococcyx californianus*), Hairy Woodpecker (*Picoides villosus*), Killdeer (*Charadrius vociferus*), Red-shouldered Hawk (*Buteo lineatus*), Red-tailed Hawk (*Buteo jamaicensis*), Scissor-tailed Flycatcher (*Tyrannus forficatus*), Turkey Vulture (*Cathartes aura*), and White-eyed Vireo (*Vireo griseus*).

Over the entire 1998 field season, the field technician observed an average of 14 species per point count, with an average of 44 individuals per site (Table 7); he encountered an average of almost 6 individuals and 2 species during each visit. The technician detected a total of 38 species at least once during the field season; American Crow, Carolina Chickadee, Northern Cardinal and Pine Warbler were observed with the highest means (0.6 – 0.8 individuals/visit). Black-crested Titmouse , Blue Jay (*Cyanocitta cristata*), Carolina Wren, Mourning Dove, and Summer Tanager also occupied point counts in higher numbers (0.3 – 0.5 individuals/visit) during the field season.

Avian species, 1999. In 1999, species that occurred in at least 80% of the point counts included American Crow, Blue Jay, Carolina Chickadee, Carolina Wren, Mourning Dove, Northern Cardinal, and Pine Warbler. The technician also observed several species from 1998 in 1999, although often not in the same numbers, including

Table 7. Mean number of individuals observed during each visit, *n* = 45 point counts, (1998 and 1999).

	1998				1999			
Species	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
American Crow	0.7	0.4	0.1	1.9	0.8	0.4	0.1	2.2
Belted Kingfisher	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Black-and-white Warbler	0.1*	0.1	0.0	0.5	<0.1	<0.1	0.0	0.1
Black-crested Titmouse	0.5	0.3	0.0	1.1	0.3*	0.3	0.0	1.4
Blue-gray Gnatcatcher	<0.1	<0.1	0.0	0.3	0.0	0.0	0.0	0.0
Blue Jay	0.3*	0.3	0.0	0.9	0.2*	0.2	0.0	1.1
Black Vulture	0.0	0.0	0.0	0.0	<0.1*	0.1	0.0	0.5
Brown-headed Cowbird	0.2*	0.2	0.0	0.6	<0.1	<0.1	0.0	0.2
Canada Goose	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Carolina Chickadee	0.8	0.4	0.0	1.6	0.6	0.3	0.0	1.6
Carolina Wren	0.4	0.2	0.0	0.9	0.4	0.3	0.0	1.4
Cattle Egret	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Downy Woodpecker	0.2*	0.2	0.0	0.6	<0.1	<0.1	0.0	0.1
Eastern Bluebird	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Eastern Phoebe	<0.1	0.1	0.0	0.3	0.1	0.1	0.0	0.6
Eastern Wood-Pewee	<0.1	<0.1	0.0	0.1	<0.1	<0.1	0.0	0.2
Great Crested Flycatcher	0.1*	0.1	0.0	0.4	0.0	0.0	0.0	0.0
Greater Roadrunner	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Great-tailed Grackle	0.0	0.0	0.0	0.0	<0.1	<0.1	0.0	0.2
Hairy Woodpecker	0.1*	0.1	0.0	0.4	0.0	0.0	0.0	0.0
Killdeer	<0.1	<0.1	0.0	0.3	0.0	0.0	0.0	0.0
Mourning Dove	0.3*	0.2	0.0	0.9	0.6	0.3	0.0	1.6
Northern Cardinal	0.7	0.4	0.0	1.6	0.8	0.4	0.0	1.6
Northern Mockingbird	<0.1	<0.1	0.0	0.6	0.2*	0.2	0.0	0.9
Painted Bunting	<0.1	<0.1	0.0	0.1	<0.1	0.1	0.0	0.2
Pileated Woodpecker	0.1*	0.1	0.0	0.3	0.1*	0.1	0.0	0.6
Pine Warbler	0.6	0.3	0.0	1.3	1.2	0.5	0.5	2.3
Red-bellied Woodpecker	0.1*	0.1	0.0	0.5	<0.1	0.1	0.0	0.3
Red-eyed Vireo	<0.1*	0.1	0.0	0.4	<0.1	<0.1	0.0	0.1
Red-headed Woodpecker	<0.1	<0.1	0.0	0.1	<0.1	<0.1	0.0	0.1
Red-shouldered Hawk	0.1*	0.1	0.0	0.4	0.0	0.0	0.0	0.0

Table 7. (Continued).

	1998				1999			
Species	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Red-tailed Hawk	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Ruby-throated Hummingbird	<0.1*	0.1	0.0	0.3	<0.1	<0.1	0.0	0.1
Scissor-tailed Flycatcher	<0.1	<0.1	0.0	0.3	0.0	0.0	0.0	0.0
Summer Tanager	0.4	0.3	0.0	1.4	0.1*	0.2	0.0	0.7
Turkey Vulture	<0.1	<0.1	0.0	0.1	0.0	0.0	0.0	0.0
Western Kingbird	<0.1	<0.1	0.0	0.1	<0.1	<0.1	0.0	0.1
White-eyed Vireo	0.2*	0.3	0.0	1.4	0.0	0.0	0.0	0.0
Whip-poor-will	0.0	0.0	0.0	0.0	<0.1	<0.1	0.0	0.1
Winter Wren	<0.1	0.1	0.0	0.3	<0.1	0.0	0.0	0.0
Yellow-billed Cuckoo	0.1*	0.1	0.0	0.3	<0.1*	0.1	0.0	0.1
Abundance	43.9	10.2	21.0	67.0	51.1	13.1	26.0	83.0
Richness	14.0	2.4	10.0	18.0	11.0	2.1	7.0	17.0

*These species will undergo further analysis to determine which disturbance variables, if any, differ between point counts where a species was present and where it was absent.

Black-and-white Warbler (*Mniotilta varia*), Brown-headed Cowbird (*Molothrus ater*), Downy Woodpecker (*Picoides pubescens*), Eastern Phoebe (*Sayornis phoebe*), Eastern Wood-Pewee (*Contopus virens)*, Northern Mockingbird (*Mimus polyglottos*), Pileated Woodpecker (*Dryocopus pileatus*), Red-bellied Woodpecker (*Melanerpes carolinus*), Red-eyed Vireo (*Vireo olivaceus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Ruby-throated Hummingbird (*Archilochus colubris*), Western Kingbird (*Tyrannus verticalis*), Winter Wren (*Troglodytes troglodytes*), and Yellow-billed Cuckoo (*Coccyzus americanus*). Species heard or seen only in 1999 included Black Vulture (*Coragyps atratus*), Great-tailed Grackle (*Quiscalus mexicanus*), and Whip-poor-will (*Caprimulgus vociferus*). Unidentified individuals recorded, but not analyzed, belonged to the duck (Family: Anatidae), hummingbird (Family: Trochilidae), owl (Family: Strigidae), vireo (Family: Vireonidae), warbler (Family: Parulidae), woodpecker (Family: Picidae), or wren (Family: Troglodytidae) families.

In 1999, 27 species were identified, with an average of 11 species and 51 individuals found at each point count, with almost 6 individuals belonging to slightly over 1 species per visit (Table 7). Therefore, the technician counted more individuals in 1999 (1998 = 44, 1999 = 51), but they belonged to fewer species (1998 = 14, 1999 = 11). Once again, American Crows, along with Carolina Chickadees, Mourning Dove, Northern Cardinals, and Pine Warblers occurred in the highest numbers (0.6 - 1.2 individuals/visit). Black-crested Titmice, Blue Jays, Carolina Wrens, and Northern Mockingbirds also occupied point counts in higher numbers (0.2 – 0.4 individuals/visit) in 1999.

Avian species, 1998 and 1999. Twenty-four species occurred in both 1998 and 1999, including American Crow, Black-crested Ttmouse, Brown-headed Cowbird, Carolina Chickadee, Carolina Wren, Downy Woodpecker, Mourning Dove, Northern Cardinal, Summer Tanager, and Yellow-billed Cuckoos. Fourteen species were found only during 1998, including Belted Kingfisher, Blue-gray Gnatcatcher, Canada Goose, Cattle Egret, and Red-shouldered Hawk. Three species were observed only in 1999: Black Vulture, Great-tailed Grackle, and Whip-poor-will.

Comparisons between point counts with presence or absence of a species. An analysis of point counts where a species occurred compared to where that species was absent showed multiple variables that differed significantly between these two types of point counts (species present vs. species absent). The particular disturbance variables that differed, however, depended on the species.

Four species, Great Crested Flycatcher, Red-eyed Vireo, Red-shouldered Hawk, and Yellow-billed Cuckoo, did not exhibit significant differences for any disturbance variable in 1998 (Table 8). However, for several other species, the point counts that contained individuals showed significant differences in disturbance variables from point counts that did not contain individuals. Of these, two species (Blue Jays, and Pileated Woodpecker) also occupied point counts with significant differences in disturbance variables from unoccupied point counts in 1999. I discuss these species in a later section

Table 8. Mann-Whitney comparisons between point counts where a species was absent and present in 1998.

Variable	Species Absent*	Species Present*	X^2	*P*-Value
Black-and-white Warbler	n = 29**	n = 16**		
Hiker heard outside of the point count	0.1	0.4	3.2	0.0759
Blue Jay	n = 17	n = 28		
Number of cars seen	0.1	<0.1	3.9	0.0486
Brown-headed Cowbird	n = 15	n = 30		
Total number of hikers	0.5	0.1	4.5	0.0330
Bicyclist heard outside of the point count	0.0	0.2	4.4	0.0357
Total number of people at a point count	0.6	0.4	2.8	0.0972
Index of disturbance caused by people	0.2	0.1	2.9	0.0887
Downy Woodpecker	n = 10	n = 35		
Traffic heard outside of the point count	0.1	<0.1	3.3	0.0677
Great Crested Flycatcher	n = 33	n = 12		
No significant differences observed				
Hairy Woodpecker	n = 28	n = 17		
Hiker heard outside of the point count	0.1	0.3	3.6	0.0585
Mourning Dove	n = 8	n = 37		
Total number of hikers	0.5	0.1	3.2	0.0730
Pileated Woodpecker	n =25	n = 20		
Hiker heard in the point count	0.2	0.8	2.9	0.0899
Bicyclist heard in the point count	<0.1	0.2	7.8	0.0054
Number of cars seen	0.1	0.3	3.2	0.0733
Red-bellied Woodpecker	n = 23	n = 22		
Hiker heard in the point count	0.1	0.7	8.1	0.0044
Number of cars seen	0.1	0.2	3.1	0.0784

Table 8. (Continued).

Species	Variable	Species Absent*	Species Present*	X^2	*P*-Value
Red-eyed Vireo		n = 36	n = 9		
	No significant differences observed				
Red-shouldered Hawk		n = 27	n = 18		
	No significant differences observed				
Ruby-throated Hummingbird		n = 36	n = 9		
	Dog	<0.1	0.2	7.0	0.0082
	Hiker heard in the point count	0.2	0.9	26.3	<0.0001
	Total number of people at a point count	0.5	1.2	9.3	0.0023
	Index of disturbance caused by people	0.2	0.6	10.2	0.0014
	Number of cars seen	0.1	0.4	7.5	0.0061
	Total index of disturbance	0.3	0.9	5.4	0.0200
White-eyed Vireo		n = 19	n = 26		
	Hiker heard in the point count	0.1	0.6	5.0	0.0248
	Traffic heard outside of the point count	<0.1	0.1	3.6	0.0579
	Index of disturbance caused by vehicles	0.1	0.2	3.4	0.0645
Yellow-billed Cuckoo		n = 32	n = 13		
	No significant differences observed				

* Numbers shown are means for each variable tested
** Number shown are the point counts (out of 45) where species were absent or present

to determine whether the differences in disturbance between occupied and unoccupied point counts remained constant between the two years.

In 1998, Black-and-white Warblers occurred in point counts containing more hikers heard outside of the 50-m radius of the point count (species absent = 0.1 people/visit, species present = 0.4 people/visit) (Table 8). Brown-headed Cowbirds occupied point counts that contained fewer total hikers (species absent = 0.5 people/visit, species present = 0.1 people/visit), and fewer total people (species absent = 0.6 people/visit, species present = 0.4 people/visit), but more bicyclists (species absent = 0.0 people/visit, species present = 0.2 people/visit). This species occurred at point counts with a lower index of disturbance caused by people (species absent, index = 0.2, species present, index = 0.1).

In 1998, the technician also observed several species of woodpeckers. He found Downy Woodpeckers at point counts that had less traffic (species absent = 0.1 times heard traffic/visit, species present = <0.1 times heard traffic/visit), and Hairy Woodpeckers occurred in point counts that contained more hikers heard outside the 50-m radius of the point count (species absent = 0.1/visit, species present = 0.3 heard/visit).

Mourning Doves occupied point counts that contained fewer total hikers (species absent = 0.5 people/visit, species present = 0.1 people/visit). Red-bellied Woodpeckers occurred at point counts that contained more hikers heard within the 50-m radius of the point count (species absent = 0.1/visit, species present = 0.7/visit), and more cars seen (species absent = 0.1/visit, species present = 0.2/visit).

Ruby-throated Hummingbirds occupied point counts with both people and vehicular disturbance. This species occurred in point counts with more dogs (species absent = <0.1/visit, species present = 0.2/visit), hikers heard within the 50-m radius of the point count (species absent = 0.2/visit, species present = 0.9/visit), and more total number of people (species absent = 0.5/visit, species present = 1.2/visit). These hummingbirds also occupied point counts with more cars seen (species absent = 0.1/visit, species present = 0.4/visit). Therefore, Ruby-throated Hummingbirds occurred in point counts with a higher index of disturbance caused by people (species absent, index = 0.2, species present, index = 0.6), and total disturbance (species absent, index = 0.3, species present, index = 0.9).

White-eyed Vireos were present at point counts with more hikers heard within the 50-m point count (species absent = 0.1/visit, species present = 0.6/visit). Automobile traffic did not seem to repel White-eyed Vireos (species absent = <0.1 vehicles heard/visit, species present = 0.1 vehicles heard/visit), and the index of disturbance from vehicles was greater at point counts containing this species (species absent, index = 0.1, species present, index = 0.2).

In 1999, Black-crested Titmice, Summer Tanager, and Yellow-billed Cuckoo showed no differences in disturbance variables in point counts where they occurred, compared to where they did not occur (Table 9). Black vultures occurred in point counts with more dogs (species absent = <0.1/visit, species present = 0.1/visit). Carolina Wrens occurred at point counts with more joggers (species absent = <0.1/visit, species present = 0.1/visit), while Northern Mockingbirds occupied point counts with more disturbance

Table 9. Mann-Whitney comparisons between point counts where a species was absent and present in 1999.

Species	Variable	Species Absent*	Species Present*	X^2	*P*-Value
Black-crested Titmouse		*n* = 11**	*n* = 34**		
	No significant differences observed				
Blue Jay		*n* = 9	*n* = 36		
	Total number of people at a point count	0.4	0.6	5.8	0.0164
	Index of disturbance caused by people	0.1	0.2	6.0	0.0147
Black Vulture		*n* = 32	*n* = 13		
	Dog	<0.1	0.1	4.5	0.0340
Carolina Wren		*n* = 7	*n* = 38		
	Jogger	<0.1	0.1	2.9	0.0909
Northern Mockingbird		*n* = 16	*n* = 29		
	Number of cars seen	0.2	0.4	4.0	0.0451
	Traffic heard outside of the point count	0.3	0.4	3.9	0.0487
	Index of disturbance caused by vehicles	0.5	0.8	4.5	0.0348
	Index of total disturbance	0.6	1.0	4.6	0.0339
Pileated Woodpecker		*n* = 26	*n* = 19		
	Dog	<0.1	0.0	3.1	0.0799
Summer Tanager		*n* = 30	*n* = 15		
	No significant differences observed				
Yellow-billed Cuckoo		*n* = 35	*n* = 10		
	No significant differences observed				

* Numbers shown are means for each variable tested

** Number shown are the point counts (out of 45) where species were absent or present from cars observed at point counts (species absent = 0.2/visit, species present = 0.4/visit) and traffic (species absent = 0.3/visit, species present = 0.4/visit). Northern Mockingbirds also occupied point counts with a significantly higher index of disturbance for vehicles (species absent, index = 0.5, species present, index = 0.8), and total disturbance (species absent, index = 0.6, species present, index = 1.0).

Two species, Blue Jays and Pileated Woodpeckers, showed significant differences in disturbance variables between occupied and unoccupied sites during both 1998 and 1999 (Tables 8 and 9). Blue Jays seemed sensitive to vehicles, but tolerant of human presence. In 1998, Blue Jays occurred in point counts containing fewer cars (species absent = 0.1 cars/visit, species present = < 0.1 cars/visit). In 1999, Blue Jays occurred in point counts containing more total people (species absent = 0.4 people/visit, species present = 0.6 people/visit), and a higher index of disturbance caused by people (species absent, index = 0.1, species present, index = 0.2)

Pileated Woodpeckers seemed to tolerate people, but not dogs. In 1998, Pileated Woodpeckers occurred in point counts with more hikers (species absent = 0.2/visit, species present = 0.8/visit) and bicyclists (species absent = <0.1/visit, species present = 0.2/visit) heard within the 50-m radius of the point count, as well as more cars seen (species absent = 0.1/visit, species present = 0.3/visit). In 1999, the only significantly different variable for Pileated Woodpeckers involved the presence of dogs: this species occupied point counts containing fewer dogs (species absent = < 0.1/visit, species present = 0.0/visit).

Significant relationships between disturbance variables and avian species. Disturbance did not seem to affect their presence at point counts within BSP for Great Crested Flycatchers, Red-eyed Vireos, Red-shouldered Hawks and Yellow-billed Cuckoos in 1998 (Table 8). Species in 1999 that did not differ between point counts with disturbance and point counts without included Black-crested Titmouse, Summer Tanager, and Yellow-billed Cuckoo (Table 9). However, some species did seem affected by the presence of people (Table 10): Pileated Woodpeckers did not occupy point counts with dogs. Brown Headed Cowbirds and Mourning Dove exhibited sensitivity to people walking, and Brown-headed Cowbirds did not tolerate higher numbers of people at a point count.

More species, however, seemed tolerant of human disturbance. Black Vultures and Ruby-throated Hummingbirds occupied point counts in the presence of dogs (Table 10). Pileated Woodpeckers, despite being intolerant of dogs (and their human handlers), did not avoid point counts with hikers heard inside the point count, nor did Red-bellied Woodpeckers, Ruby-throated Hummingbirds or White-eyed Vireos. These species, along with Black-and-white Warblers, Hairy Woodpeckers, and Carolina Wrens occupied point counts despite the fact that pedestrians (e.g., hikers and joggers) also occurred in them. Bicyclists did not seem to affect Pileated Woodpeckers or Brown-headed Cowbirds, and higher numbers of people did not seem to affect Blue Jays or Ruby-throated Hummingbirds.

Table 10. Relationships between disturbance variables and the presence of avian species at BSP.

The species is sensitive to human disturbance	The species is tolerant of human disturbance
Dogs	
Pileated Woodpecker 1999	Black Vulture 1999
	Ruby-throated Hummingbird 1998
Hikers heard inside the point count	
	Pileated Woodpecker 1998
	Red-bellied Woodpecker 1998
	Ruby-throated Hummingbird 1998
	White-eyed Vireo 1998
Hikers heard outside of the point count	
	Black-and-white Warbler 1998
	Hairy Woodpecker 1998
Total number of hikers observed or heard	
Brown-headed Cowbird 1998	
Mourning Dove 1998	
Joggers observed or heard	
	Carolina Wren 1999
Number of bicyclists heard in the point count	
	Pileated Woodpecker 1998
Number of bicyclists heard outside the point count	
	Brown-headed Cowbird 1998
Total number of people observed or heard	
Brown-headed Cowbird 1998	Blue Jay 1999
	Ruby-throated Hummingbird 1998
Total number of cars observed	
	Northern Mockingbird 1999
Blue Jay 1998	Pileated Woodpecker 1998
	Red-bellied Woodpecker 1998
	Ruby-throated Hummingbird 1998
Automobile traffic seen or heard	
Downy Woodpecker 1998	Northern Mockingbird 1999
	White-eyed Vireo 1998
Index of disturbance caused by people	
Brown-headed Cowbird 1998	Blue Jay 1999
	Ruby-throated Hummingbird 1998
Index of disturbance caused by automobiles and traffic	
	Northern Mockingbird 1999
	White-eyed Vireo 1998
Total index of disturbance	
	Northern Mockingbird 1999
	Ruby-throated Hummingbird 1998

The degree of mechanical disturbance also related to the presence of various avian species. Blue Jays and Downy Woodpeckers seemed to avoid point counts that included disturbance from vehicles. Many other species, however, did not avoid point counts with vehicular disturbance. Pileated Woodpeckers, Red-bellied Woodpeckers and Ruby-throat Hummingbirds tolerated elevated numbers of cars, while White-eyed Vireos tolerated higher levels of traffic. Northern Mockingbirds tolerated both higher numbers of cars and more traffic at point counts.

Although several species occurred in point counts with higher indices of disturbance, Brown-headed Cowbirds did not tolerate a higher index of human disturbance. Blue Jays and Ruby-throated Hummingbirds, however, tolerated a higher index of human disturbance. White-eyed Vireos tolerated a higher index of vehicular disturbance, Ruby-throated Hummingbirds tolerated an elevated total index of disturbance, and Northern Mockingbirds tolerated a higher index of disturbance from both vehicles and total disturbance.

Differences in species abundances between control, trail, road, and campground sites. I analyzed any species that occurred on > 7 point counts to determine if their mean abundances differed between control sites, point counts with trails, point counts near or alongside roads, and campgrounds (Table 11). In 1998, six species (American Crow, Blue Jay, Carolina Wren, Northern Mockingbird, Summer Tanager and White-eyed Vireo), as well as species richness and abundance, differed between these four

Table 11. Kruskall-Wallace analysis showing significant differences in bird species between control, trail, road, and campground point counts in BSP.

Variable	No trail (Control) (*n* = 7)	Trail (*n* = 32)	Road (n = 4)	Campground (*n* = 2)	X^2	*P*-Value* (*df* = 3)
1998						
American Crow	0.7	0.6	0.7	1.5	15.2	0.0017
Blue Jay	0.3	0.3	0.1	0.5	7.0	0.0720
Carolina Wren	0.5	0.3	0.4	0.4	6.4	0.0943
Northern Mockingbird	<0.1	<0.1	0.1	0.1	12.3	0.0065
Summer Tanager	0.6	0.4	0.3	0.1	12.1	0.0070
White-eyed Vireo	0.1	0.3	0.1	0.4	11.4	0.0098
Richness	5.0	4.6	4.9	5.8	8.8	0.0327
Abundance	6.2	5.6	5.9	7.2	10.6	0.0141
1999						
Mourning Dove	0.5	0.6	0.5	0.2	8.7	0.0338
Northern Mockingbird	0.2	0.2	0.3	0.4	6.7	0.0831

*significant at $P \leq 0.10$

categories (Fig. 6). All species occurred in all four categories of point counts, but in various numbers, depending on the species. Carolina Wren (0.5/visit) and Summer Tanager (0.6/visit) occupied control point counts in the highest numbers, but control point counts contained few Northern Mockingbirds (<0.1/visit) and White-eyed Vireos (0.1/visit). Point counts with trails contained more American Crows and Summer Tanagers, but the fewest Carolina Wrens and Northern Mockingbirds (0.3 and <0.1/visit, respectively). Sites associated with roads contained high numbers of American Crows (0.7/visit), Carolina Wrens (0.4/visit), and Summer Tanagers (0.3/visit), but fewer Blue Jays (0.1/visit), Northern Mockingbirds (0.1/visit), and White-eyed Vireos (0.1/visit). Campgrounds contained the most American Crows (1.5/visit), Blue Jays (0.5/visit) and White-eyed Vireos (0.4/visit), but the fewest Summer Tanagers (0.1/visit).

In 1999, only two species occurred in significantly different numbers in the four site types. Mourning Dove occurred in all site types (control sites = 0.5 individuals/visit, road sites = 0.5/visit), but in the highest numbers (0.6/visit) in trail and the lowest numbers in campground sites (0.2/visit) (Fig. 7). As in 1998, Northern Mockingbirds in 1999 occupied all types of sites (control and trail = 0.2/visit, road = 0.3/visit), but occurred in the highest numbers (0.4/visit) in point counts associated with campgrounds.

Significant differences in species richness and abundance occurred only in 1998 (Table 11, Fig. 8). The highest species richness (5.8 species/visit), as well as abundance (7.2 individuals/visit) occurred in campgrounds, while the other categories contained similar richness (control sites = 5.0 species/visit, trail sites = 4.6 species/visit, road sites

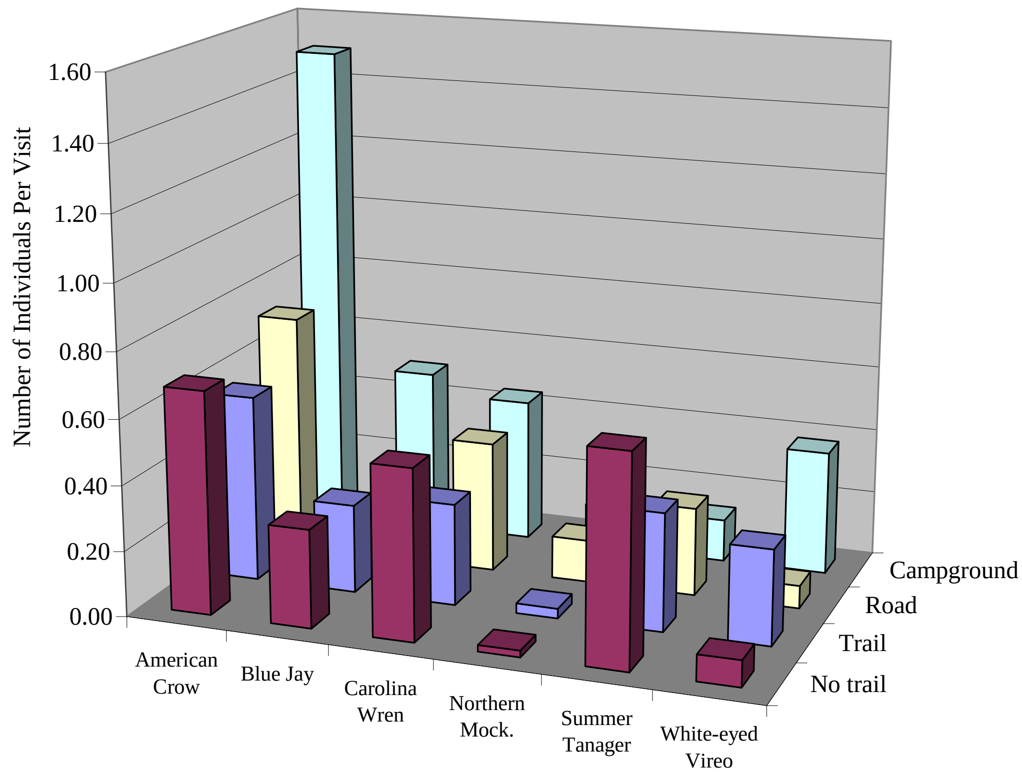

Fig. 6. Significant differences for avian species in four point count categories (control, trail, road, and campground) in 1998 in BSP.

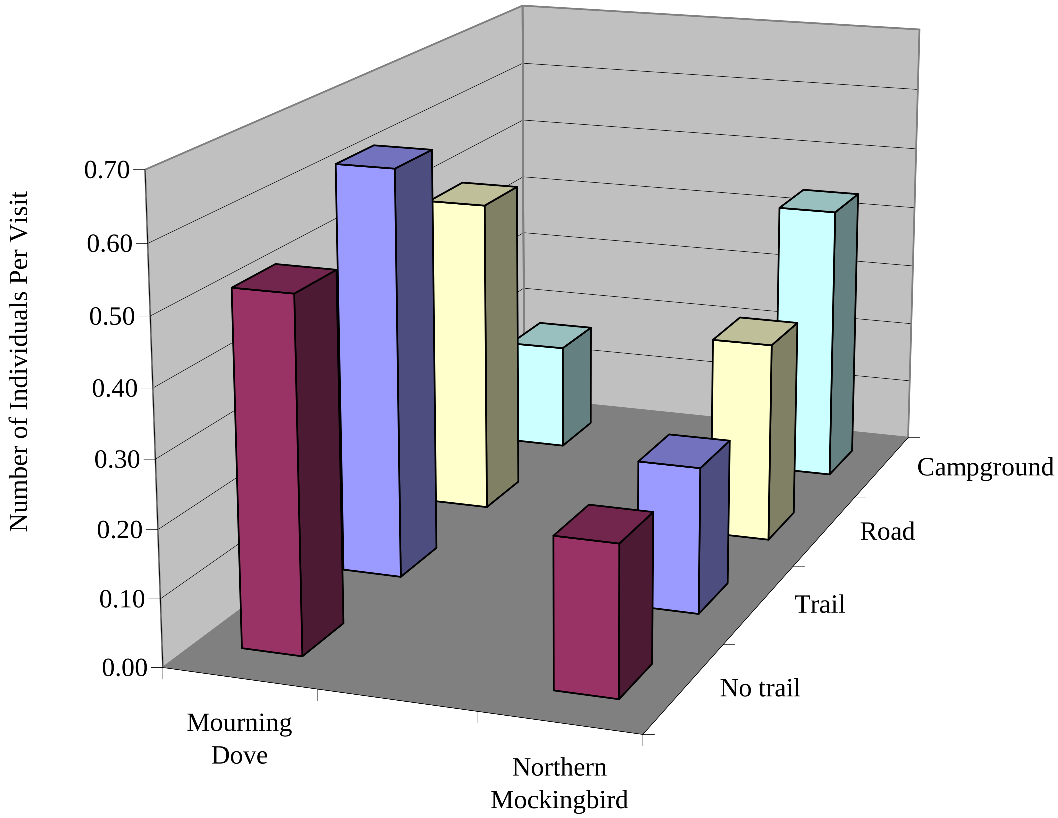

Fig. 7. Significant differences for avian species in four point count categories (control, trail, road, and campground) in 1999 in BSP.

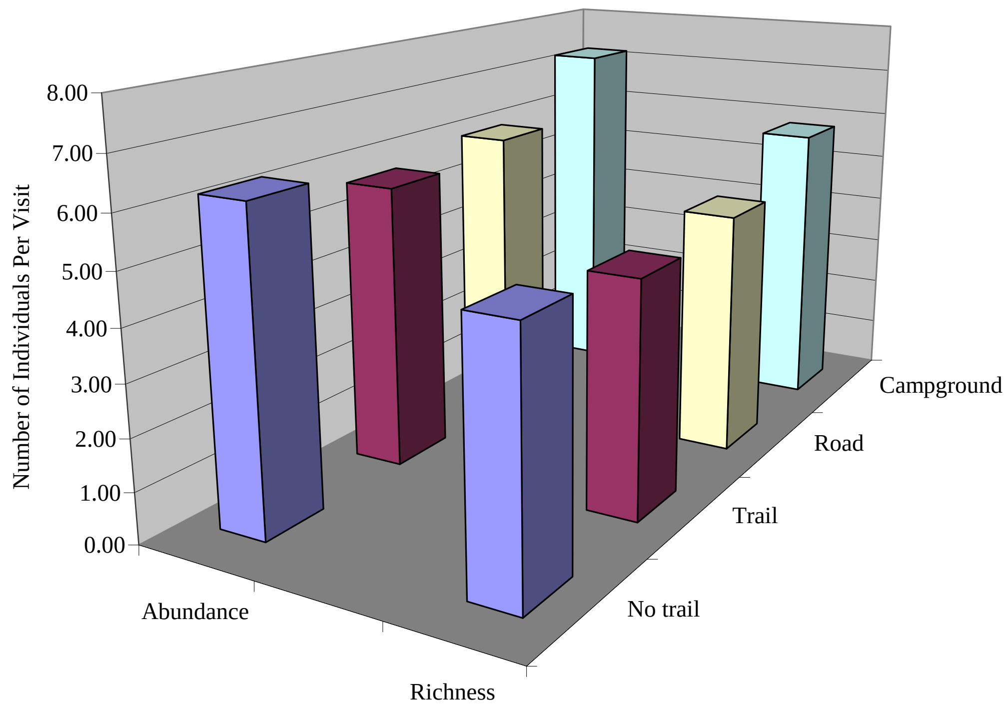

Fig. 8. Significant differences for 1998 avian species richness and abundance in four point count categories (control, trail, road, and campground) in BSP.

= 4.9 species/visit) and abundance (control sites = 6.2 individuals/visit, trail sites = 5.6 individuals/visit, road sites = 5.9 individuals/visit).

DISCUSSION AND CONCLUSIONS

Disturbance in BSP

Much of BSP is developed to some degree for recreation, with many areas accessible by vehicles. Several areas within BSP experienced significant sources of disturbance; almost half of all point counts experienced some form of human presence, such as hikers, bicyclists, campers and anglers in 1998 (with slightly lower levels in 1999). People tended to use the same point counts for a variety of activities, exposing birds to prolonged, all-day activities of various disturbance levels and group sizes. Only small portions of the park contain areas remote enough to have few or no humans present.

The most disturbed point counts had several types and high numbers of people. Although the frequency and degree of disturbances differed between 1998 and 1999, the same point counts received the most disturbance during both years. While vehicular traffic was recorded in higher levels in 1999, during both years the point counts with the most visitors also experienced the most traffic, which agrees with Van der Zande and Vos' (1984) study that showed most visitors to an area arrive by car, and remain near their cars during their visit (Yalden 1992).

The indices of disturbance at BSP, whether from humans, vehicles, or total disturbance, also show that some point counts experienced high amounts of disturbance. Although the field technicians found some sites that had no humans present, many sites did have an index of disturbance > 0 from humans and/or vehicles, which resulted in 62% of the point counts in 1998, and 91% of the point counts in 1999, having an index of total disturbance > 0. As expected, campgrounds received the most disturbance from both humans and vehicles, with an average disturbance index of 0.8 (1998 and 1999) for people, which means that in 10 visits to a campground, people were observed 8 of those times. The total index of disturbance at campgrounds in 1998 equaled 1.1, which means that during each visit to a campground, the technician recorded some type of disturbance. Campgrounds in 1999 experienced a higher index of total disturbance (2.7) because of the increased disturbance from vehicles. The more inaccessible, remote control sites had much lower levels of disturbance, because few people ventured to these areas. Trail sites also experienced less disturbance, while road sites experienced more disturbance, not only from vehicles, but from people, too.

Humans as disturbance. This study classified people according to their activity, to examine whether the activity, instead of the presence of a human *per sé*, could impact birds. Pedestrians can impact bird communities if they approach a bird too closely or aggressively, and can actually be more disruptive than vehicular traffic (Klein 1993). Joggers may impact ducks and shorebirds (Burger 1981, 1986), and people at beaches and shores may impact shorebird breeding (Norman and Saunders 1969). Different types of people used the same point counts at BSP, often during the same census period. Pedestrians, particularly hikers or joggers, in BSP occurred on almost half of the point counts surveyed, in groups of up to 5 people in both years. The technicians rarely encountered anglers, probably because the point counts did not occur within the vicinity of the lake, but occurred mostly in the forested areas some distance from the lake. Many day users at BSP remained near the developed campground areas, which agrees with

Yalden's (1992) findings that picnickers remain near their parked cars. In addition to hikers, bicyclists used BSP, but in low numbers (in 1998 bicyclists = 0.1/visit) and in few areas (bicyclists in 1998 occurred in 8 point counts), because campgrounds and roads are the easiest places to ride bicycles, compared to the unpaved trails at BSP. I did not analyze other people, such as anglers and birdwatchers, separately because they occurred only infrequently, but I did include them in the analysis of the effects of the total number of people observed at a point count.

Some species did appear to be sensitive to the presence of people. Fewer Brown-headed Cowbirds and Mourning Doves occurred in point counts with more total hikers, and seemed to be sensitive to pedestrians. Interestingly, these species did not respond differently to quiet or loud hikers, but rather to the number of people that visited the point count at any one time, suggesting that there might be a threshold of the number of people that a species is sensitive to: both species occurred at a site with 0.1 hikers/visit, and did not occur in point counts with 0.5 hikers/visit. Brown-headed Cowbirds did occupy point counts with bicyclists present, perhaps because this type of person is within the cowbird's presence for only a few seconds while traveling through the point count. On the other hand, several species seemed to tolerate humans, particularly hikers, even if the people talked loudly while walking through the point count. Pileated Woodpeckers, Red-bellied Woodpeckers, Ruby-throated Hummingbirds and White-eyed Vireos occupied point counts with loud people (e.g., heard within the 50-m radius of the point counts), and Black-and-white Warblers and Hairy Woodpeckers tolerated people heard from more than 50-m away. Carolina Wrens tolerated joggers, and Pileated

Woodpeckers tolerated bicyclists, perhaps because these people did not remain within the point count for a long period of time. Only one species, Brown-headed Cowbirds, exhibited sensitivity towards the total number of people encountered at one time, while Blue Jays and Ruby-throated Hummingbirds seemed insensitive to even larger groups of people. It is not surprising that these two species tolerate humans, since Blue Jays commonly reside in towns, particularly residential areas (Smith 1979), while Ruby-throated Hummingbirds often inhabit parks (Robinson et al. 1996).

Roads and vehicles as disturbance. The type of road and the resulting volume of traffic may affect a road's impacts on birds. Although less-used secondary roads may provide good foraging sites because of their low traffic volume, and utility poles and wires for perching sites (Varland et al. 1993), larger roads cause significant avian mortality (Case 1978). Because BSP's perimeter lies adjacent to heavily traveled roads (e.g., an interstate highway and the city of Bastrop's roads), as well as having a road cut through the park, great potential exists for disturbance to some species. The field technicians observed and heard vehicles at many point counts within BSP, particularly in 1999. Disturbance from passing vehicles, even those not seen, occurred even more frequently. In 1999, the technician recorded vehicular disturbance at 87% (n = 38) of the point counts.

Busy roadways may lead to long-term displacement of individuals away from roadways (McLellan and Shackleton 1988, Reignen et al. 1996). One species, Downy Woodpeckers, exhibited sensitivity to traffic, occurring less frequently in point counts with higher amounts of moving vehicles, and may suffer from displacement away from areas associated with roads, equivalent to a 'loss' of habitat for this species. However, two species, Northern Mockingbird and White-eyed Vireos, occurred in higher numbers in point counts near roads. Since roads function as edges (Boag et al. 1984), they may allow an increase in edge-related passerines (Wunderle et al. 1987) such as Northern Mockingbirds and White-eyed Vireos, but apparently, not all edge-related species (e.g., Downy Woodpeckers) benefit from roads.

Several species occupied point counts that contained more cars (in contrast to the vehicles heard and recorded as traffic, cars were parked around campgrounds or trailheads and counted individually). Northern Mockingbirds, Pileated Woodpeckers, Red-bellied Woodpeckers, and Ruby-throated Hummingbirds occupied point counts in higher numbers where cars occurred. Only one species, Blue Jay, appeared sensitive to the presence of cars.

Finally, roads serve as corridors for predators; both mammalian and avian predators take advantage of the lack of barriers along roadways to reach their prey (Anglestam 1986, Dreschel et al. 1991, Varland et al. 1993, Breininger et al. 1995). However, in BSP, neither mammalian (e.g. dogs, cats and fox) or avian predators (American Crows, Blue Jays) (Meiklejohn 1994) occurred in higher numbers at point counts associated with roads, suggesting that these species do not use roads as travel corridors. In fact, Blue Jays occurred in the lowest numbers in point counts associated with roads, compared to control, trail, and campground point counts.

The results of this study suggest that responses to vehicles and traffic may be species and context specific. In Lovejoy et al.'s (1986) study, Red-shouldered Hawks strongly avoided paved roads, but in BSP, this species' abundance was not reduced in point counts associated with roads.

Indices of disturbance. The index of disturbance for each point count reflects the total number of disturbance events (by people, vehicles, or the total number of events) that occurred, divided by the number of times a point count was visited. For most species, the index of disturbance did not differ between the presence or absence of a species; however, the presence of five species did reflect differences in the index of disturbance in sites where they occurred compared to where they were absent. Only Brown-headed Cowbirds responded negatively to an increased index of disturbance. Cowbirds did not occupy point counts with frequent visits by humans, possibly because they are heavily trapped by humans to control brood parasitism (Lowther 1993), and may have become sensitive to humans (e.g., their index of disturbance = 0.1). Blue Jays and Ruby-throated Hummingbirds occurred in point counts with a higher index of disturbance, because of their tolerance to various forms of pedestrians. At BSP, Ruby-throated Hummingbirds may be more tolerant than Blue Jays, because the hummingbirds have a higher index of disturbance (0.6) than Blue Jays (0.2). Since White-eyed Vireos and Northern Mockingbirds tolerated automobiles, they occurred in point counts with a higher index of vehicular disturbance (0.2 and 0.8, respectively), perhaps because these point counts provided their preferred edge habitat, in spite of the increased levels of disturbance. Two species, Ruby-throated Hummingbirds and Northern Mockingbirds, occupied point counts with a high total index of disturbance (0.9 and 1.0, respectively), indicating that the combined disturbances from people and vehicles did not repel these species.

Nest predators. The campgrounds at BSP are characterized by decreased ground cover and a less complex structure, which may increase the visibility of open ground nests and enhance the risk of nest predation (Jokimäki and Huhta 2000). Bastrop State Park contains potential mammalian and avian nest predators. Mammals often find nests as a result of human activity (Willis 1973, Gottfried and Thompson 1978), but avian predators often cause most of the nest damage, particularly in urbanized areas (Götmark 1992, Major et al. 1996, Matthews et al. 1999). At BSP, the technicians observed two potential mammalian nest predators (foxes and dogs), but they did not occur with any frequency (in 1998 dogs occurred on 4 point counts, in 1999 on 8 point counts; foxes in 1998 occurred on 2 point counts, and were absent in 1999) or in high numbers (dogs in 1998 = <0.1 dogs/visit, 1999 = <0.1 dogs/visit; foxes in 1998 = <0.1/visit).

Dogs are an important source of disturbance, since unleashed dogs can cause great damage to young ground-nesting birds by scattering or killing them (Watson 1979) or by destroying eggs (Latta et al. 1995). However, compared to Yalden and Yalden's (1988) findings, where dogs accompanied visitors at a 1:2 ratio, dogs in BSP occurred rarely and in low numbers (6 dogs in 1998, and 13 dogs in 1999). Both Black Vultures and Ruby-throated Hummingbirds occupied point counts that contained dogs, and seem tolerant of dogs, at least if they accompany humans. On the other hand, fewer Pileated Woodpeckers occupied point counts containing dogs, because they may perceive a higher risk of predation from dogs than other avian species do. Another well known mammalian nest predator, free-roaming house cats can cause problems in protected areas (Sykes and Clench 1998), by reducing the nesting success of ground-nesting birds (Gilbert 1989). However, in this study, the field technicians did not detect any stray cats over either field season, suggesting that their importance in nest predation within BSP might be inconsequential. Perhaps predators in BSP avoid human activities (Osborne and Osborne 1980), minimizing predation risks at BSP, which agrees with Götmark's (1992) conclusions.

American Crows and Blue Jays, both nest predators, occurred at BSP, particularly in campgrounds and may pose a threat to fledglings, rather than nestlings (O'Grady et al. 1996). Although Götmark and Ahlund (1984) suggest that crows do not increase their predation success in the presence of human, more studies need to examine the risk these predators pose to nesting birds within BSP.

Resident vs. migrant species. In this study, sensitivity to disturbance did not depend on an individual's migratory status, or whether it is an edge or interior species. Two resident (Black-crested Titmouse and Red-shouldered Hawk) and three migrant species (Great Crested Flycatcher, Red-eyed Vireo, and Yellow-billed Cuckoo) showed no responses to disturbance at all, nor did they occur in lower abundances in more disturbed areas within BSP. Despite Flather and Sauer's (1996) study that showed that resident species tolerate disturbance better than migrants, Brown-headed Cowbirds and Mourning Dove, both year round residents at BSP, appeared sensitive to disturbance, as did Summer Tanagers, a neotropical migratory species. Both resident and migratory species tolerated disturbance from people (i.e., resident = American Crow, neotropical migrant = Black-and-white Warbler), vehicles (i.e., resident = Northern Mockingbird) or both (i.e., resident = Pileated Woodpecker, neotropical migrant = Ruby-throated Hummingbird).

The edge habitats inherent along roadsides and in campgrounds did not repel species based on their migratory status, either. Summer Tanagers, a migratory species, did show sensitivity to edge habitats, and occurred in the highest abundance in control sites. On the other hand, another migratory species, White-eyed Vireos occurred in the highest numbers in campgrounds, and the lowest numbers in control sites.

No differences existed, either, between edge and interior species in their sensitivity towards, or tolerance of, disturbance. Edge species such as American Crows, and Great Crested Flycatchers tolerated disturbance, as did Black-and-white Warblers, Hairy Woodpeckers, and Red-eyed Vireos, all interior species. Some edge species, surprisingly, did exhibit sensitivity to disturbance: fewer Blue Jays, Downy Woodpeckers, and White-eyed Vireos occupied point counts near roads, Brown-headed Cowbirds were sensitive to people and more Summer Tanagers occurred in control sites, compared to trail, road, or campground point counts.

Habituation to disturbance. The results of this study suggest that many species that use BSP in the summer may have become habituated to visitors, although other species did not become habituated. Boudreau (1968) suggested that Brown-headed Cowbirds habituate to humans; the results of my study show that this species did not seem to habituate to the presence of humans in BSP. Rodgers and Smith (1997) suggest that species with a history of association with humans may habituate to human presence, which might be the case with Blue Jays, and Black-crested Titmice in BSP. However, the reverse may also be true: species that are hunted and killed by humans, such as Brown-headed Cowbirds and Mourning Dove, may become more sensitive and fearful of humans, as has happened with crows and ravens in areas where humans hunt them or destroy their nests (Götmark and Ahlund 1984, Knight 1984, Verbeek and Caffrey 2002).

Habituation may occur relatively rapidly: some species can habituate to humans within a period of 2–17 days (Conomy et al. 1998). In addition to some resident species, some migrant species at BSP habituated to human disturbance, perhaps because I conducted my field research in May, several months after these migrants had arrived in the park, giving them time to acclimate to humans. Many species at BSP, regardless of migratory status, tolerated human disturbance, perhaps because, through repeated exposure to users of the park, they learned that humans would not harm them (Burger and Gochfeld 1991). Additionally, many areas within BSP experienced low, relatively quiet levels of human presence (although some species such as Black-and-white Warblers tolerated people heard even outside of the 50-m point count radius), instead of erratic and startling disturbance events, which would make it harder for individuals to habituate to (Marsden 2000). Several species (e.g., Blue Jay, Northern Mockingbird, Ruby-throated Hummingbird, and White-eyed Vireo) appeared to habituate to a higher index of disturbance, which could mean they can tolerate a higher, continual disturbance, so long as no sudden, unexpected disturbance occurs (Hockin et al. 1992).

Management of Species Affected by Disturbance at BSP

American Crow. American Crows, the only species in BSP to occur on all 45 point counts in both years of field research, appeared in some of the highest numbers of all species. Freeman (1996) considered crows an abundant year-round resident throughout the park. These higher may numbers reflect an increase in crow populations throughout the U. S. (Sauer et al. 1997), or may result more from a shift in distribution from rural to urban areas (McGowan 2001) then a significant increase in population size. Because they occupied all 45 point counts, I could not determine whether significant differences in any disturbance types existed between point counts where crows occurred compared to where they did not occur. These results agree with Verbeek and Caffrey's (2002) findings that crows occupy a wide variety of habitats. Crows require two types of habitat for successful reproduction: open areas (e.g., meadows, parks, agricultural fields, etc.) for ground feeding, and scattered trees, forest edges, and woodlots for shelter, nesting and safety; both these habitat types exist in BSP. At BSP, crows occurred in significantly higher numbers in campgrounds, which provide the edge habitat this species prefers (Whitcomb et al. 1981, Wilcove 1985). Since American Crows are significant avian nest predators (Götmark and Ahlund 1984, Ehrlich et al. 1988), and can cause agricultural damage (Johnson and Altman 1983), research should examine the long-term population trend of American Crows, and whether they affect the reproductive success of other species at BSP.

Black-and-white Warbler. Long-distance neotropical migrants, Black-and-white Warblers commonly reside throughout the eastern and central U. S. during the summer months. This species, unlike many other neotropical migrants, is not showing a nationwide decline (Galli et al. 1976), however, BBS data (Kricher 1995) show a decline in the Edwards Plateau of central Texas, and Bastrop's bird checklist (Freeman 1996) shows they are uncommon in the summer. This interior-forest species may be found in mixed deciduous – coniferous forests, but strongly prefers mature deciduous forests, foraging between the canopy and forest floor, probing the bark of trees for insects. This species uses the most habitat types of any wood-warbler (Arendt 1992), which includes disturbed habitats (including forest edges, parks, and gardens) in its wintering grounds (Kricher 1995), so it is not surprising that Black-and-white Warblers at BSP occur in point counts with higher numbers of loud hikers. It is surprising, though, that this interior species did not occur in higher numbers in the control (e.g., remote) areas of BSP, compared to the edge habitat of campgrounds and roads. Given their declining numbers, despite their apparent tolerance to people, remote areas within the park should be left undisturbed to provide this ground nesting species areas with sufficient undergrowth and shrubs to allow for successful reproduction.

Blue Jay. The Blue Jay is a common (Freeman 1996) year-round resident of BSP (Tarvin and Woolfenden 1999), and occurred in sufficient numbers to analyze both in 1998 and 1999. Urbanization and the resulting changes in vegetation, and increased use of bird feeders (Smith 1978) have caused the Blue Jay's range to expand westward in the U. S. As an edge species (Graber et al. 1987), Blue Jays inhabit a wide variety of habitats, including deciduous, coniferous and mixed woodlands, as well as towns, particularly residential areas with large oak trees (Smith 1979). In BSP, Blue Jays occupied point counts with more people, and a higher index of disturbance caused by people, indicating that this species tolerates humans. The highest abundance of Blue Jays in BSP occurred in campgrounds, which provided lawns where they can easily forage and collect nesting materials (Tarvin and Woolfenden 1999). Despite their seeming tolerance of people, Blue Jays avoided point counts with more cars, particularly road-associated point counts. Blue Jays occur more often in forest edges (Whitcomb et al. 1981, Wilcove 1985) than in forest interiors (Welsh and Healy 1993), so I expected this species to use roadsides to travel, but this did not occur in BSP.

Although Blue Jay abundance has declined across the U. S., most of the decline has occurred in the east, with central and western regions remaining stable (Sauer et al. 1997). Because Blue Jays are nest predators (Vander Haegen and Degraaf 1996), edge species and (to some small degree) agricultural pests, research should focus on population trends, particularly in relation to any species at BSP that are declining in abundance (Wilcove 1985, Engles and Sexton 1994), and their impacts on nesting species. Additional research should be conducted to determine why Blue Jays seem to tolerate people, but not vehicles.

Black Vulture. Observed only in 1999, Black Vultures occurred in 13 point counts as an uncommon species in BSP, despite the fact that Freeman (1996) considers this a common species within the park. This resident species does not build a nest; instead individuals lay their eggs on the bare ground, in a hollow tree, abandoned building or other dark place (Buckley 1999). Black Vultures exhibit complex social behaviors and gather together in communal roosts in the evening, an important event in this species' social life (Buckley 1996). Vultures require two types of habitat, one for breeding and one for foraging. They breed and roost in isolated, dense woodlands containing undisturbed stands of trees. Vultures require thicker and taller trees for roosts, and prefer conifers over deciduous roost trees, since conifers provide protection from the wind and minimize nighttime temperature declines (Thompson et al. 1990). They use open habitat, often near roads, when searching for carcasses (Coleman and Fraser 1989), but roads in BSP did not contain more vultures than other sites. Black Vultures may congregate and roost in disturbed sites, such as army bases or parks, forming extremely large colonies (Prather et al. 1976, Wright et al. 1986). Although Black Vultures will abandon a nest site if disturbed, they did not show differences in their use of point counts in response to various types of disturbance in BSP. This species tolerated the presence of dogs, which is surprising, since dogs can destroy any eggs and young on the ground (Coleman and Fraser 1989, Rabenold and Decker 1990).

The Black Vulture population within the U. S. has increased, but populations in Texas, Georgia, Louisiana, and South Carolina have decreased (Buckley 1999), mostly because of a loss of high-quality breeding sites (including isolated, abandoned buildings, Rabenold and Decker 1990), a shortage of safe nest sites (Stewart 1984) and scarcity of food resources in intensively tilled agricultural areas (Buckley 1999). The decline of this species in several states has resulted in its receiving a Partners In Flight IIIA Tier B score, which contains species that warrant conservation concern, even though some areas may show a population increase (Carter et al. 2000, Panjabi 2001). Due to its decline and its vulnerability to disturbance, this species should undergo further monitoring at

BSP, have access to undisturbed sites containing mature trees, and researchers should examine Black Vulture responses to human disturbance in more detail.

Brown-headed Cowbird. Brown-headed Cowbirds, a year-round resident species in BSP, is North America's best known brood parasite (Lowther 1993). This species prefers wood-field ecotones containing low or scattered trees growing among brushy thickets, fields, pastures, or residential areas for its breeding habitat (Gates and Gysel 1978, Brittingham and Temple 1983, Johnson and Temple 1990). Cowbirds at BSP exhibited sensitivity to hikers, higher numbers of people, and a higher index of human disturbance, but they tolerated bicyclists. Despite being an edge species, campgrounds and roads did not attract cowbirds, even though these areas provide better feeding habitat than forests for this species (Hunt 1995).

Cowbird numbers have decreased significantly in Texas due to trapping in their breeding areas (Lowther 1993). Although Freeman (1996) considers Brown-headed Cowbirds common in BSP, the technician observed them frequently only in 1998; they were rarely seen in 1999. The reason for this drastic decline in observations in 1999 remains unknown, since the point counts did not have greatly changed management activities between the years. Since Brown-headed Cowbirds show higher sensitivity to human disturbance than many of the species they parasitize, they may only minimally impact other species at BSP. Further study should address the effects of human disturbance on Brown-headed Cowbirds, and the resulting impacts of brood parasitism by this species at BSP.

Carolina Wren. The Carolina Wren, a generalist species, is a common (Freeman 1996, my results), year-round resident in BSP, although this species shows both increased and decreased populations throughout its range (Haggerty and Morton 1995). Forest fragmentation and thickets have benefited this species (Brewer et al. 1991), because Carolina Wrens live in a wide variety of habitats, including moderate to dense shrub or brush (Conner et al. 1983, Breininger and Smith 1992), mixed pine-hardwood forests (Hamel et al. 1982) and wooded residential areas with shrubs (Brewer et al. 1991), which may reduce the chances of parasitism by Brown-headed Cowbirds, a significant source of nest failures (Haggerty and Morton 1995). My results show that Carolina Wrens tolerated joggers, which agrees with Haggerty and Morton's (1995) study showing that Carolina Wrens are usually not sensitive to human disturbance, but contrasts with Burger's (1991) study in which slow-moving birdwatchers had less of an impact than joggers or other fast-moving people. These wrens did occur in higher numbers in control sites, which suggests that, given the opportunity, this species prefers areas without human disturbance. Management of this species should center on providing sufficient tree density and cover in areas throughout the park, and research should further examine the effects of disturbance on this species.

Downy Woodpecker. The Downy Woodpecker is one of the smallest, most numerous woodpecker species in North American (Jackson and Ouellet 2002), and was the most the most numerous woodpecker species in BSP, even more common in the early field season of 1998 than Freeman (1996) reports. A year-round resident at BSP, Downy Woodpeckers inhabit open, deciduous woodlands, orchards, and human-modified forests in urban areas. At BSP, disturbance by humans did not significantly affect Downy Woodpecker occurrence at point counts (including campgrounds), whereas they occurred in fewer numbers at point counts with increased vehicular traffic. These results are surprising, since this edge species readily inhabits urban woodlots and can live in urban and suburban residential areas, even nesting in fence posts (Jackson and Ouellet 2002). Roadways provide edge habitat, but these birds may avoid roadside areas because of the rapidly-moving vehicles, or lack of suitable habitat.

Downy Woodpecker populations remain stable (Sauer et al. 2000), but continued deforestation, clearing of fencerows and increased use of metal fence posts could negatively impact this species (Sherman 1996). Management of Downy Woodpeckers at BSP should include retaining snags, even within campgrounds, and sufficiently large trees, both within and outside of campgrounds, away from heavily traveled roads. More study is required on why this species tolerates humans, but exhibits sensitivity to vehicular traffic.

Hairy Woodpecker. Hairy Woodpeckers, a year-round resident at BSP, occupied sufficient point counts for analysis only in 1998, and was fairly common that year, compared to Freeman's (1996) study, which showed Hairy Woodpeckers occur rarely in BSP. Hairy Woodpeckers live and nest in mature, mixed-hardwood forests, as well as woodlands in the suburbs which have enough mature trees (Jackson et al. 2002). This forest-interior species (Robbins 1979) can occur in small woodlots, parks, residential areas and cemeteries, but usually in low numbers (Jackson et al. 2002). Hairy Woodpeckers at BSP occurred in point counts that had loud hikers (e.g., heard outside of the 50-m radius of the point count), indicating that this species tolerates humans (Robbins 1979). No significant differences in abundance arose when I categorized the point counts into control, trail, road, and campground sites, suggesting that this species tolerates even heavily-used areas of BSP.

Hairy Woodpecker populations are declining steadily (Hess et al. 2000), probably due to forest fragmentation (Robbins 1979). Management of Hairy Woodpeckers at BSP should include leaving sufficient snags and mature trees throughout BSP, even in campgrounds, since this species requires at least 4 ha woodlots to maintain breeding populations (Robbins 1979).

Mourning Dove. The Mourning Dove is one of the most abundant and widespread terrestrial birds in North America (Mirarchi and Baskett 1994). This species has benefited from human landscape changes, and has expanded its distribution in North America, occupying rural and urban landscapes. It tends to avoid heavily forested areas (Mirarchi and Baskett 1994), preferring more open woodlands and edges between forests and grasslands (Tomlinson and Dunks 1993). A resident species in BSP, Mourning Doves readily live in cities and suburbs, and nest close to humans (Mirarchi and Baskett 1994), indicating tolerance to humans. Results of the effect of human disturbance on Mourning Doves conflict; observers may lead predators to Mourning Dove nests (Morrow and Silvy 1982), and although Nichols et al. (1984) found similar success rates of Mourning Dove nests visited at daily and weekly intervals on their study area, Westmoreland and Best (1985) found that researchers commonly induced nest failures in Mourning Dove studies. My results suggest that, at least in BSP, Mourning Doves may be more sensitive to human disturbance than is believed: they did not occur in point counts containing more hikers, and significantly fewer individuals occupied point counts in campgrounds, compared to control, trail, or road-associated point counts. Mourning Doves have experienced a moderate decline in several areas of the U.S. (Tomlinson et al. 1995), although they are still common throughout much of their range, including BSP (Freeman 1996). The greatest threat for this species results from loss of breeding habitat, so major management activities at BSP should focus on providing open areas for nesting away from campgrounds and heavily-used trails.

Northern Mockingbird. The Northern Mockingbird, a year-round resident throughout much of the U. S., favors parkland, cultivated lands, second growth habitat, and suburban habitats (Derrickson and Breitwisch 1992). In this study, Northern Mockingbirds tolerated higher numbers of cars and traffic, and a higher index of vehicular disturbance, along with occupying point counts near roads. This species also occupied point counts in campgrounds, which contained the most people, in addition to higher traffic and more cars, which suggests that disturbance from people does not repel these birds, either.

Mockingbird densities show a significant decline in recent years in Texas for unknown reasons, despite their ability to use a wide variety of habitats (Droege and Sauer 1989, Derrickson and Breitwisch 1992). Mockingbirds are common in BSP (Freeman 1996), and in 1999 they occurred in 29 point counts; however, this species occupied only 7 point counts in BSP in 1998, with fairly few individuals seen per visit. This species has received a IIIA Tier B score from Partners in Flight (Carter et al. 2000, Panjabi 2001) because of its population decline and conservation concern. As an edge species that seems to tolerate human disturbance, BSP may provide suitable edge habitat along roads and in campgrounds, but, given their declining populations, further monitoring should determine whether Northern Mockingbird populations are declining or stable within this park.

Pileated Woodpecker. The largest woodpecker in Texas, Pileated Woodpeckers inhabit BSP year round (Bull and Jackson 1995). Pileated Woodpeckers appear tolerant of hikers and bicyclists, occurring in higher numbers in point counts with these types of people. However, this species was the only species I analyzed that occurred in point counts with fewer dogs, which indicates sensitivity to this potential predator (Latta et al. 1995). In 1998, Pileated Woodpeckers associated with point counts that contained more cars, but did not occur in significantly different numbers in control, trail, road or campground sites. These results suggest that Pileated Woodpeckers can use areas throughout the park, if they contain large enough trees for cavities (Bull and Jackson 1995) and dense vegetation for prey (Conner 1981), since Pileated Woodpeckers use areas with higher densities of large trees (both living and dead) and a closed canopy (Bull and Holthausen 1993). If the surrounding trees in BSP are tall enough for them to feel protected, Pileated Woodpeckers may more readily tolerate human disturbance.

Breeding Bird Surveys show no significant changes in population within the central U. S. (Bull and Jackson 1995); according to Freeman (1996), this species is fairly uncommon in BSP. Although Pileated Woodpeckers occupied enough point counts to analyze in both 1998 and 1999, they did not occur in high numbers during either year, suggesting a wide distribution, but in low numbers. With increasing removal of large trees and forested habitats that accompany urbanization in central Texas, this species of woodpecker may lose significant areas for living and reproducing, so management for Pileated Woodpeckers within BSP should focus on providing enough large trees and snags for nesting and roosting.

Red-bellied Woodpecker. Red-bellied Woodpeckers occupied enough point counts in 1998 for analysis, and occurred in the second highest abundance of any woodpecker species in BSP, fewer only than Downy Woodpeckers. Residents at BSP year round, Red-bellied Woodpeckers inhabit forests with relatively mature hardwoods containing large-diameter trees. These woodpeckers nest and forage in forests with greater tree density and midstory/understory density, and require large snags for nesting (Short 1982), although they readily nest and roost in dead limbs on live trees (Shackelford et al. 2000).

This generalist species seems to do well in a human-dominated area and tolerates human activities near nesting and roosting sites (Shackelford et al. 2000). My results support these conclusions, since Red-bellied Woodpeckers at BSP tolerated both hikers and automobiles. Management of this species should concentrate on leaving enough mast-producing hardwood (e.g., oak) trees throughout the park, and conducting research on the tree-size threshold needed to provide nesting sites, as well as continued monitoring to determine if a threshold of disturbance exists for these woodpeckers, beyond which they will no longer use a site.

Ruby-throated Hummingbird. The technician observed Ruby-throated Hummingbirds, reported by Freeman (1996) as a common neotropical migrant species, in Bastrop only in 1998 on 9 point counts in low numbers. In addition to nectar from flowers, these hummingbirds eat tree sap and small insects (Miller and Nero 1983). This species occupied point counts at BSP disturbed by dogs, hikers, higher numbers of people, and cars. No significant differences in abundance between control, trail, road, and campground sites existed, suggesting that Ruby-throated Hummingbirds tolerate higher levels of disturbance, and use any available habitat throughout BSP, regardless of the presence of humans, supporting Robinson et al.'s (1996) study that these hummingbirds readily inhabit human-used parks.

The population status of this species is unclear, but may be in decline, and although this species currently requires no active management (Robinson et al. 1996), monitoring of Ruby-throated Hummingbirds in BSP should continue, and more research conducted into how much disturbance this species can tolerate within the park before they leave an area.

Summer Tanager. Summer Tanagers, a neotropical migrant species, occurred in several point counts during both 1998 and 1999, in relatively high numbers, particularly in 1998, which agrees with Freeman's (1996) classification of this species as fairly common in BSP. Tanagers prefer open, deciduous forests, often near gaps and edges (Robinson 1996). Although disturbance variables did not affect tanager occupation of point counts, this species did occur in the highest abundance in control sites, and the lowest in campground sites, suggesting that this species may be responding to some level or type of disturbance that I did not measure.

Population trends show long-term declines in east Texas (Robbins et al. 1986), mostly in response to habitat destruction (Robinson 1996). Management of this species should focus on providing edge habitat with sufficient ground cover for insect prey, with continued research on Summer Tanagers within the park, and their responses to humans.

White-eyed Vireo. A neotropical migrant (Hopp et al. 1995), the White-eyed Vireo is classified as common throughout BSP (Freeman 1996), but the results of this project indicate this species was only fairly common in 1998 and rare in 1999. White-eyed Vireos at BSP occupied point counts disturbed by both people and vehicles. Hikers did not affect their presence at point counts, suggesting that this species tolerates humans. In fact, these vireos occurred in the highest numbers in campgrounds, and their lowest numbers occurred in control sites. Although these birds prefer dense secondary deciduous scrub (Bent 1950, Graber et al. 1985), campgrounds may provide preferred habitat for this edge species, since they occupy areas such as overgrown pastures, abandoned farmland, and wood margins (e.g., with low shrubby vegetation), and avoid dense, tall vegetation in east Texas (Conner et al. 1983).

Automobile traffic did not repel White-eyed Vireos, which seems to contradict the low numbers that occurred in point counts associated with roads. However, the technician also recorded traffic (i.e., moving cars) at campground and trail point counts, in addition to road sites, which may provide some habitat features that allow these vireos to occupy them, while point counts near roads may lack the necessary features for this species. Even well hidden nests in dense growth are parasitized by Brown-headed Cowbirds (Hopp et al. 1995), and perhaps campgrounds and areas with increased traffic provide relief from Brown-headed Cowbird parasitism in BSP, because cowbirds avoid these areas.

The major management issue involves the destruction of scrub lands, a preferred habitat for this species, since most landowners do not value this type of vegetation (Hopp et al. 1995). Because of its broad habitat use, this vireo is not considered at risk (Reed 1992), but recent significant declines (Sauer and Droege 1992) suggest that park managers should maintain, and increase, scrub habitat at BSP, by letting shrubs grow around the edges surrounding campgrounds and along trails.

Management of Species Not Affected by Disturbance at BSP

Five species at BSP (Black-crested Titmouse, Great Crested Flycatcher, Red-eyed Vireo, Red-shouldered Hawk, and Yellow-billed Cuckoo) were not affected by any disturbance parameter I measured. Two these species, Black-crested Titmouse and Red-shouldered Hawk, inhabit BSP year round; the rest are neotropical migrants. Only Red-eyed Vireos are an interior species; the other species prefer edge habitat. These species all occupied point counts throughout BSP, without regard to the type of disturbance present, or the category of the point count (control, trail, road, or campground).

Black-crested Titmouse. The Black-crested Titmouse, a common, year-round resident at BSP (Freeman 1996), occurred on most point counts, and in some of the highest numbers, during both field seasons. Titmice occupy mostly deciduous forests, but also occur in mixed deciduous-coniferous forests (Brauning 1992). During this study, they occupied point counts throughout BSP, and Black-crested Titmice did not show any significant responses to disturbance, suggesting they tolerate human disturbance, as supported by the fact that they occur in parks, suburbs and orchards (Brauning 1992). Although parasitized by Brown-headed Cowbirds (Grubb and Pravosudov 1994), this species does not seem to be declining; management should focus on providing sufficient tall trees with cavities for nesting, and maintaining the closed canopy of the forest at BSP.

*Great Crested Flycatcher***.** Great Crested Flycatchers occupied 12 point counts, in low numbers in BSP in 1998, but were not observed in 1999, despite being considered fairly common in BSP (Freeman 1996). These neotropical migrants occupy edge habitat instead of forest interiors (Lanyon 1997). Their preferred habitat for breeding contains open deciduous or mixed woodlands and woodland edges, including parks and other urban areas with abundant large trees but a more open canopy (Fitzpatrick 1980). No disturbance variables affected this species' distribution within BSP, nor did this species occur in different numbers in control, trail, road, or campground point counts, which suggests that they occur throughout the park, and that the park contains appropriate habitat for these flycatchers.

Because of the benefits of habitat fragmentation for this species, its wide variety of habitat use and its tolerance of humans, Great Crested Flycatchers seem to be maintaining a stable population size (Lanyon 1997). Competition for nest cavities may occur between Great Crested Flycatchers, Red-headed and Red-bellied Woodpeckers, but flycatchers nest more often in dead limbs of live trees and in live trees themselves, which may minimize competition (Stauffer and Best 1982). Management for this species within BSP should focus on maintaining edge habitat within the park, allowing low vegetation to grow close to the edges, and placing hanging nest boxes on chains (Morrison 1988) in open woodlands with easy access to the entrance, to supplement natural cavities.

Red-eyed Vireo. Red-eyed Vireos, a common neotropical migrant inhabiting mostly eastern North America (Cimprich et al. 2000), occurred in BSP only in a few point counts, and in lower numbers than Freeman's (1996) estimates. An interior species, these vireos breed in both deciduous and mixed deciduous-coniferous forests (Barlow and Rice 1977, Graber et al. 1985), and search for insects in the canopy layer of trees (Robinson 1981, Cimprich et al. 2000).

Red-eyed Vireos did not seem to respond to any disturbance variables, nor did they occur in different abundances in the different categories of the park (control, trail, road or campground). Although not currently endangered or threatened, Red-eyed Vireos should be monitored closely to prevent unexpected species declines, because even though they seem to tolerate human disturbance (at least the types I measured) they are susceptible to brood parasitism by Brown-headed Cowbirds, which may cause long-term declines (Cimprich et al. 2000).

Red-shouldered Hawk. Red-shouldered Hawks, a fairly common resident species at BSP (Freeman 1996), occurred at several point counts in 1998, but not in high numbers per visit. This species favors mature, open, mixed deciduous-coniferous forests (Crocoll 1994), with variable amounts of understory vegetation (Dijak et al. 1990, Szuba et al. 1991). Although inconclusive regarding the effects of human disturbance on Red-shouldered Hawks, studies suggest that these hawks respond negatively to disturbance. Lovejoy et al. (1986) noted Red-shouldered Hawks avoided homes and paved roads, and human disturbance may have caused nest failures in California (Wiley 1975), and the retreat of some New Jersey populations into the remotest areas of the forests (Bosakowski and Smith 1989). In this study, however, I found no disturbance variables that repelled this species from point counts, nor did I find any differences in hawk abundance between control, trail, road and campground point counts. It seems that these hawks tolerate humans well at BSP, and can therefore make use of the entire park; in fact, this species often uses habitat with a more open, parklike appearance (Crocoll 1994).

The general population trend for Red-shouldered Hawks suggests a long-term decline, particularly in the eastern states (Bednarz et al. 1990, Peterson and Crocoll 1992). Data suggesting population increases in Texas must be viewed skeptically, since BBS data are not accurate for hawks with large territories (Crocoll 1994). Populations of Red-shouldered Hawks have declined due to fragmentation of large contiguous forest tracts (Peterson and Crocoll 1992) that favor competing species such as Great Horned Owl (*Bubo virginianus*) and Red-tailed Hawk (Bednarz and Dinsmore 1982, Bryant 1986). To protect this species within BSP, management practices should focus on maintaining mature habitat throughout the park, including heavily used areas. Creating openings within the forest (<4 ha, Bednarz and Dinsmore 1982) is not recommended, both by other studies (Jacobs and Jacobs 1993), and the fact that no significant differences within the four site categories existed, which suggests that more open areas within BSP do not contain more Red-shouldered Hawks. Monitoring this species, particularly with respect to optimal breeding habitat and responses to human disturbance, should continue within the park.

Yellow-billed Cuckoo. Yellow-billed Cuckoos occurred in BSP in several point counts, although not in high numbers, making it an uncommon neotropical migratory species during the two field seasons, compared to Freeman's (1996) report of it as a common species. Yellow-billed Cuckoos prefer open woodland with clearings and low, dense scrubby vegetation near water. Although this species inhabits abandoned farmlands and orchards, and dense thickets along streams, they avoid heavily forested areas and urban areas (Eaton 1988). This species did not respond to disturbance variables, nor did it occur in higher numbers in any particular type of site (control, trail, road or campground) in BSP, suggesting that these cuckoos tolerate disturbance. Slud (1964) reported that cuckoos returned to particular perches after disturbance. But, according to Dobkin (1994) and Laymon and Halterman (1989), cuckoos are sensitive to residential development and require at least 22 ha, and preferably 80 ha, for successful breeding. Despite its apparent tolerance towards human disturbance, research should examine whether a threshold of disturbance exists, above which this species abandons the area.

Populations of these cuckoos are declining rapidly throughout its range, and are already extirpated in Oregon, Washington and possibly Nevada due to habitat destruction and pesticides (Hughes 1999). Texas populations also declined significantly in the past several years, perhaps due to the decreased availability of insect food for the young due to pesticide use (Laymon 1980). Because of this drastic decline, Partners In Flight lists this species as a IA Tier B species (Panjabi 2001), with high overall priority and conservation concerns throughout its entire range. Management strategies should focus on leaving areas of heavy shrub and underbrush (particularly near water; Gaines 1974), providing food for insect prey (e.g., caterpillars), monitoring pesticide use in surrounding agricultural areas, and continued monitoring of Yellow-billed Cuckoos in BSP, particularly in heavily used areas, to determine if this species still commonly occurs, or if it has declined in the park.

Potential Problems

This study contains several shortcomings, which I will mention and then discuss how each could influence my results and conclusions. First, I did not conduct an experimental study; I was not able to census an undisturbed area and then re-census it after disturbance. Secondly, I could not control the type or frequency of any human activities, which makes it difficult to untangle the interactions between multiple types of disturbance. Bastrop State Park contains many highly disturbed areas, and species within this park have had to become habituated, at least to some extent, to disturbance. Since highly sensitive species would not use this park, I could not measure the true species richness and abundance that this type of habitat can theoretically support.

I only censused BSP over two breeding seasons, which will affect conclusions about the effects of human disturbance on the bird community within BSP. I only surveyed during May and June, so I cannot draw conclusions about populations that winter in the park. Surveying for such a short period does not provide the accurate picture of species within the park that year-round observations would provide. Additionally, longer-term studies would detect lags in responses to changes in disturbance or habituation.

Because I wanted to examine the influence of human disturbance on bird species, I measured the disturbance variables that I believed had the highest potential to impact species, but I may have missed some significant variables. The indices of disturbance I calculated also may not have been accurate or fine tuned enough to differentiate the various environmental cues that some species respond to.

The fixed-radius point count method I used has fewer and less severe problems than other survey methods and can provide relative indices of abundance and bird species distribution. However, for some species, unlimited-radius, or some other survey technique may have been more appropriate. My analysis compared four categories of disturbed sites, but I may not have categorized the sites within BSP in the best way to maximize contrasts between the levels of disturbance this park receives. Also, several species did not appear in sufficient quantities to analyze, so my analysis could not detect relationships between disturbance variables for these species.

During the field season, I balanced the visitation frequency to each site against maximizing the daily number of sites the field technician visited. The technician visited each point count at least eight consecutive weeks, but the point counts did not represent all areas of BSP equally: far fewer campground, road, and control sites existed, compared to trail sites, which could affect my conclusions regarding the effects of human disturbance within these habitats. The abundance of several species varied significantly between the 1998 and 1999 field seasons, usually with more individuals observed in 1998. These differences could result from changes within the park (but vegetation and management strategies did not change), species-specific reasons, or, most probably, observer reliability. To minimize within-year observer mistakes, the same observer conducted the field research the entire season. However, different technicians conducted the field research in 1998 and 1999, and despite their experience, differences in identification and detection abilities could have occurred. The technician in 1999 recorded more generic vireos, warblers, and woodpeckers, compared to the more specific species recorded in 1998. Because observer error may influence species detection, I did not compare species abundance or richness between the two years. Other methods of surveying, such as using two observers working together at a point count, increase the costs of a field study, as well as add another potential disturbance to the remote point counts and influence the species that occur in an area.

I also relied on the assumption that abundance provides the best measure of the effects of disturbance on a species. However, if BSP contains immigrants from surrounding areas, but these individuals are not breeding successfully within the park, this “sink” does not correctly indicate the effects of disturbance on a species.

Productivity may more successfully indicate a habitat's quality, but this measurement lies beyond the scope of this project.

Also, responses to disturbance depend on a variety of other factors, such as a species' ability to habituate or move to another area, or that individual's history with humans. This study did not identify individual birds in order to follow their daily exposure to disturbance, nor did it track responses of individuals to certain types of disturbance through the field season. Most importantly, the capability of some species to acclimate to humans should not be used as justification for reducing vigilance against the potential effects of human disturbance on birds in BSP. I am sure that some species in BSP have not habituated to human disturbance, but they may have occurred in too few numbers (perhaps because of human disturbance) to analyze, or they may have left the point count upon first detection of the field technician. Additionally, I do not know whether species that use BSP in the winter months, with fewer humans present, may habituate to people.

Future Research

The results from this study suggest several other areas of research on the effects of human disturbance on bird species in BSP. This study examined species presence in the park during a short span within the breeding season, but birds may use different habitats in different seasons. Additional study should address the effects of human disturbance early in the breeding season (i.e., establishing territories, searching for nest sites) and during winter, when different migratory species use BSP for their wintering range. The effects of disturbance on bird species, in various parts of BSP, including edges near the golf course and non-forested areas, needs further investigation.

The behavior of individuals needs examination to determine if human disturbance affects a species' activity budget, foraging behavior and return to disturbed sites. Because some humans approach wildlife, the tolerance distance (the distance a human can approach a bird without disturbing it) should be determined for species vulnerable to disturbance. Future research should include investigating which species become habituated and which ones show increased sensitivity to humans, and whether migrant or resident species are more negatively affected by disturbance within the park. Because BSP is subjected to multiple types of human disturbances, and some species respond negatively to human disturbance, techniques that mitigate disturbance effects should be developed and tested for their success, to minimize the effects of "normal" human behavior at BSP.

Management Recommendations

I recommend the following management guidelines for BSP to alleviate disturbance effects on birds, allow ample recreational opportunities, and minimize conflict between the two:

1. Conduct long-term monitoring of species within the park and continue research regarding their reproductive success, habitat use, and responses to disturbance to increase understanding of the complex dynamics of the bird community within a human-dominated landscape.

2. Protect interior forest habitat and restore degraded areas to preserve contiguity and other habitat requirements of the most sensitive species

3. Prevent creating new forest openings to minimize Brown-headed Cowbird nest parasitism.

4. Provide buffer strips (about 50-m wide) between recreation areas and bird habitat to provide shelter, nesting sites and protection from disturbance.

5. Avoid maximizing species diversity within the park simply to obtain the most species, since many narrowly-distributed specialists will be negatively affected.

6. Maintain areas within the park that are “zero-use” regions kept free of human impacts, including temporary closure of areas to humans, or banning certain activities.

7. Minimize the effects of recreation by keeping activities located within already-developed areas of the park.

8. Limit future development to areas already developed, and find alternate areas for activities that will damage birds and their habitats.

9. Minimize damage to trails by monitoring trail use and maintaining gravel cover on the most heavily-used trails; no new trails should be built within BSP at this time.

10. Plant hedges along edges of campgrounds to soften edge effects, and minimize disturbance.

11. Implement public education programs that provide information about the birds within the park and how these species benefit from park policies that may restrict human access to certain areas.

12. Develop a detailed protection and restoration plan for vulnerable species that focuses on protection of existing populations of species of conservation concern.

Conclusions

I analyzed 20 species, including seven neotropical migratory species, to determine the effects of human disturbance on these species. Heavy human use in some areas of the park has affected the avian species occurring in campgrounds, compared to control, trail and road-associated sites. Most species tolerated human disturbance, occupying point counts that had higher levels of human, vehicular or both types of disturbance. Both resident (i.e., American Crows, Northern Mockingbirds) and neotropical migratory (i.e., Ruby-throated Hummingbirds, Yellow-billed Cuckoos) species tolerated higher levels of human disturbance. A few species (e.g., Brown-headed Cowbirds, Mourning Doves) showed sensitivity towards disturbance, which could result from persecution by humans, through control activities or hunting. A bird's migratory status did not automatically make it more or less sensitive to disturbance; resident species were both tolerant (i.e., Black-crested Titmouse) and sensitive (i.e., Downy Woodpecker), and some migrant species (e.g., Great Crested Flycatchers) tolerated disturbance, while others (e.g., Summer Tanagers) did not. Contrary to my expectations, interior species, such as Black-and-white Warblers and Hairy Woodpeckers also tolerated disturbance. My results suggest that, in protected areas where species are not harassed or hunted, species can become habituated to human presence through experience and learning. Thus, it seems that BSP currently provides both recreational opportunities for people and species protection, at least for some species of birds. Projects such as this one can increase understanding of the factors that influence bird occupation of an area, and also assist in the development of management techniques to minimize conflicts between humans and protection of species.

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