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Vegetation Status of the Keoladeo National Park, Bharatpur, Rajasthan, India (April 2009)

Scientific Investigations Report 2009–5193

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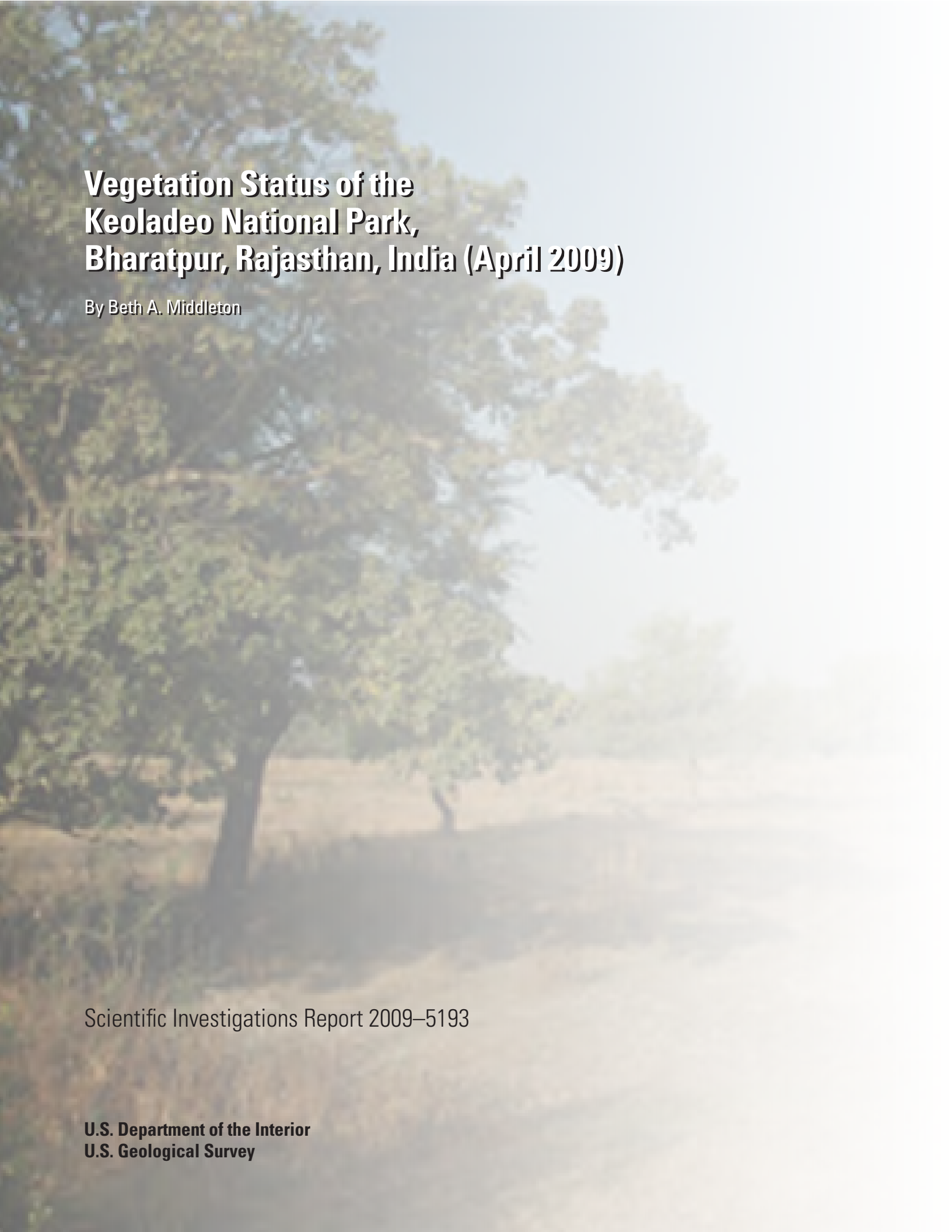

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Volume	
cubic meter (m^3)	264.2	gallon (gal)
cubic meter (m^3)	0.0002642	million gallons (Mgal)
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)
cubic meter (m^3)	0.0008107	acre-foot (acre-ft)

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Abstract

The biodiversity of aquatic plant species may be reduced in the future by drought and/or climate change in monsoonal wetlands. After a number of years of low water levels, the aquatic vegetation of the Keoladeo National Park in Bharatpur, Rajasthan, India, was assessed. Though likely reduced in areal extent, most of the aquatic species were found in locations in the park that contained the seed bank of aquatic species in the 1980s. Some of the species of concern observed included *Cyperus rotundus*, *Nymphoides indica*, *Paspalum distichum*, *Potamogeton pectinatus*, *Scirpus tuberosus,* and *Vallisneria natans*. While it is likely that the abundance of these species has declined over time, this cannot be determined quantitatively without detailed field studies designed to replicate the 1980s analyses.

Introduction

Hydrologic fluctuation drives vegetation change in monsoonal wetlands (figs. 1 and 2; Middleton and others, 1991; Middleton, 1999a, b) so that any changes in water availability related to shifts in climate or water use could affect species biodiversity. Longer periods of flooding and drought may occur in the future because of the increased storm activity and drought related to climate change that is predicted for India (National Centre for Medium Range Weather Forecasting [NCMRWF], 2009). Extreme rainfall events have become more common, and the monsoon rains have become less predictable during the last 25 years in India as compared to the previous 100 years (Mani and others, 2009). Changes in rainfall have ramifications for the natural biodiversity of India.

The succession of aquatic vegetation in monsoonal wetlands in northern India occurs over a regular annual

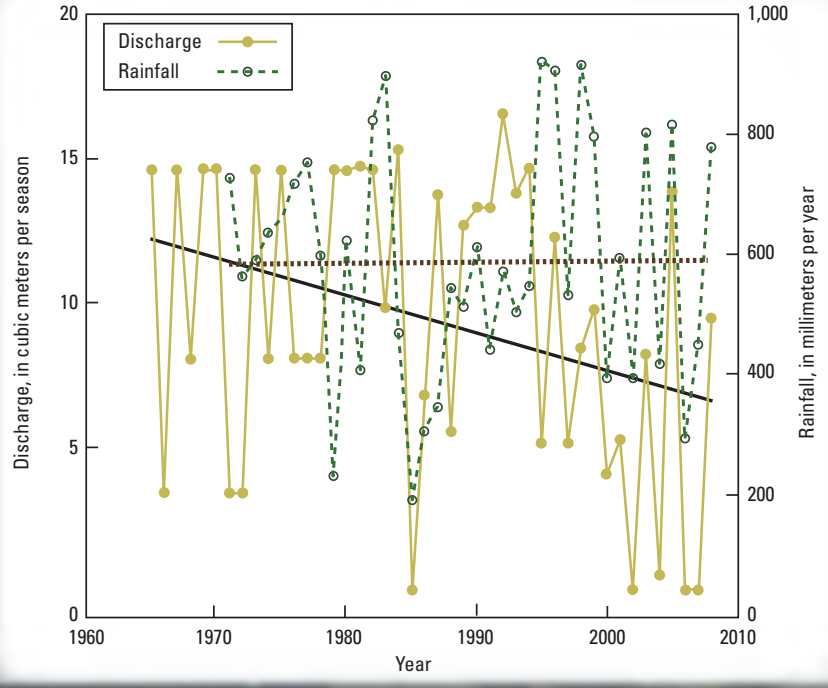

Figure 1. Annual fluctuation in water quantity released into the Keoladeo National Park from Ajun Bund (temporary reservoir) via the Ghana Canal from 1965 to 2008 and in rainfall in the park. Data are from the Irrigation Department, Bharatpur, Rajasthan. The water in the Ajun Bund originates in the Gambhir River (Vijayan, 1991). Water is discharged from the bund (dam) after the annual monsoon from September through February. The data are given per the year of the monsoon even though the discharge may continue into the first few months of the following year. Regression lines show the change in discharge (solid yellow, y = 268.66 – 0.1305x, r = 0.324) and rainfall (dashed green, y = 253.09 + 0.1687, r = 0.009) over time.

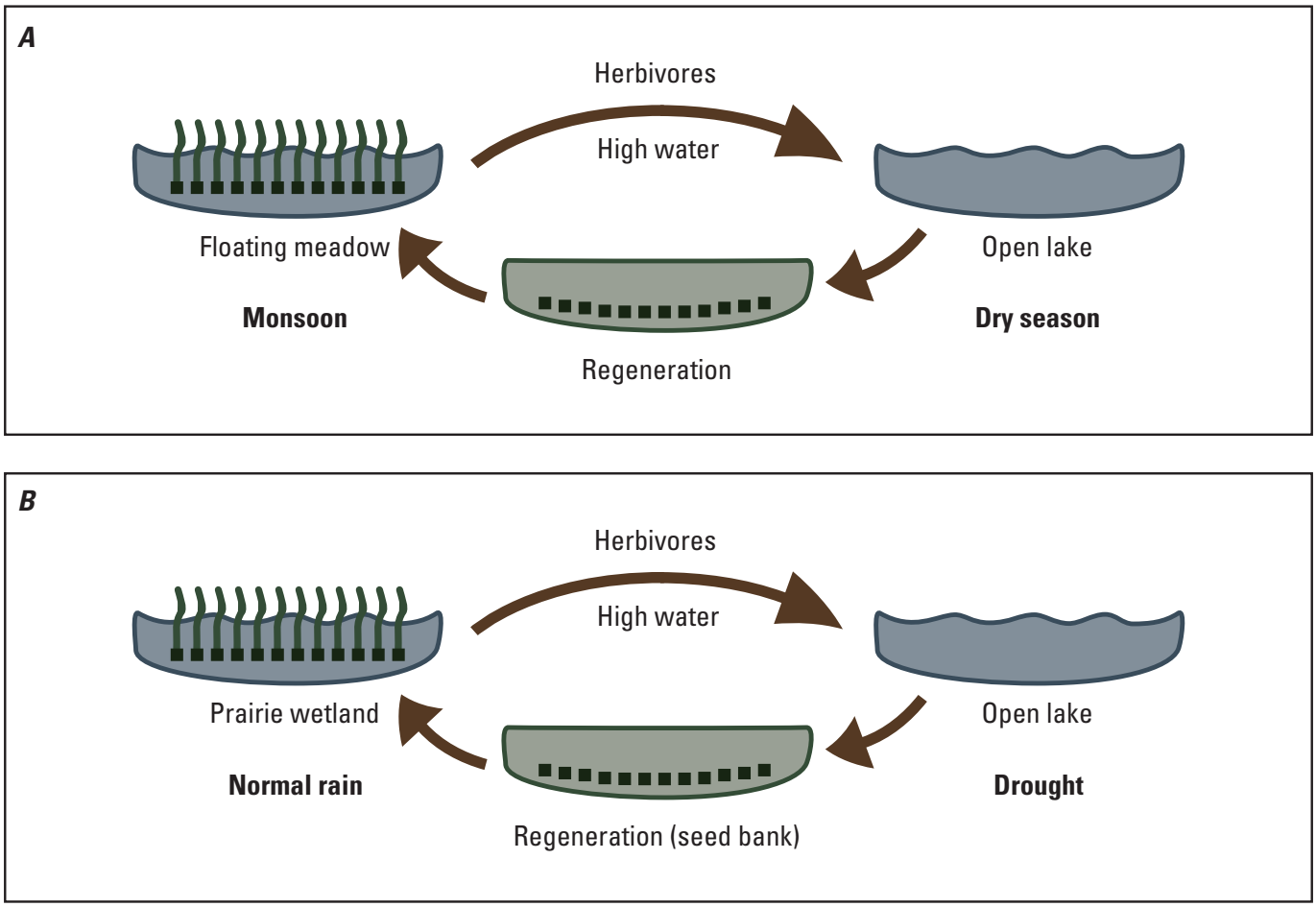

Figure 2. Succession cycle of monsoonal wetlands with flooding following the monsoon (October through March) and drawdown during the dry season (April through July). *A*, The vegetation cycle of monsoonal wetlands (1 year). The monsoon fails in some years so that the wetland is dry until the next monsoon. *B*, The vegetation cycle of prairie potholes (5–25 years), which are also accustomed to long-term drought, is given for comparison (Middleton, 1999a).

cycle driven by the rains of the monsoon (fig. 2). During the monsoon season, seeds germinate and rhizomes expand as the soil becomes moist. As the water deepens as the wetland floods, plants grow into the water column. During the flooded season, most aquatic species will die if cut under the water by herbivores (Middleton, 1990), and the plants do not regrow during the flooded season (fig. 2). Open water areas often form in the grazing areas of geese and other species during this time, and few species can regrow into these open water areas. The waters recede during the hot months of the summer season (March–June), and the vegetation cycle begins again with the next monsoon. Sometimes the monsoons fail for a period of years (Middleton and others, 1991; Middleton, 1999a) so that little aquatic vegetation reestablishes in those years.

Years of continuous drought related to climate change could reduce the overall biodiversity of species in monsoonal wetlands such as those in the Keoladeo National Park, Bharatpur, Rajasthan. The key information necessary to predict if these aquatic species can survive long-term drought has to do with their life history responses to drought at the seed, seedling, and adult stages, but the details are not well known for any wetland type (Middleton, 1999b, 2009). Wetlands with recurring drought are often populated by species with seeds that are well adapted to drought (Capon and Brock, 2006), and this may be true of species of monsoonal wetlands. Certain species of other wetlands prone to drought such as the prairie wetlands of midwestern North America can survive as seeds in the soil for at least 50–70 years of farming (Galatowitsch and van der Valk, 1996). Nevertheless, because long-term monsoon failure may become more protracted with climate change (NCMRWF, 2009), concerns exist that the biodiversity of species in wetlands may be affected.

Flooding from the 2008 monsoon and from river discharge into the Keoladeo National Park in early 2009 was relatively normal, following a number of dry years (fig. 1). The overall mean discharge into the park from the Ajun Bund has been decreasing since the 1960s, as apparent in the

negative slope of the linear regression (fig. 1). Local observers indicate that a number of once common species may now be uncommon (for example, *Nymphoides indica*; table 1), even following normal rains. Therefore, the objective of this project was to rapidly assess the biodiversity of the Keoladeo National Park to determine if there is a need for a more comprehensive investigation.

Methods

Specific areas of the Keoladeo National Park were searched by Brijendra Singh and Bachu Singh from October 2008 through April 2009 and by the author of this report in April 2009. Aquatic plant species were searched for in flooded blocks, which had seed banks of these rare species in the 1980s (table 1; figs. 3 and 4; based on data from Middleton and others, 1991, and Middleton, unpub. data). Notes were made on species of concern found in the standing vegetation.

Results and Discussion

A number of aquatic species of concern (see examples in fig. 5) were located by searching flooded areas of the Keoladeo National Park including *Cyperus rotundus*, *Nymphoides indica*, *Paspalum distichum*, *Potamogeton pectinatus*, *Scirpus tuberosus*, and *Vallisneria natans* (table 1). The searches included K, L, E, F, N, B and D Blocks. The temporary lake (jheel) in G Block was not flooded in April 2009 (Laxmi Mudgal, oral commun.) and was not checked as a part of this survey. Some of these species were also noted in

Table 1. Aquatic species of concern in the Keoladeo National Park based on the observations of Bachu Singh, Brijendra Singh, and others (from October 2008 through April 2009).

[The species of concern are listed by presence/absence in the seed banks of various blocks of the park in the 1980s based on data from Middleton (unpub. data) and Middleton and others (1991). The presence of species is noted with a plus sign (+), absence with a minus sign (-), and possible presence with a question mark (?). Note that adult individuals of *Eleocharis acutangula* were observed in an ephemeral pond in J Block in 1984 but not in 2009. This information is from the datasets of Dr. Beth Middleton, collected during the 1983–87 Iowa State University Research Program (reported in Middleton and others, 1991). Species found during a field search in April 2009 are indicated with an asterisk (*). *Nymphaea* spp. were located by Dr. Parkshit Gautam (World Wildlife Fund) in 2008 in the park. Italics indicate that the status was updated as a result of the April 2009 field search. Dr. Malavika Chauhan assessed seeds in an aquatic seed bank survey in 2000–2003, which included D Block and are indicated by a number sign (#). *Paspalum distichum* and *Vallisneria natans* were noted in the standing vegetation during July 2005–6 in a survey of these blocks not including G Block, but the species were not recorded by block in the published study (Chandra and others, 2008)]

		Block							
Species	**Status**	**K**	**L**	**E**	**F**	**G**	**N**	**B**	**D**
Aponogeton natans	declining	-	-	-	-	-	-	-	-
Cyperus rotundus	declining	+	+	+*	+	-	-	+	-
Eleocharis acutangula	extirpated?	+	-	-	-	-	-	-	-
Eleocharis dulcis	extirpated?	-	-	+	-	?	-	-	-
Eleocharis palustris	extirpated?	-	-	+	-	+	+	-	-
Limnophyton obtusifolium	extirpated?	+	+	+	+	+	-	+	-
Najas minor	extirpated?	+	+	+	+	+	+	+	-
Nymphaea nouchali	declining	+	+	+	+	-	-	+	-
Nymphaea pubescens	declining	-	-	-	-	-	-	-	-
Nymphoides indica	*declining*	-#	-#	+*	+	-	+	-*#	+#
Polygonum glabrum	extirpated?	-	-	-	-	-	-	-	-
Paspalum distichum	declining	+#	+*#	+*	+	+	+#	+#	+#
Potamogeton crispus	declining	-	-	+	-	-	-	-	-
Potamogeton pectinatus	declining	-	-	-	-	-	-	-	+#
Potamogeton nodosus	declining	-	-	-	-	-	-	-	-
Sagittaria guayanensis	extirpated?	+	-	+	-	+	-	+	-
Scirpus littoralis	declining	-	-	+	-	-	-	-	-
Scirpus tuberosus	declining	-	-*	-	-	+	+	-	-
Vallisneria natans (*spiralis*?)	extirpated?	+#	+	+	+	+	+	+	+#

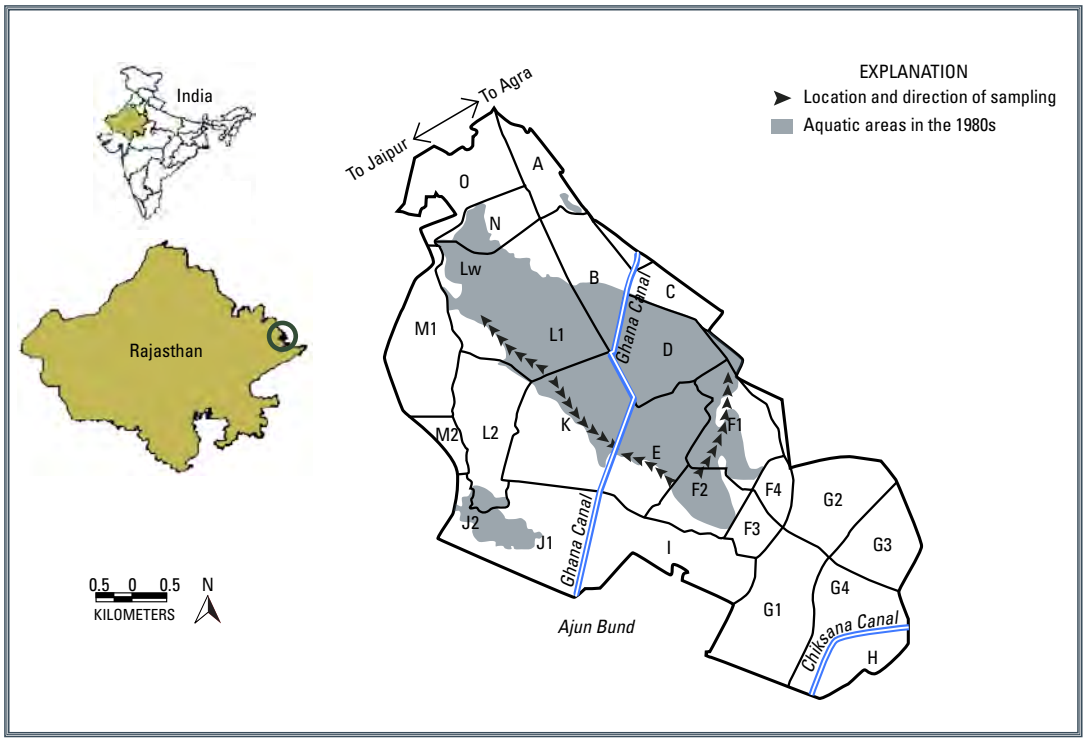

Figure 3. Map of seed bank collection locations in the seed bank studies in goose grazing areas in K, L, E, and F Blocks in the Keoladeo National Park in May 1984 (Middleton and others, 1991). Other samples were made in G, N, and B Blocks in 1983. A shovelful of soil was collected at stratified random positions at 200-m intervals along each transect for the 1984 study of goose grazing areas (Middleton and others, 1989).

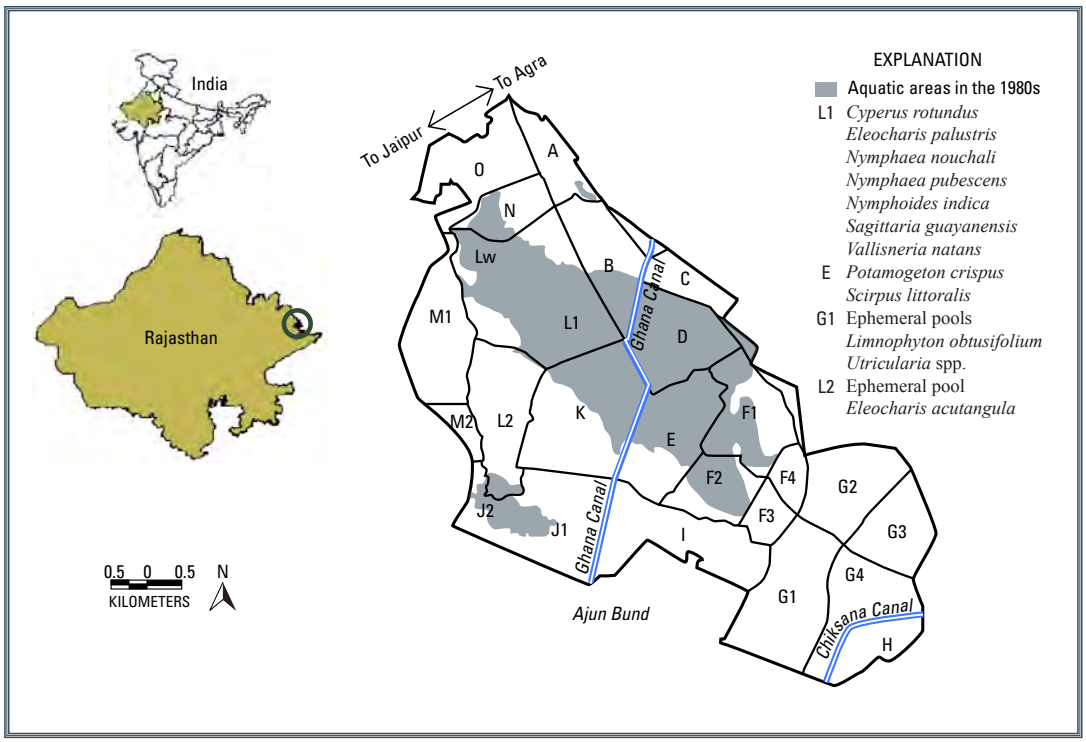

Figure 4. Search locations for species of concern in 2009 in the Keoladeo National Park based on the locations of species in the seed banks of the 1980s (Middleton and others, 1991; Middleton, unpub. data).

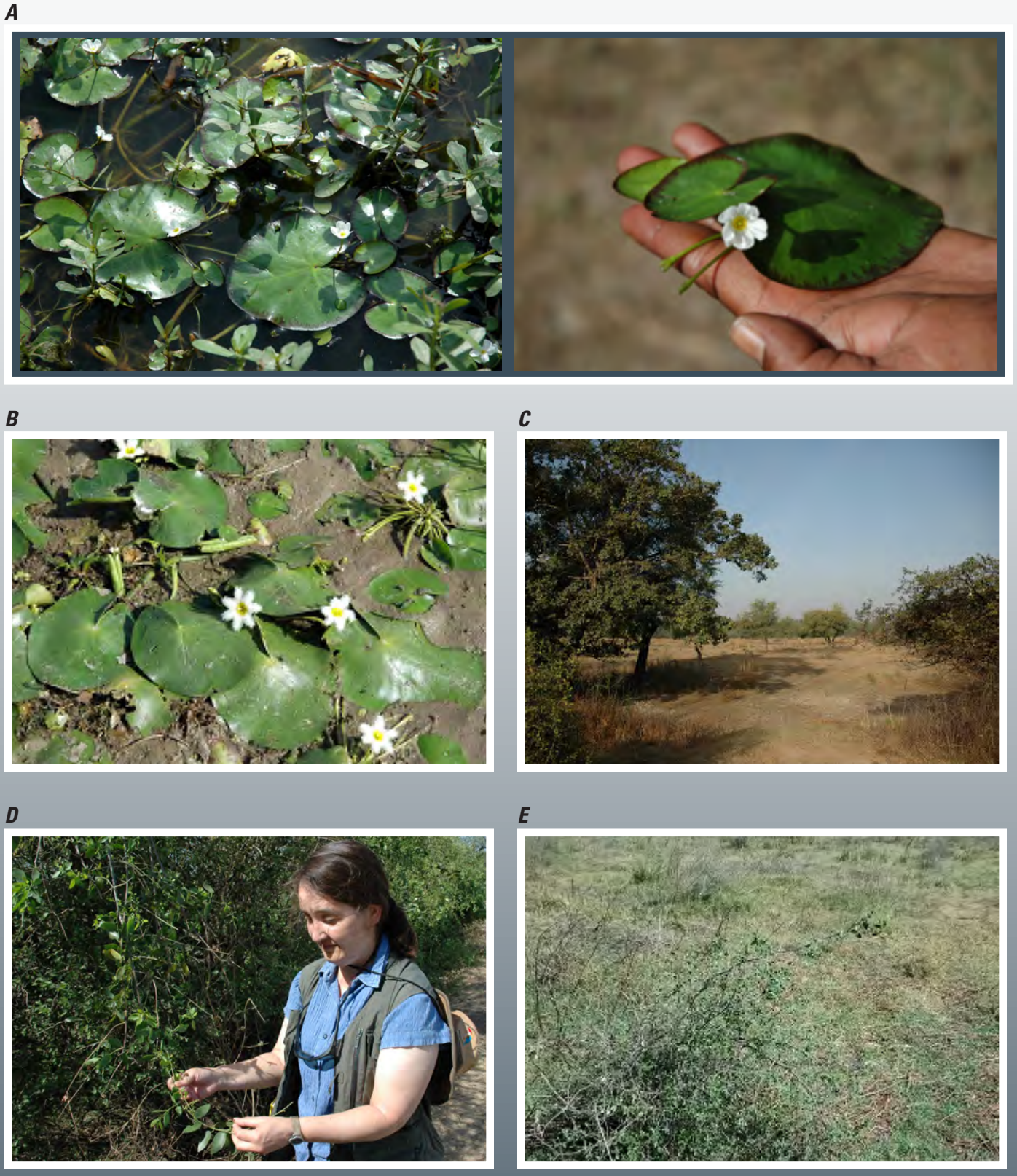

Figure 5. Photographs of species in the Keoladeo National Park. *A, Nymphoides cristata. B, Nymphoides indica* (common name water snowflake). *C, Mitragyna parvifolia* (common name kadam [left]). *D,* Author Beth Middleton holding specimen of *Salvadora oleiodes. E, Zizyphus mauritiana.*

seed bank or biomass surveys conducted in the aquatic blocks of the park since 2000 (Chauhan, 2004; Chandra and others, 2008).

Although the walking survey of the flooded blocks of the park was thorough in April 2009, it is possible that certain species were missed (table 1). Some species were not detected in the vegetation including members of the Cyperaceae such as *Eleocharis acutangula*, *E. dulcis*, *E. palustris*, and *Scirpus littoralis* (table 1). These species were common in the 1980s (Middleton and others, 1991). *Nymphaea nouchali* and *N. pubescens* were not observed in the vegetation by this team in April 2009; however, the absence of *Nymphaea* spp. was not surprising because water lilies are seldom seen so late in the growing season (Middleton, personal observation). *Nymphaea* spp. were observed in the Keoladeo National Park by Dr. Parkshit Gautum in 2008, so *Nymphaea* spp. are still present in the vegetation.

A number of savanna species of concern (see examples in fig. 5) were observed in the park including *Maerua arenaria* (observed by K.R. Anoop, Keoladeo National Park Director), *Capparis decidua*, *Dichanthium annulatum*, *Mitragyna parvifolia*, *Prosopis cineraria*, *Salvadora oleoides*, and *Zizyphus mauritiana* (table 2).

The findings of this brief survey suggest that there may be no permanent loss of many of the species of concern that were present in the Keoladeo National Park in the 1980s. Observations suggest that the abundance of some of these aquatic and savanna species may be reduced in recent times (Middleton, personal observation). A convincing way to determine if there are changes in the actual abundance of species over time would be to repeat the quantitative vegetation surveys of the 1980s as conducted by the Bombay Natural History Survey (Vijayan, 1991) or Middleton and others (1991). While this brief study cannot definitively say that particular species are missing or less abundant than in the

Table 2. Savanna species of concern in the Keoladeo National Park, based on the observations of Bachu Singh, Brijendra Singh, and others (from October 2008 through April 2009).

[The species of concern are listed by presence/absence in the seed banks of various blocks of the park in the 1980s based on data from Middleton (unpub. data) and Middleton and others (1991). The presence of species is noted with a plus sign (+), absence with a minus sign (-), and possible presence with a question mark (?). No seed bank sampling was conducted in savanna habitat in 1983–87, but a seed bank from these species was sometimes noted in aquatic habitats. This information is from the datasets of Dr. Beth Middleton, collected during the 1983–87 Iowa State University Research Program (reported in Middleton and others, 1991). Species found during a field search in April 2009 are indicated with an asterisk (*). *Maerua arenaria* was located by K.R. Anoop, Keoladeo National Park Director. Italics indicate that the status was updated as a result of the April 2009 field search]

			Block						
Species	**Habitat**	**Status**	**K**	**L**	**E**	**F**	**G**	**N**	**B**
Abrus precatorius	climber	scarce	-	-	-	-	-	-	-
Capparis decidua	woodland	extirpated?	-	-	-	-*	-	-	-
Crataeva religiosa	woodland	declining	-	-	-	-	-	-	-
Dichanthium annulatum	woodland	*declining?*	-	-	-	-*	-	-	-
Indigofera tinctoria	woodland	extirpated?	-	-	-	-	-	-	-
Indigofera trita	woodland	extirpated?	-	-	-	-	-	-	-
Iseilema laxum	woodland	extirpated?	-	-	-	-	-	-	-
Maerua arenaria	woodland	declining	-	-	-*	-	-	-	-
Mitragyna parvifolia (kadam)	woodland	declining	-	+	+	+	-	-	-*
Prosopis cineraria	woodland	declining	-	-*	-	-	-	-	-
Salvadora oleoides	woodland	declining	-	-*	-	-	-	-	+
Tinospora cordifolia	climber	scarce	-	-	-	-	-	-	-
Wattakaka volubilis	climber	scarce	-	-	-	-	-	-	-
Zizyphus mauritiana	woodland	declining	-	-	-	-*	-	-	-

1980s, the team did ascertain that a number of the species of concern are present in the Keoladeo National Park.

Acknowledgments

Many thanks to members of the Keoladeo Naturalist Society, who helped with the species list and field work in the Keoladeo National Park, including Brijendra Singh, Bachu Singh, Laxmi Kant Mudgal, and Om Prakash Mudgal. Also, thanks to Harsh Vardhan (administrative secretary) of the Tourism and Wildlife Society of India, K.R. Anoop (director) of the Keoladeo National Park, and Parkshit Gautum of World Wildlife Fund India for advice on the project. The report was prepared in collaboration with the Tourism and Wildlife Society of India and the Keoladeo Naturalist Society (U.S. Geological Survey [USGS] Technical Agreement T-09-763a and USGS Agreement T-09-763b, respectively). Nomenclature follows Maheshwari (1963) and Cook (1996).

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