

A Rapidly Expanding Population of Great Indian Plantain (*Arnoglossum reniforme*) in Southeastern Minnesota

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Abstract - Garvin Heights Park in Winona, MN, USA contains several blufftop habitats (2 dry bedrock bluff prairies, 2 dry hill oak savannas) that are home to an apparently introduced population of Great Indian Plantain (*Arnoglossum reniforme*), a species threatened in Minnesota due to the harmful effects of invasive species, human impact, and climate change. A systematic census of plantain was conducted in these habitats during September–November 2024 to assess 1) overall population densities, 2) abundances of reproductive stage plants versus immature rosettes, 3) plantain distributions among habitats, and 4) associations between plantain density and overhead canopy coverage. In total, 2966 plantain (80% immature, 20% flowering) were found in an area of 1.19 ha; a dramatic increase in population size from previous counts in 2018 (613 plants) and 2020 (801 plants). Highest overall plantain densities (up to 139 plants/100 m²) were observed in one of the savannas with moderate to high canopy coverage, but mature flowering plants were 1.5 times more abundant in the prairies lacking overhead canopy cover. Densities of mature flowering plantain were significantly and negatively associated with canopy cover. In stark contrast to populations elsewhere in its native range, the population of Great Indian Plantain in Garvin Heights Park has been expanding rapidly in recent years and currently represents the largest documented population of Great Indian Plantain in Minnesota.

Introduction

Prairie and savanna habitats in the USA have been critically reduced in abundance and fragmented by a variety of anthropogenic activities such as cultivation (including silviculture), livestock grazing, and fire suppression leading to woody encroachment (e.g., Leach and Givnish 1996, 1999; Alstad et al. 2016). Consequently, many of the flora and fauna native to these habitats have declined or become extirpated and ecosystem functions have been altered or lost (Haddad et al. 2015, Alstad et al. 2016, Warneke et al. 2022, Orrock et al. 2023).

The native range of Great Indian Plantain (GIP), *Arnoglossum reniforme* (Hook.) H. Rob. (Asteraceae) spans 21 states across the eastern, central, and southeastern USA (USDA Natural Resources Conservation Service 2025), but the species is rare in 9 states forming the periphery of the species' range and has been extirpated from Maryland (Kartesz 2015). At the northwestern edge of the range, GIP is listed as "threatened" in Minnesota (Anderson 2018) and as "special concern" in Wisconsin (Bleser 2025). In Minnesota limited specimens in herbarium collections and few encounters during comprehensive botanical surveys during the past 40 years corroborate the species' rarity in the state (Anderson 2018), with a majority of populations having fewer than 100 individuals and limited to the 9-county southeastern part of the state (Anderson 2018). Further declines of already small populations continue due to habitat degradation and losses to agriculture, urbanization, and river modifications (Anderson 2018). GIP has been assigned a coefficient of conservatism (C-value) of 8 in Missouri and Iowa (Ladd and Thomas 2015; Lynch et al. 2020) and 10 in Illinois (Benda 2025), indicating that the species has a relatively restricted range and is found mostly in natural areas with few disturbances (Minnesota Board of Water and Soil Resources 2010, Ladd and Thomas 2015, Benda 2025).

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GIP is a long-lived perennial forb that typically appears in wooded habitats (Anderson 2018), often in woodland margins and openings on the alluvial soils of floodplain terraces along streams and rivers (Eggers and Reed 1988; Anderson 2018). However, GIP is also found in mesic and dry-mesic bluffland forest and adjacent mesic prairies (Bleser 2025), growing on thin calcareous soils (Missouri Botanical Garden 2025) associated with dolomitic bedrock outcroppings (Minnesota Wildflowers 2015; Bleser 2025). GIP can tolerate full sun to partial shade (Minnesota Wildflowers 2015, Missouri Botanical Garden 2025).

GIP grows as a basal rosette with large (up to 60 cm diameter) palmate-veined, toothed, and semicircular-to-kidney-shaped leaves (Fig. 1A) for 1 to 2 years before developing into a tall (up to 3 m) flowering stalk (Fig. 1B). It is not known if GIP can remain in the juvenile rosette form for more than 2 years as some other perennials can do (Runkle 2016), or if individuals that flowered previously can revert back to the rosette stage in subsequent years (Battey and Lyndon 1990, Tooke et al. 2005). Plants can have multiple stems growing from the same fibrous root crown (Anderson 2018). Flowering occurs in June through August, with white to cream or greenish flowers that are small, tubular, and arranged in multiple flat-topped clusters (corymbs or umbels, 12–30 cm across) at the top of stiff, unbranched, grooved stems that can be green to deep purple red in color (Minnesota Wildflowers 2015, Missouri Botanical Garden 2025). Flowers are pollinated by a diverse assemblage of insects, including several types of bees, wasps, and flies (Robertson 1928). Small fruits (achenes) develop from mid-July through late August (Anderson 2018, Bleser 2025) with a tuft of spreading hairs attached to the tip of a dark brown to purple, bullet-shaped seed (Minnesota Wildflowers 2015).



Figure 1. Great Indian Plantain (*Arnoglossum reniforme*) rosettes (A) and mature flowering plant (B) in Garvin Heights Park, Winona, MN during fall 2024. Photos by Taylor Dietz (A) and Neal Mundahl (B).

In contrast to declining populations elsewhere in Minnesota, we noted the presence of what appeared to be a large and expanding population of GIP in a “natural” city park atop a bluff overlooking the Mississippi River in Winona, MN. Previous counts by university classes had found as many as 240 flowering GIP within a portion of the park during a single growing season (N. Mundahl, unpublished data), a population size that would place it among the largest in the state (Minnesota Wildflowers 2015). Consequently, we chose to conduct a comprehensive, systematic survey of the GIP population within the park during fall 2024, including both immature rosettes and flowering plants growing in a mosaic of dry bluff prairie and bur oak savanna habitats. We also compared abundances of both life stages of GIP to canopy coverage in order to assess possible habitat suitability of prairies and savannas for GIP success.

Study Site

Great Indian Plantain was surveyed at Garvin Heights Park in Winona, MN (44° 02' 03.45" N, 91° 39' 06" W) between September and November 2024. The 12-ha natural park, established in 1924, is jointly owned and managed by the City of Winona and Winona State University. The park encompasses a mosaic of dry bedrock bluff prairie, dry hill oak savanna, and southern dry to mesic oak-hickory woodland (Minnesota Department of Natural Resources 2005, Winona County Historical Society 2020) located on a blufftop ridge overlooking the city and the Mississippi River floodplain. While the park retains some of its natural character, this delicate bluff habitat has been impacted by human activity and invasive species (Rozumaski et al. 2020). Ongoing site restoration and management (including irregular prescribed fires at intervals of 2 to 8 years as needed, on all prairies and savannas) have been focused on controlling non-native woody vegetation (e.g., buckthorns [*Rhamnus* spp.], honeysuckles [*Lonicera* spp.]) and encouraging the recovery of native shrubs, forbs, grasses, and sedges (Mundahl and Walsh 2022).

Over 220 species of plants including Great Indian Plantain have been documented recently within the park (N. Mundahl, unpublished data). Common trees include *Quercus macrocarpa* Michx. (Bur Oak), *Betula papyrifera* Marshall (Paper Birch), *Quercus rubra* L. (Northern Red Oak), and *Carya ovata* (Mill.) K. Koch (Shagbark Hickory). Shrubs present in the park include *Amorpha canescens* Pursh (Lead Plant), *Rosa arkansana* Porter (Prairie Wild Rose), and *Physocarpus opulifolius* (L.) Maxim. (Ninebark), as well as invasive buckthorns and honeysuckles. Common grasses on site include *Andropogon gerardii* Vitman (Big Bluestem), *Sorghastrum nutans* (L.) Nash (Indian Grass), *Bouteloua curtipendula* (Michx.) Torr. (Side-oats Grama), and *Elymus hystrix* L. (Bottlebrush Grass). Forbs such as Great Indian Plantain, *Solidago rigida* L. (Stiff Goldenrod), *Agastache nepeoides* (L.) Kuntze (Yellow Giant Hyssop), *Eutrochium maculatum* L. (Tall Boneset), *Rudbeckia triloba* L. (Brown-eyed Susan), and *Eupatorium purpureum* (L.) E.E. Lamont (Sweet Joe Pye Weed) appear in both prairie and savanna habitats. Finally, common sedges include *Carex molesta* Mack. ex Bright (Field Oval Sedge), *Carex sprengelii* Dewey ex Spreng. (Long-beaked Sedge), and *Carex grisea* Wahlenb. (Wood Gray Sedge).

The first documented connection between Great Indian Plantain and Garvin Heights Park occurred when GIP appeared in a seed mix from Prairie Moon Nursery, Winona, Minnesota that was applied to savanna habitat during a restoration project in 2005 (N. Mundahl, unpublished data). GIP seed comprised 907 g of the 17,324 g (5.2% by mass) of the 61-species seed mix spread into the larger of 2 savannas within the park. Based on hand-written field notes, this mix was applied to the southerly 80% of the large savanna, as the northerly 20% of the savanna had been seeded the previous year with a seed mix lacking GIP.

Materials and Methods

Field work

To conduct GIP surveys in Garvin Heights Park, the area occupied by the species was divided into 4 habitats (Fig. 2A and B). These included 2 sections of bur oak savanna (large savanna and small savanna, both with scattered trees; Fig. 3A) and 2 dry bluff prairies (upper prairie and lower prairie, both lacking trees; Fig. 3B). Boundaries around and between habitats were drawn with the aid of an on-line mapping app (GPS-based Fields Area Measure [FAM] Web App [<https://fams.app>]) that facilitated the creation of multiple subplots, all with the same area (277 m²) within each habitat (Fig. 2B). Combined, 43 subplots (3–28 in the various habitats) totaling 1.19 ha were surveyed.

The 2 life stages (rosettes and mature flowering plants) of GIP were tallied separately within each subplot. Subplots were navigated individually using the FAM app, with subplot boundaries marked with orange flags immediately prior to surveying. Each subplot was systematically and thoroughly searched for every GIP rosette and adult plant before moving on to the next subplot.

Canopy coverage estimates were made to assess sunlight growing conditions for GIP in each of the 43 subplots. Canopy coverage was estimated by taking a digital photo fac-

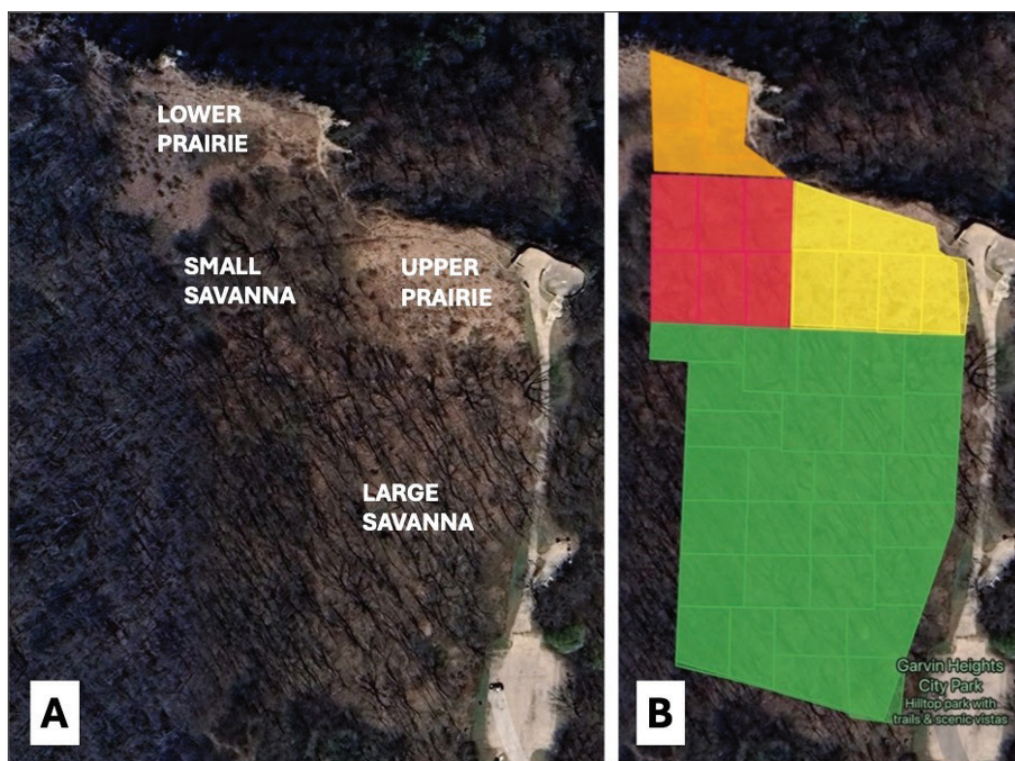


Figure 2. Aerial view of the 4 habitats surveyed for Great Indian Plantain at Garvin Heights Park, Winoona, MN (A) and the 4 habitats delineated into 277-m² subplots by the Field Area Measure Web app (B). Orange, red, yellow, and green colors designate the lower prairie, small savanna, upper prairie, and large savanna, respectively.

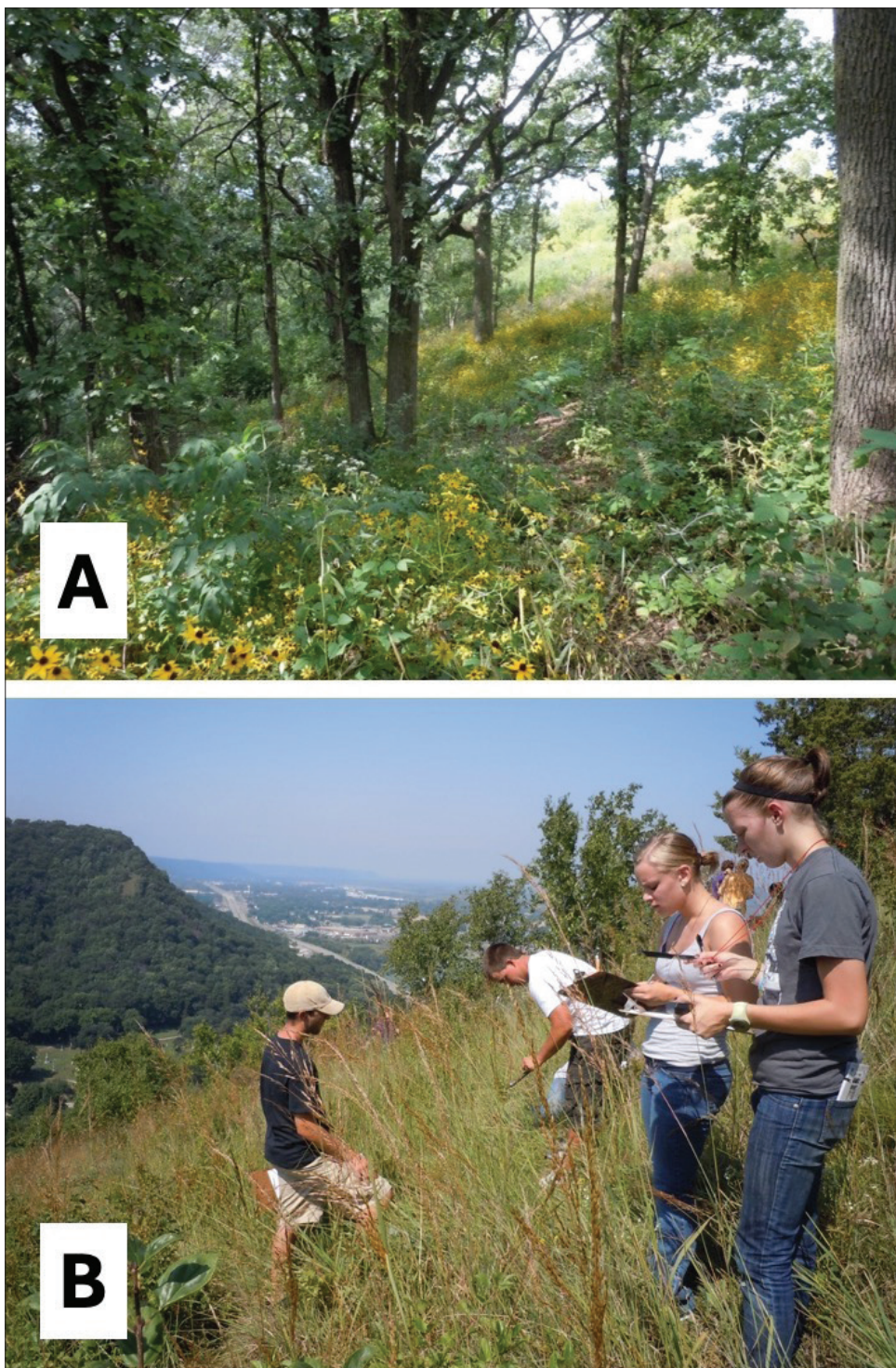


Figure 3. View of the large Bur Oak savanna (A) and the upper prairie (B) in Garvin Heights Park, Winona, MN. Photos by Neal Mundahl.

ing upwards into the canopy from three randomly selected locations within each subplot. Coverage in each photo was estimated using a modification of the technique described by Winn et al. (2013) and assigned to one of eight coverage class index categories (1 = 0%, 2 = <5%, 3 = 5–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–95%, 7 = 95–99%, 8 = 100%; modified from Daubenmire 1959).

Data analyses

Several different analyses were performed on the GIP data collected at Garvin Heights Park. First, total plant counts in each subplot were used to create a density map showing the distribution of GIP throughout the Garvin Heights prairies and savannas, indicating what habitats had the highest densities. These counts were then compared among the 4 habitats using a Kruskal-Wallis test (instead of ANOVA, because data were not normally distributed) to determine if any differences in population densities existed among the habitats. Separate Kruskal-Wallis tests also were used to compare numbers of flowering GIP and numbers of rosettes among the 4 habitats. Chi-square goodness of fit tests were used to compare distributions of plants between the 2 life stages separately, in each of the 4 habitats. Chi-square contingency table tests were used to determine if distributions of plants between life stages differed among the 4 habitats, as well as between the 2 prairie habitats, and between the 2 savanna habitats. Simple linear regression analysis was used to determine if there was a significant relationship between GIP flower counts and rosette counts in the subplots across all habitats. Linear regression analyses were also used to compare average canopy coverage index values for each subplot to total GIP counts, flowering plant counts, and rosette counts in each subplot to assess patterns of canopy coverage on GIP abundance. Finally, canopy coverage indexes were compared among the 4 habitats with a Kruskal-Wallis test. All statistical tests were conducted using the VassarStats Website for Statistical Computation (vassarstats.net).

Results

Across the 4 habitats at Garvin Heights Park, 2966 *Arnoglossum reniforme* plants were counted: 579 plants in the upper prairie, 514 in the lower prairie, 687 in the large savanna, and 1186 in the small savanna. Subplot counts ranged from 0 to 386, with 92% of all plants observed in the small savanna, lower prairie, and 4 subplots nearby (Fig. 4). A majority (53%) of the subplots held fewer than 10 GIP (<4 plants/100 m²). GIP densities differed significantly among the 4 habitats for both life stages and for total plants (Fig. 5, Table 1).

Immature GIP rosettes outnumbered mature flowering plants in all 4 habitats (all X^2 P values <0.0001; Fig. 5), comprising nearly 80% of all GIP counted. Rosettes were significantly more dominant (contingency table $X^2 = 174$, $P < 0.0001$) in savanna habitats (rosette to flowering plant ratios 6.5:1 in large savanna and 6.9:1 in small savanna) than they were in the prairies (ratios 1.9:1 in upper prairie and 2.2:1 in lower prairie; Fig. 5). However, rosette to flowering plant ratios did not differ between the 2 prairies (contingency table $X^2 = 1.44$, $P = 0.231$) or between the 2 savannas (contingency table $X^2 = 0.14$, $P = 0.709$). The numbers of GIP rosettes and flowering plants in individual subplots were significantly and positively correlated with one another by simple linear regression: flowering plant count = 0.208 rosette count + 2.54, $t_{41} = 7.07$, $P < 0.0001$, $r^2 = 0.55$.

As expected, the 2 prairie habitats had very low canopy coverage index values (corresponding to ~5% canopy coverage) compared to the savannas (corresponding to ~70% canopy coverage), with index values differing significantly among habitats (Table 2).

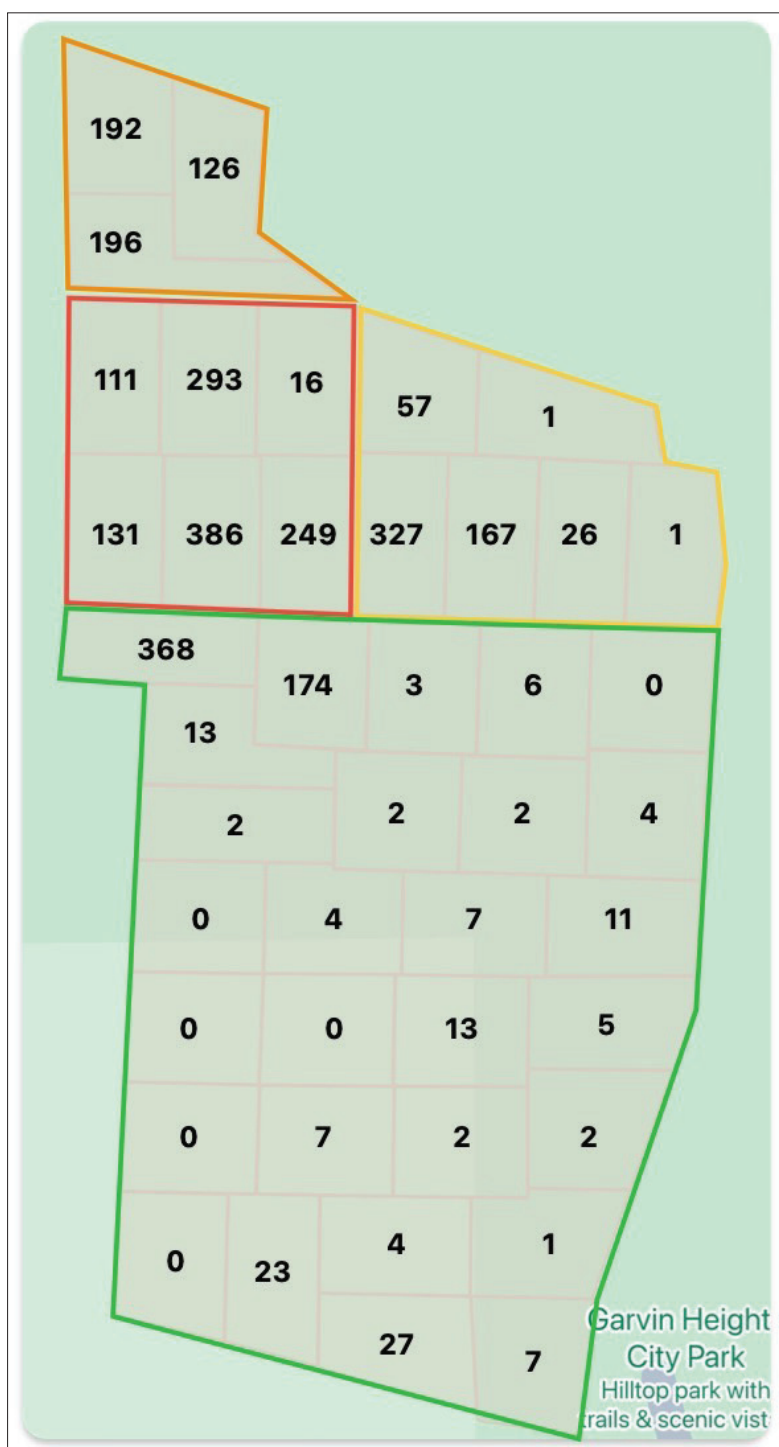


Figure 4. Total counts of Great Indian Plantain in individual subplots in Garvin Heights Park, Winona, MN during fall 2024. Orange, red, yellow, and green lines outline the lower prairie, small savanna, upper prairie, and large savanna, respectively.

Subplot densities of rosettes, flowering, and total GIP all were negatively correlated to subplot canopy coverage values (Table 3), but only for flowering GIP was this relationship significant, with highest densities present in subplots with the lowest canopy coverage.

Discussion

Based on the present study, Garvin Heights Park appears to have the largest population of GIP documented in Minnesota, with nearly 3000 individuals present in 2024. Previous surveys have reported a majority of populations in Minnesota are represented by fewer than 100 plants (Anderson 2018), although it is not clear that those surveys included both immature rosettes and mature flowering plants. Anecdotal evidence has suggested that a population in Mower County, 110 km southwest of Winona, numbering in the “hundreds”, was discovered in 2010 after a landowner removed a dense understory of buckthorn and boxelder from along a stream (Minnesota Wildflowers 2015, Anderson 2018). No other populations of GIP have been reported in the vicinity of Garvin Heights Park, other than garden or landscape plantings, nor could we find any reports of populations larger than the one at Garvin Heights Park anywhere within the species’ native range in the USA. Kentucky and Tennessee, in the center of the species’ range, have documented populations in 14 and 30 counties, respectively, and the Tennessee-Kentucky Plant Atlas (Shaw et al. 2023) lists 80 herbarium specimens of the species collected from the 2 states. However, we were unable to find documentation of any population sizes within either state.

There were significantly more GIP at Garvin Heights Park in 2024 than had been documented previously (N. Mundahl, unpublished data). In 2016, only 3 mature flowering GIP were noted in the southwestern corner of the upper prairie, but no systematic count

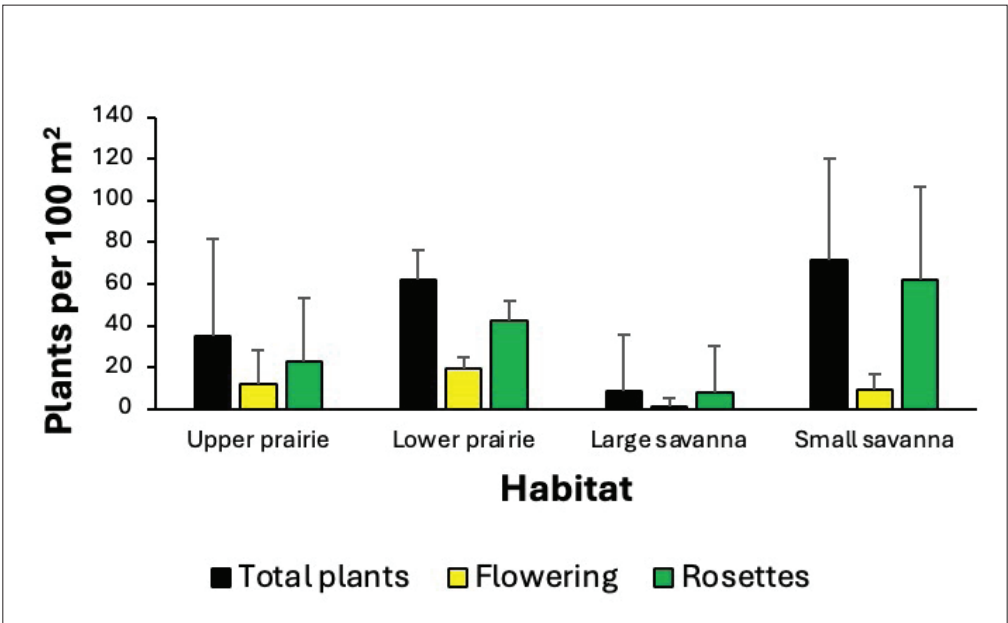


Figure 5. Mean (+SD) densities of Great Indian Plantain (displayed as total plants, mature flowering plants, and immature rosettes) in subplots within 4 habitats in Garvin Heights Park, Winona, MN during fall 2024.

was made, and numbers of immature rosettes present were not documented. By 2018, 613 plants (565 rosettes, 48 flowering) were documented within the upper prairie, the small savanna, and the extreme northwestern section of the large savanna. In 2020, 801 plants (558 rosettes, 243 flowering) were counted in those same habitats. In 2024, the same habitats contained 2307 plants (1873 rosettes, 434 flowering), a 2.9-fold increase in total abundance and a 1.8-fold increase in flowering plants in the 4 years since the previous survey. Overall, the 2966 GIP counted in all savanna and prairie habitats in 2024 (2365 rosettes, 601 flowering) represent a 3.7-fold increase in total abundance and a 2.5-fold increase in flowering plants compared to the 2020 survey. These increases indicate the presence of a rapidly expanding population of GIP in Garvin Heights Park. In the face of declining populations in so many regions, increasing populations of GIP appear to be very rare (Steinauer 2021).

Table 1. Kruskal-Wallis test statistics comparing total and life-stage densities of Great Indian Plantain among 4 habitats in Garvin Heights Park, Winona, MN during fall 2024.

Plant grouping	df	Kruskal-Wallis <i>H</i>	<i>P</i>
Total plants	3	16.20	0.0010
Rosettes	3	15.93	0.0012
Flowering plants	3	16.17	0.0010

Table 2. Canopy coverage index values and Kruskal-Wallis test statistics comparing 4 habitats in Garvin Heights Park, Winona, MN during fall 2024.

Habitat	<i>n</i>	Mean	SD	Kruskal-Wallis <i>H</i>	<i>P</i>
Upper prairie	18	1.1	0.5	54.63	<0.0001
Lower prairie	9	2.3	1.9		
Large savanna	84	5.5	1.1		
Small savanna	18	5.6	1.2		

Table 3. Simple linear regression test statistics comparing total and life-stage densities of Great Indian Plantain in subplots versus subplot canopy coverage values in Garvin Heights Park, Winona, MN during fall 2024.

Plant grouping	df	<i>t</i> value	<i>P</i>	<i>r</i> ²
Total plants	41	−1.03	0.3090	0.025
Rosettes	41	−0.54	0.5921	0.007
Flowering plants	41	−2.72	0.0095	0.153

Flowering GIP were first observed in a dry bluff prairie at Garvin Heights Park in 2016. A search of specimens in the Joseph P. Emanuel Herbarium at Winona State University failed to find any previous records of GIP from this locality. Given the large size and conspicuousness of this species, it is unlikely that its presence at Garvin Heights Park would have been overlooked (Anderson 2018) and that at least one specimen would have been collected and deposited in the herbarium after the property passed into public ownership more than a century ago. However, the species appeared in a seed mix (907 g of GIP seed, an estimated 128,000 seeds) applied to the southern 80% of the large savanna during a Garvin Heights restoration project in 2005. Together, these observations suggest that GIP is not native to Garvin Heights Park, but likely became established after 2005 via seeding, and recently has been very successful. It is not known why the species' presence in the park was not observed "officially" until 2016 if seeds were planted 11 years earlier in 2005. Regrowth of invasive buckthorn and honeysuckle within the park may have interfered with GIP growth or simply prevented it from being noticed for many years. Interestingly, the first observations of GIP in the upper prairie and the highest densities of GIP observed in subsequent years, including 2024, were all located outside and to the north of the portion of the large savanna where GIP seeds were originally planted in 2005, and where GIP densities still remained low in 2024.

Although the highest total densities of GIP in Garvin Heights Park were located in the small savanna habitat, that result was largely due to high densities of immature rosettes. Mature flowering GIP were 1.5 times more abundant in the prairie habitats than they were in the savannas, and ratios of rosettes to flowering plants were much more balanced in prairies than in savannas. These results suggest that savannas with their higher canopy coverage may be more suitable habitats for immature GIP, but prairies with little to no canopy appear to be more suitable for reproductive GIP. Only densities of flowering GIP were correlated significantly and negatively with canopy coverage. Savanna habitats with their higher canopy coverage may retain higher soil moisture levels during the early summer months (Ovington et al. 1963, Ko and Reich 1993, Wilson and Kleb 1996, Williams and Albertson 2004), providing a better environment for GIP seed germination and seedling survival. However, the understory habitat in savannas may not provide sufficient sunlight to power the level of photosynthesis or energy allocation needed for mature GIP plants to properly develop, flower, and set seed (Bazzaz et al. 1987). GIP seeds may not germinate or GIP seedlings may not survive on prairies during dry years, but even infrequent rainy years may be sufficient for GIP plants to become established and ultimately reach maturity in prairies. Consequently, flowering GIP were found more frequently in prairies than in savannas at Garvin Heights, despite there being more than twice as many rosettes in savannas than in prairies. The preference of mature GIP for woodland margins and openings (Eggers and Reed 1988, Anderson 2018) suggests a need for more sunlight for GIP to reproduce successfully. Proper management of prairie and savanna remnants can prevent loss of species diversity, suppress invasion by non-native species, and help to retain system functions (Leech and Givnish 1996, Damschen et al. 2008, Brudvig et al. 2009, Alstad et al. 2016).

Great Indian Plantain has established a large population, the largest in the state, at Garvin Heights Park in Winona, Minnesota after being seeded during a habitat restoration project in 2005. Immature rosettes dominate this population and are most abundant in savanna habitats where soil moisture conditions are likely good for seed germination and seedling survival. However, mature flowering GIP are most common in the 2 dry bluff prairies in the park, where full sunlight is available for growth, flowering, and seed production. Even small, protected remnant habitats (Damschen et al. 2008, Brudvig et al. 2009) like the prairies and savannas in Garvin Heights Park, if properly managed, can serve an important role in conserving and enhancing rare species such as GIP.

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