Using GIS to Focus Field Inventories of Rare and Endemic Plants at Badlands National Park, South Dakota

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Background

In southwest South Dakota there is a unique landscape known as the "Big Badlands" (Gries 1996) or the "White River Badlands" (O'Harra 1920) that is characterized by the presence of barren erosional features, known as "badlands," interspersed with mixed-grass prairie. These features form a dynamic land surface prone to landslides and rapid erosion, creating new land surfaces in the form of outwash plains at the base of buttes and scoured gullies, with each geologic formation lending unique soil chemistry and texture to its deposition (O'Harra 1920; USDA–Soil Conservation Service 1971, 1986, 1996).

Deeper soils mantling the buttes, hills, and alluvial valleys support relatively dense and diverse plant communities, typically grasslands. Soils on and adjacent to badland exposures and in drainage channels are rapidly deposited, and support a sparse plant community (Von Loh et al. 1999). These processes have shaped a variety of habitats for plants that are able to cope with rapidly changing substrate, variable moisture, and short-term competition. As these plants exist within a typical Northern Great Plains environment, they are also influenced by landscape processes of frequent fire, herbivory, and drought (Wright and Bailey 1980).

There are several rare plant species that are known to live in the barren badlands habitat, including some species that are considered endemic to the Northern Great Plains, a region generally considered depauperate of endemic flora (Great Plains Flora Association 1986). The interspersed grassland provides habitat for other species that are rare due to their local occurrence at the edge of their range.

Established in 1939, Badlands National Park is located in the Big Badlands landscape and preserves one of the nation's largest mixed-grass prairies. Yet the National Park Service (NPS) lacks information on rare plant inventory and distribution throughout the park's 244,000 acres. Nine state-listed rare species, including four endemics, have been confirmed within the park incidentally during the course of other studies, or they are known from similar habitats near the park. In 2003, the park initiated a two-year study to document the location and distribution of these nine rare plant species based on potential habitat at the park.

Project Objectives

The study's objectives are to:

- Use a geographic information system (GIS) to define potential habitat of the nine state-listed rare plant species, based on spatially explicit habitat parameters found in the literature, from known sites, and on voucher labels.
- Inspect probable habitat for the presence of the nine state-listed rare plant species.
- Document the presence or absence of each species in each polygon searched. Verify habitat characteristics, map distribution, and describe the population. Collect voucher specimen for species not previously vouchered in the park.
- Formalize documentation of presence (or absence) by recording observations and vouchers in various NPS databases and the South Dakota Natural Heritage Database.
- Make baseline data available for subsequent studies beyond the scope of this project.

Methods

An attempt was made to use GIS to focus field inventory efforts in order to maximize efficiency and provide the most information for proactive protection of the rare plant populations and their habitat, whether occupied or unoccupied. The distribution and abundance of many plants are influenced by the spatial arrangement of suitable habitats across landscapes (Ritters et al. 1997), and the quantification of such species–environment relationships represents the core of predictive geographical modeling in ecology (Guisan and Zimmerman 2000). Knowledge of which habitat parameters most accurately predict the occurrence of a rare plant species, and the likelihood that the species will occur given specific site conditions, is fundamental to effective management of rare species (Simberloff 1988; Brussard 1991; Falk and Olwell 1992; Wiser et al. 1998).

Three different approaches are being used to document the distribution and abundance of these nine species (see Table 1). The approach chosen reflects the information available for each species, its life history and habitat characteristics, and its relative importance to management.

Preliminary Results

The most intensively investigated species is *Astragalus barrii*, a long-lived perennial endemic species that is rare throughout its entire range. This species is known from several locations in and near the park, although it has never been systematically inventoried in the park. It exhibits consistent and precise habitat correlations that can be analyzed using GIS and existing geospatial data, making it feasible to accurately predict its occurrence based on habitat. Using ESRI ArcGIS 8.2 software, four categories of habitat characteristics (geology, soils, vegetation, slope) were scored based on their association with *A. barrii*, as indicated in the literature, on existing vouchers, and from documented populations.

Each record in each layer was given a score of 0, 1, or 2, where *0* represents no association, *1* represents weak or imprecise association, and *2* represents strong association. Each habitat parameter was given equal weight. All four layers were then summed on a 200x200-m grid cell covering the entire park. The result is that the entire surface of the park is scored on a linear scale of 0 to 8, with *8* representing the best, and *0* the worst, habitat for *A. barrii* (Dingman 2003). These scored raster cells were then converted into polygons representing contiguous habitat with the same score. Sixty polygons were then haphazardly selected across the full range of habitat scores, with more samples drawn from the high-score

Table 1. Nine state-listed rare plant species will be studied to document location and distribution within Badlands National Park, South Dakota.

Family	Scientific Name	Duration	Endemism	Investigation Approach
Fabaceae	*Astragalus barrii* Barneby	Perennial, blooms Apr-Jun	endemic	Intensive search and study to create predictive habitat suitability model
Polygonaceae	*Eriogonum visheri* A. Nels.	Annual, blooms Jul-Sep	endemic	Focused corridor search to map populations along roads and trails
Asteraceae	*Thelesperma megapotamicum* Spreng.	Perennial, blooms May-Sep	edge of range	Focused corridor search to map populations along roads and trails
Boraginaceae	*Cryptantha cana* A. Nels.	Perennial, blooms May-Jul	endemic	Focused corridor search to map populations along roads and trails
Brassicaceae	*Lesquerella arenosa* (Richards.) Rydb. Var. *argillosa* Rollins & Shaw	Annual, blooms May-Jun	endemic	Opportunistic encounters to map populations
Ranunculaceae	*Clematis hirsutissima* Pursh	Perennial, blooms May-Aug	edge of range	Opportunistic encounters to map populations
Asteraceae	*Chrysothamnus parryi* A. Gray	Perennial, blooms Aug-Sep	edge of range	Opportunistic encounters to map populations
Asteraceae	*Townsendia exscapa* Richards.	Perennial, blooms Mar-May	edge of range	Opportunistic encounters to map populations
Asteraceae	*Townsendia grandiflora* Nutt.	Biennial, blooms May-Jul	edge of range	Opportunistic encounters to map populations

polygons and fewer from the low-score polygons.

These sites will be inspected during the flowering season in 2003 for the purpose of recording presence and absence of *A. barrii* and other habitat and population information. These data will then be used to refine a predictive habitat suitability model that will then be validated on the adjacent Buffalo Gap National Grasslands. Such a model could then be used to anticipate the location of existing populations as well as unoccupied but suitable habitat for future populations. This information will assist park managers in proactively preserving the species and its habitat (Table 2).

Table 2. The habitat parameters of geology, soils, vegetation, and slope have been scored based on their association with *Astragalus barrii*, as indicated in the literature, on existing vouchers, and from documented populations. The result is that the entire surface of the park is scored on a linear scale of 0 to 8, with *8* representing the best, and *0* the worst, habitat for *A. barrii*. This preliminary habitat suitability model will be refined and validated during spring 2003 by searching a sample of polygons in each score to verify the habitat parameters and confirm presence or absence of the species.

Score	Number of Polygons	Min area (m^2)	Max area (m^2)	Mean area (m^2)	Total area (ha)	# Polygons to survey
0	414	25541	3284042	89542	3707	5
1	858	25541	2003028	78861	6766	5
2	1115	25541	38867515	234373	26133	5
3	1492	25541	13959491	101380	15126	5
4	1600	25541	5582687	82147	13144	5
5	1172	25541	9050160	155899	18271	5
6	1101	25541	1473910	81211	8941	10
7	485	25541	689177	63564	3083	10
8	247	25541	1504397	97173	2400	10
Total	8484	-	-	-	97571	60

Eriogonum visheri, *Thelesperma megapotamicum*, and *Cryptantha cana* have habitat specificity that can be analyzed using GIS and existing geospatial data. However, the available habitat information is too imprecise or the species are too ubiquitous in their distribution to make predictive habitat suitability modeling feasible. Probable habitat, as defined using GIS, will be searched with the highest-priority search areas located within 700 m of improved roads and 100 m of designated trails. Because visitor use and management activities are concentrated along road and trail corridors, this approach maximizes search efficiency and also provides the information most needed by managers to avoid and minimize impacts to the plants and their habitats. As populations of these species are identified and mapped, it may be possible to better define their habitat preference and then use GIS to develop habitat suitability models for these species (Table 3).

Probable habitat for five other species could not be defined using GIS due to the lack of habitat specificity demonstrated by the species and/or the resolution of existing spatial data. Some of these species tend to be microsite-specific, such as "thin" areas of prairie that are not discernable based on the resolution of existing geospatial data, thus making it impossible to pick out microsite habitats. These species will not be subjected to a focused inventory effort. Park field employees and cooperators will be trained to recognize these species and report sightings. Species occurrences will be documented as populations are opportunistically encountered and verified. If enough populations are found, it may be feasible to better define their habitat characteristics and use GIS to define probable habitats for future inventory efforts.

In summary, GIS was used to the extent possible to focus field inventory efforts for the short flowering season of each species, thus increasing the efficiency and efficacy of this inventory project. The effort to document

Table 3. Probable habitat maps for *Cryptantha cana*, *Thelesperma megapotamicum*, and *Eriogonum visheri* were created based on the habitat parameters of geology, soils, vegetation, and slope. The 2003–04 inventory work will focus on those habitats, and possibly populations, that are within 700 m of improved and 100 m of designated trails. From this information, we hope to gain the information needed to create a habitat suitability model that will focus future inventory efforts more effectively.

species	Total # of polygons in park	Area (m^2) of probable habitat in park	# of polygons in corridor	Area (m^2) of probable habitat in corridor
Cryptantha cana	164	2529	75	117
Thelesperma megapotamicum	968	1,532,873	326	46,578
Eriogonum visheri	86,026	539,744	20,834	223,092

location and distribution of these species will provide the information needed for more meaningful environmental analyses and proactive preservation of these species and their habitats.

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