

1988, 1990, and 1993 yielded 500, 545, 50, 0, and 0 plants, respectively (MDC 2002a). To date, the maximum population estimate at the Izard County, AR, site has been "tens of thousands of plants," in 1997, while in 1999 only a few plants were found at the same site (Theo Witsell, *in litt.* 2002). Irregular monitoring (a minimum of 4 years of data between 1993 and 1999) at seven Nature Conservancy registry sites yielded similar fluctuations in population numbers as described elsewhere, with estimates ranging from 0 to 47 plants at the smallest population and 3 to 3,448 plants at the largest (Susanne Greenlee, TNC, *in litt.* 1999, MDC 2002a).

TABLE 1.—ANNUAL POPULATION ESTIMATES OF MISSOURI BLADDERPOD ON BLOODY HILL GLADE (WILSON'S CREEK NATIONAL BATTLEFIELD) AND IN 21 PLOTS AT ROCKY BARRENS CONSERVATION AREA, GREENE COUNTY, MO, 1988–2001

[From Thomas 1998; Tim Smith, *in litt.* 2002; John Boetsch, *in litt.* 2002]

Year	Estimated population size (number of plants)	
	Bloody Hill Glade	Rocky Barrens Conservation Area (21 plots)
1988 .....	58,351	—
1989 .....	31,911	—
1990 .....	10,154	—
1991 .....	303,446	—
1992 .....	24,611	110
1993 .....	0	1,211
1994 .....	0	200
1995 .....	18,514	2,295
1996 .....	88,166	224
1997 .....	33,873	3,584
1998 .....	30,475	1,283
1999 .....	66,650	320
2000 .....	72,623	143
2001 .....	145,604	2
Average .....	63,170	<sup>1</sup> 937

<sup>1</sup> Average within 21 permanent plots—total population size at this site is much larger.

An examination of the status of most extant sites following the procedures established by Hickey (1988) was conducted in the spring of 2000. Hickey visited 52 extant sites between April and May and noted that: (1) Populations of the species were found in the same terrace or rock shelf as they were in 1988–1990, and (2) some sites exhibited lower numbers than in 1988–1990, apparently attributable to the drought conditions, increase in cedar density or encroachment of other woody vegetation, or competition from exotic

species of brome grasses (*Bromus spp.*). Increases in population density at some locations apparently resulted from tree removal and maintained grazing (Hickey 2000). Continued long-term monitoring of some larger sites in Missouri and the site in Izard County, AR, is also planned.

In years when germination, overwinter survival, seedling establishment, and plant growth are ideal, *Lesquerella filiformis* populations can be so large as to make rangewide population estimates extremely difficult. Despite the difficulty, estimates made by Hickey (1988) at 55 sites in Missouri yielded approximately 400,000 plants. Had rangewide estimates been taken in 1991 when 303,446 plants were estimated at Bloody Hill Glade, Wilson's Creek National Battlefield (Table 1, Thomas 1998), the population that year likely would have exceeded 500,000 plants. However, given the extreme annual fluctuations in population size, only long-term monitoring efforts patterned similarly to the protocol developed for the Wilson's Creek National Battlefield (Kelrick 2001a, 2001b) can accurately reflect the true population status and trend of this species and effectively evaluate the efficacy of management regimes on bladderpod habitat (Thomas 1998).

The current 63 extant sites have the following Natural Community rankings by The Nature Conservancy (TNC): (1) 11 (10 in Missouri and 1 in Arkansas) are graded A (*i.e.*, are relatively stable and undisturbed natural communities with a high diversity of conservative species); (2) 18 (all in Missouri) are graded B (*i.e.*, late successional or lightly disturbed communities, or recently lightly disturbed or moderately disturbed in the past but now recovered, and the biological diversity has not been greatly reduced); (3) 1 in Arkansas is graded AB (*i.e.*, intermediate between A and B); (4) 17 in Missouri are graded C (*i.e.*, midsuccessional, moderately to heavily disturbed communities, or moderate recent disturbance or heavy past disturbance with decreased recent disturbance); and (5) 16 in Missouri are graded D (*i.e.*, early successional or severely disturbed communities where the structure and composition of the community has been severely altered with few characteristic native species present) (MDC 2002a, Theo Witsell, *in litt.* 2002).

Threats identified by the Service at the time of listing (52 FR 679, January 8, 1987) were: (1) Vulnerability of small populations to overcollecting and human disturbance, (2) lack of research on proper management techniques necessary to maintain and promote

populations of the species, (3) potential impacts of annual maintenance activities to populations located on highway rights-of-way, (4) seed destruction by insects and fungal infections, and (5) inadequate protection or management on public and private property necessary for the species' continued existence. Subsequently, the Service (1988) documented the presence of exotic plant species, such as *Bromus tectorum* (a cheat grass), in bladderpod habitat as a significant threat, and this was further supported by observations by Hickey (1988, 2000) and Thomas (1996, 1998). Additionally, Hickey (1988, 2000) and Thomas (1996) identified development, especially land-use changes resulting from urban expansion, as a major threat to the species, and Hickey (1988) noted an increase in grazing pressure at some of the sites discovered during a four-county survey.

Although no specific reclassification (endangered to threatened) criteria were provided in the Recovery Plan, the following recovery (delisting) criteria were given: 30 self-sustaining populations, 15 of which are in secure ownership, must be at least one-half acre in size each and show self-sustaining populations for at least 7 years (U.S. Fish and Wildlife Service 1988). We indicated that these recovery goals could be accomplished through the following actions: (1) An inventory of suitable habitat for new populations, (2) the protection and management of existing populations, (3) the continued monitoring of populations and initiation of research on the species, (4) the development and initiation of management programs on protected sites, (5) the establishment of new populations on public land, and (6) the development of public awareness and support to further the conservation of the species.

Although some information gaps concerning the life history requirements of *Lesquerella filiformis* remain, research conducted since the species was listed in 1987 has significantly improved our understanding of the ecological needs of this species. Dr. Michael Kelrick (Truman State University, MO) has conducted and supervised graduate student work on demographics, seed bank ecology, matrix population dynamics used in the development of a population model and protocol for long-term monitoring, analyses of the effectiveness of various management prescriptions utilized to restore and enhance bladderpod habitat, reproductive success, fecundity, and factors influencing germination, seedling establishment and vegetative