# Monitoring *Antennaria arcuata* (Box pussytoes) in BLM Exclosures, west-central Wyoming – 2017



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ABSTRACT

*Antennaria arcuata* (Box pussytoes, Meadow pussytoes) was among the earliest of Wyoming plant species proposed for listing as endangered in 1976. Circumstantial information from fenceline contrasts lead to questions whether it is impacted by grazing, based on its presence in lightly-grazed pastures and absence in adjoining heavily-grazed pastures. The Bureau of Land Management (BLM) constructed two Exclosures in 1982 and 1984, then conducted monitoring inside and outside of them to evaluate species' response to grazing along permanent belt transects. Ensuing visits by botanists and range conservationists over the years, since the time of transect work, failed to find any survival of the species along the transects inside the Exclosures or elsewhere in the Exclosures. The purpose of this study was to revisit the two Exclosures for what they might tell us about *A. arcuata* and its habitat since the most recent data in 1988. The two Exclosure transects were revisited in 2017 to characterize the current vegetation in comparison with original conditions, and the Exclosure areas were searched. It was discovered that both Exclosures maintain low numbers of *A. arcuata* surviving in small areas apart from the transects. Vegetation changes suggest a decline of a wetland-dependent sedge species and increases in upland or facultative upland species. Affects are also tempered by hummock formation, as they create microhabitat islands of low competition on one hand, but high soil moisture evaporation on the other. This work constitutes a pilot study and initial ideas are presented for further evaluating *A. arcuata* response to grazing in light of all the challenges of separating cause and effect.

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Cover photo: The Atlantic City Exclosure has one of the most conspicuous vegetation changes taking place between 1988 and 2017. A portion of the transect currently has high cover of silver sagebrush (*Artemisia cana* var. *viscidula*) that was not recorded as present in 1988. This is a view from a post placed at the Exclosure transect midpoint, facing east.

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**INTRODUCTION**

In 1975, *Antennaria arcuata* (Meadow pussytoes; also called Box pussytoes[1]) was included in the first list of species considered for designation under the Endangered Species Act (ESA) (USDI Fish & Wildlife Service 1975). It was later proposed as Endangered by the Smithsonian Institution (Ayensu and DeFilipps 1978), and became a Category 2 candidate for listing under the ESA beginning in 1980 (U.S. Fish and Wildlife Service 1980) when the only known extant populations were in Fremont County of west-central Wyoming, now part of the BLM Lander Field Office (FO).

In 1984, two documents were prepared by John Winnepenninkx, BLM, and signed off by the Area Manager:

1. Atlantic City Exclosure Monitoring Plan, Project No. 4683 (Winnepenninkx 1984a)
2. Gilespie Monitoring Exclosure, Meadow pussytoes study, Project No. 5482 (Winnepenninkx 1984b)

Copies of both documents were provided to the Wyoming Natural Diversity Database (WYNDD) in 2015 by Tanya Skurski (BLM Lander FO).

Both Exclosures had the same basic study objectives, to determine the effects of grazing on *Antennaria arcuata*. The Atlantic City Exclosure was built in 1982 and data first collected from it in 1983 by Area staff; later reread in 1988. The explicit purpose of the Atlantic City Exclosure study was: "Through monitoring it is hoped that knowledge will be gained to determine if the plant is declining or increasing (measured in terms of dry weight production and percent frequency) due to grazing pressure and trampling by 1993." The Gilespie Monitoring Exclosure was built in 1984 and data first collected from it in 1988, also by Area staff.

The BLM work represented by construction of the two original Exclosures, and replicable studies in them provided a model for testing hypotheses and a window into habitat trends and requirements of this sensitive species. The purpose of this study was to revisit the two Exclosures to collect comparable vegetation monitoring data for what they might tell us about *A. arcuata* and its habitat. It was also proposed as a project that might provide a common framework compiling any prior data-collecting work and observations, and basis for discussion.

There has been limited transect data or *Antennaria arcuata* data in particular collected since 1988, including reports that the species is absent from the exclosure (Fertig 1996, Skurski 2013). A set of photographs taken in 2013 was provided to WYNDD by Tanya Skurski after she had visited the Atlantic City Exclosure. She mentioned that frequency data was collected outside the Atlantic City Exclosure. She later visited the Gilespie Exclosure transects.

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[1] *Antennaria arcuata* has been called meadow pussytoes as a common name in all Wyoming reports to date. The PLANTS database uses the common name "Box pussytoes" as do some federal agencies now in Wyoming, and some other states in its distribution. In the 2018 Wyoming plant species of concern list, the common name was changed to Box pussytoes.

**SPECIES BACKGROUND**

*Antennaria arcuata* was maintained on the Category 2 list of candidate species by the U.S. Fish and Wildlife Service under the ESA from 1980-1996. In 1996, the Category 2 recognition was discontinued and candidate species were redefined to mean only those species for which the Service has sufficient information indicating that immediate listing is appropriate. In 2001, *Antennaria arcuata* was designated sensitive by Wyoming BLM (USDI BLM 2001), and retained on the sensitive list in the most recent update (USDI BLM 2010).

The status of *Antennaria arcuata* has been addressed in a series of study reports that involved surveys for it and compiled the most complete information available on it (Marriott 1986, Fertig 1996, Heidel 2013). The first of these was in 1986 after the BLM exclosures were constructed, and after extensive surveys had been conducted, when it was known from 20 locations in Fremont County, Wyoming. At the same time, there were only two locations known for it in Nevada and one in Idaho. In 2012, it was surveyed in the Upper Green River watershed (Heidel 2013) after its discovery there by Steve Laster (BLM) in 2000. The status of this species has also been addressed in project reports that targeted multiple species and which expanded known distribution of *A. arcuata* (Heidel 2015). It is currently known from both the Sweetwater and Green River drainages of the BLM Lander, Pinedale and Rock Springs Field Offices. It is documented at 32 known discrete locations in Wyoming, though one may no longer be extant.

The only trend information for *Antennaria arcuata* is presented in Fertig (1996) based on 1995 census results at 12 (of 20) Fremont County locations in comparison with available earlier data. Fertig reported that there were seven populations in apparent decline, one stable and four that had apparently increased. He also initiated two demographic studies and proposed them as warranting repeat monitoring every year or two, as alternatives or additions to the exclosure studies.

This study represents pilot work in revisiting the exclosures to evaluate *Antennaria arcuata* long-term trends, population viability and species' vulnerability or resiliency.

**STUDY AREA**

The two *Antennaria arcuata* monitoring Exclosures are located in Fremont County, within 10 air miles of Atlantic City (Figure 1).

The Atlantic City Monitoring Exclosure location is: T28N R99W SW1/4SW1/4, Sec./ 4), six miles southeast of Atlantic City, directly east of the Phelps-Dodge Road where the road crosses a small unnamed tributary of Willow Creek [Part of record no. 005, in the Atlantic City Quad].

The Gilespie Exclosure location is: T29N R98W NE1/4NW1/4, Sec. 26, 10 miles east-southeast of Atlantic City and 1/8 mile south of the Atlantic City-Hudson Road, accessible via BLM Rd 2315 on Diamond Creek, but out of view from the road. [Part of record no. 012, in the Radium Springs Quad].

Figure 1. *Antennaria arcuata* Exclosure study areas, Fremont County, Wyoming
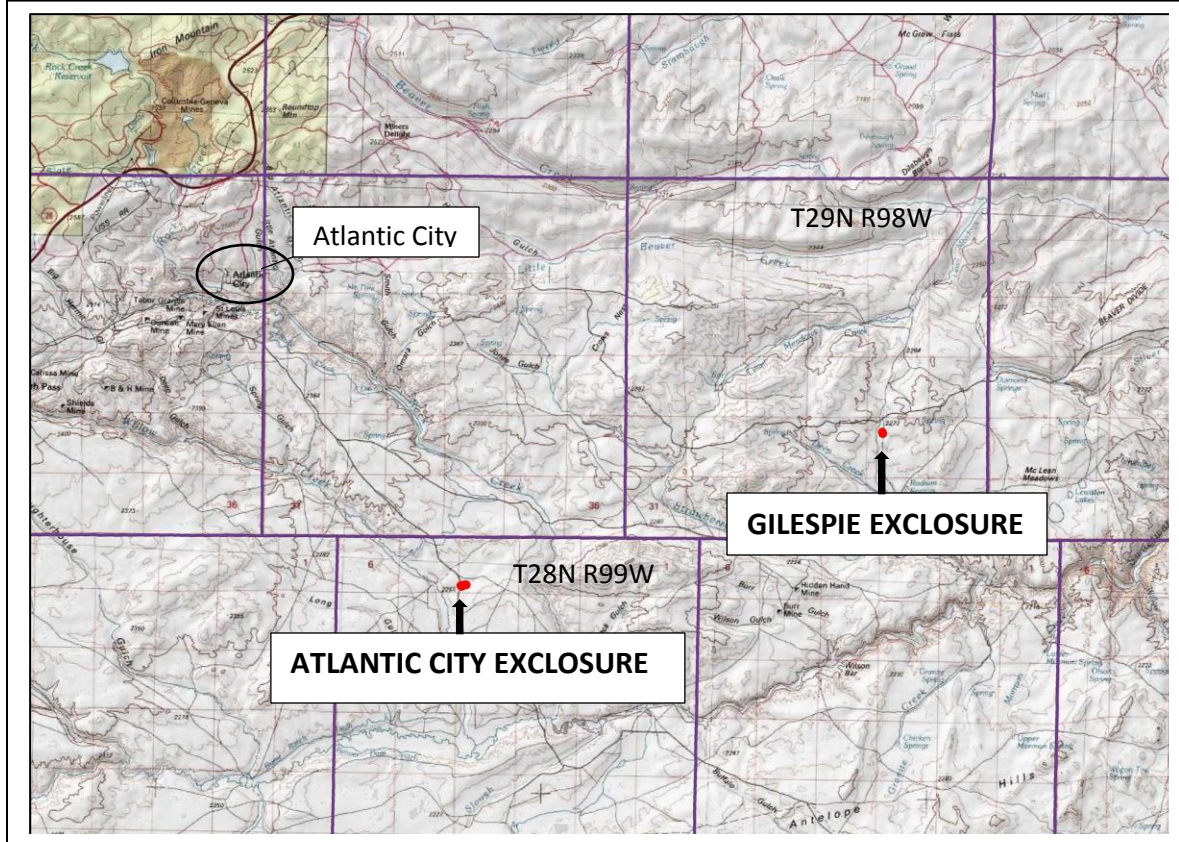


The outlines of the Exclosures, established over 30 years ago, show up on aerial photography. The digital images are reprinted in Figures 2 and 3. The three transects that were visited in 2017 are superimposed. Each monitoring transect and basis for relocating it from the original BLM diagrams, with comments superimposed, are presented in Appendix A.

Figure 2. Atlantic City Exclosure and two transects revisited in 2017 (star marks *Antennaria arcuata* within Exclosure)

Figure 3.  Gilespie Exclosure and the one transect revisited in 2017 (stars mark *Antennaria arcuata* within Exclosure)
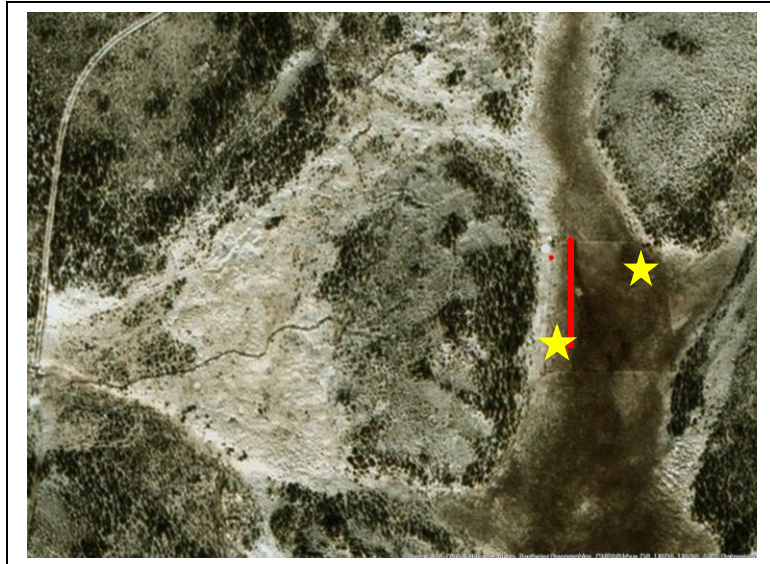


**METHODS**

Detailed *Antennaria arcuata* monitoring plans and ensuing records were prepared as part of the original BLM Exclosure and monitoring design, and are stored in BLM Lander FO project files. The Atlantic City Exclosure Monitoring Plan is Project No. 4683 (Winnepenninkx 1984a).  The Gilespie Monitoring Exclosure is Project No. 5482 (Winnepenninkx 1984b). The plans also include: Introduction, Objectives, Procedures, and brief guidelines for schedule, data storage, analysis, interpretation and evaluation. They include diagrams of transect layouts.  Both Exclosures had two transects inside the Exclosure and at least two transects outside the Exclosure.

Five transects were originally laid out inside/outside the Atlantic City Exclosure (Appendix A). Each was represented on a map prepared by drafting techniques on separate pages.  The two interior transects were to measure production and frequency.  The production transect was laid in a straight line with marked endpoints that could be relocated in 2017 (Figure 2).  The frequency transect inside the Exclosure was laid out in an irregular line to coincide with *Antennaria arcuata* distribution.  It could not be relocated. In addition, there were two frequency transects laid outside the Atlantic City Exclosure, one located to the east of the Exclosure in two straight segments with an angle between them. The other one, located to the west of the Exclosure, was laid out in an irregular line between the Exclosure and the road, and it could not be relocated. Finally, a fifth transect was laid outside the Exclosure for big game pellet counts. It extended outside of alkaline meadow habitat and no effort was made to relocate it. In other words, two of five transects were relocated by permanent endpoints.

Four transects were originally laid out inside/outside the Gilespie Exclosure. They were represented as a set on a diagrammatic map prepared by drafting techniques on a single page rather than on separate pages, but there were two different versions of the diagrammatic map, and they had different transect orientations. The two versions might have represented a proposed layout version vs an actual layout. One interior transect was laid out in a straight line to measure both production and frequency. It had marked endpoints that were relocated. The second interior transect was also diagrammed as a straight line, and designed to measure production. Its endpoints could not be relocated. One exterior transect was laid in a straight line to measure production and frequency. It did not have endpoints that could be relocated. A fourth transect was laid outside the Exclosure for big game pellet counts. It extended outside of alkaline meadow habitat and no effort was made to relocate it. In other words, only one of at least four transects was relocated by permanent endpoints.

In the original BLM monitoring, productivity was measured and work was conducted at the end of the growing season (late September to late October), which would have made it difficult to get complete species lists. The "green weight" biomass was measured but most plant material was probably dessicated by that time. Outside the Exclosure, % utilization was also recorded. There were notes that it took two people two days to make all of the vegetation measurements per Exclosure study (i.e. four days of work per Exclosure). Dominant plants in the original monitoring results were identified to species, and most others were included as genus-level determinations. By contrast, the 2017 visits to the Exclosures were made by one person over the course of two days between 2-4 August when virtually all plants in the Exclosures could be identified to species. A premium was placed on walking the Exclosure to understand conditions before collecting transect data. Voucher specimens were collected in the Atlantic City Exclosure and running species lists were prepared for both Exclosures (Appendix B). Fieldwork outside the Exclosure was limited to transects (or trying to locate them) and checking extent of population boundaries. Very rough population estimates were made at the same time.

The original sampling frames were 1 ft x 1 ft, gridded into 25 cells (Figure 4). The original sampling frames were used for mapping and calculating frequency of *Antennaria arcuata* plants. For this project, a plexiglass 1 ft x 1 ft frame was cut and gridded (Figure 5) instead making a frame out of metal, wood or PVC, for want of the original. The sampling frame was placed 20 ft apart along the transect. The placement of frames along some of the transects were marked by a pair of "angle iron" stakes in opposite corners of the frame into which the frame fit (Figure 4).

Originally, both productivity (total biomass, by species) and *Antennaria arcuata* frequency were measured. There was not an opportunity to resolve questions about replicating biomass measurements based on clipping vegetation. The vegetation inside the Exclosure had standing stubble, long arching leaves extending into/out of the sampling area, and there was a high amount of hummocked relief such that many of the 1 ft x 1 ft sampling areas as projected vertically downward from a flat frame had much higher surface area than a 1 ft² sampling area.

Figure 4. Placement of the 1 ft x 1 ft sampling frame along the Atlantic City transect outside the Exclosure in 2013 (photo provided by T. Skurski)



Estimates of vegetation cover were substituted for production measurements, using the gridded 1 ft x 1 ft frames and the following cover classes: Trace, 1-5% 6-15%, 16-25%, 26-35%, 36-45%, 46-55%, 56-65%, 66-75%, 76-85%, 86-100%. They were assigned median values (e.g., 0.5, 3, 10, 20,…) for preliminary analysis. The resulting cover values were strongly skewed by the amount of space between hummock vegetation and by the amount of vegetation on them (Figure 5). Methods were based on the premise that a species having high productivity would also have high cover, and vice versa. There is assumed to be a positive relation, without trying to draw any precise correlation. Despite the fundamental differences between measurements of cover and production between the original BLM monitoring data and 2017 data, this approach seemed like the best approach to characterize vegetation changes under the circumstances.

The 1980's monitoring data results were originally recorded on a "range trend plot data worksheet." The Atlantic City Exclosure had data collected in at least 1983 and 1988; the Gilespie Exclosure had data collected in at least 1988. Duplicate copies of the 1988 data forms were made, for use in recording 2017 vegetation cover values directly besides the prior entries, to ensure that all species present originally were sought in 2017. Any additional species found in plots were recorded below the original entries and collecting was done to characterize typical species or species that warranted herbarium verification work.

Methodology questions run through this study and the work was initiated without having obtained 2013 data, studied the 2013 photos or knowing if transects could be relocated. An expeditious approach was taken without a way to get answers. This project was originally discussed in very general terms as an opportunity to collect hard data for a long-term study and showcase the earlier BLM work that did not appear to have quantitative follow-up or formal results since 1988. The 2013 photographs (including Figure 4) represent a related study. Even if precise replication had been possible, the prospect of discussing project assumptions, design, and

scope could have led in many directions between the time it was proposed and the time it was conducted.  In the absence of such discussions, a simple approach was taken, one that can be revisited or expanded.  Brief descriptions of the settings for the three relocated transects are provided below.

Figure 5.  Placement of the 1 ft x 1 ft sampling frame along the Atlantic City transect outside the Exclosure in 2017
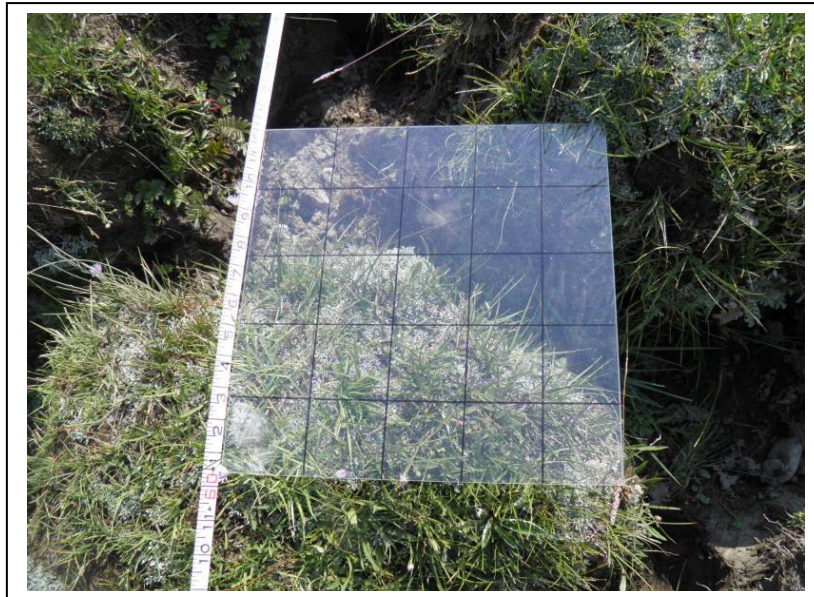


Atlantic City Exclosure productivity transect runs in the middle of the Exclosure, following the drainage pattern (east-west). There is not a channel but a broad bottomland with diffuse drainage. The hummock formation is very pronounced for over half of the transect, with some hummocks that may be higher than they are wide.  South of the transect is an area where water has been impounded, possibly exaggerating hummock features, and with a small evaporated drawdown flat in the center that skirts the transect, supporting *Rorippa tenerrima* (Modoc yellowcress) on the dried mud. It is possible that the elevation of the road culvert is a factor in water retention in that part of the Exclosure.

Atlantic City productivity transect outside the Exclosure is located directly upstream from the Exclosure, to the east of it.  The transect follows two straight lines with a bend in the middle, and it crisscrosses a diffuse channel.  Transect segments that extend outside of the channel have some of the driest habitat of the three transects.

Gilespie Exclosure productivity transect runs along the broad bottomland with diffuse drainage (north-south), parallel to it, at the edge of the drainage between it and the western margin of the Exclosure.  The hydrological conditions along the transect do not appear to have standing water at any time of the growing season.

**RESULTS**

The *Antennaria arcuata* frequency transects that were set up within Exclosures to monitor its frequency could not be relocated in 2017, but there were no *A. arcuata* plants present in the general areas where they were once placed. Between 1983-1988, the frequency of *A. arcuata* at the Atlantic City Exclosure dropped from 75% across the ten 1 ft² plot areas to 0%. They have not reappeared and one scenario is that *A. arcuata* has little or no colonization capacity but reproduces primarily or exclusively by spreading vegetatively, most readily within hummocks. The productivity transects that were relocated apparently did not have *A. arcuata* present in their original placement and they do not at present.

One of the more interesting results is that *Antennaria arcuata* persists within both Exclosures in 2017, contrary to prior reports and communications. The plants are located off the transects, in very small areas and with low numbers. The settings where it persists are on low hummocks with low vegetation cover and seasonally semi-moist subsurface conditions (southwest corners of both Exclosures), and on the edge of high hummocks located beside a spring (northeast corner of Gilespie Exclosure).

Five graminoid plant species comprised over 90% of total 1988 plot productivity and nine Graminoid plus herb species comprised over 90% of total 2017 plot cover among revisited transects (Table 1). They are listed along with their National Wetland Plant List indicator values for the western mountains and valleys region of the country.

Table 1. Species comprising primary components of productivity (1988) and cover (2017) in Exclosure transects

| Scientific name | Common name | Wetland indicator value[2] |
|---|---|---|
| *Achillea millefolium* | Yarrow | Facultative upland |
| *Antennaria microphylla* | Littleleaf pussytoes | Not recognized as a wetland species |
| *Artemisia cana* var. *viscidula* | Silver sagebrush | Facultative upland |
| *Carex nebrascensis* | Nebraska sedge | Obligate |
| *Carex praegracilis*[3] | Clustered field sedge | Facultative wetland |
| *Deschampsia cespitosa* | Tufted hairgrass | Facultative wetland |
| *Koeleria cristata* | Junegrass | Not recognized as a wetland species |
| *Juncus balticus* | Baltic rush | Facultative wetland |
| *Muhlenbergia richardsonis* | Mat muhly | Facultative |

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[2] From USDI NOAA 2018

[3] *Carex praegracilis* was documented in 2017 and is inferred to correspond to "*Carex* spp." as recorded in 1988 plot data. While other species of *Carex* were present and collected in 2017, none were common. *Carex praegracilis* has been observed by the author in a variety of alkaline meadow settings and grazing intensity settings.

Figure 6. 1988 productivity and 2017 cover data from three transects (Atlantic City Exclosure, Atlantic City outside Exclosure, Gilespie Exclosure)
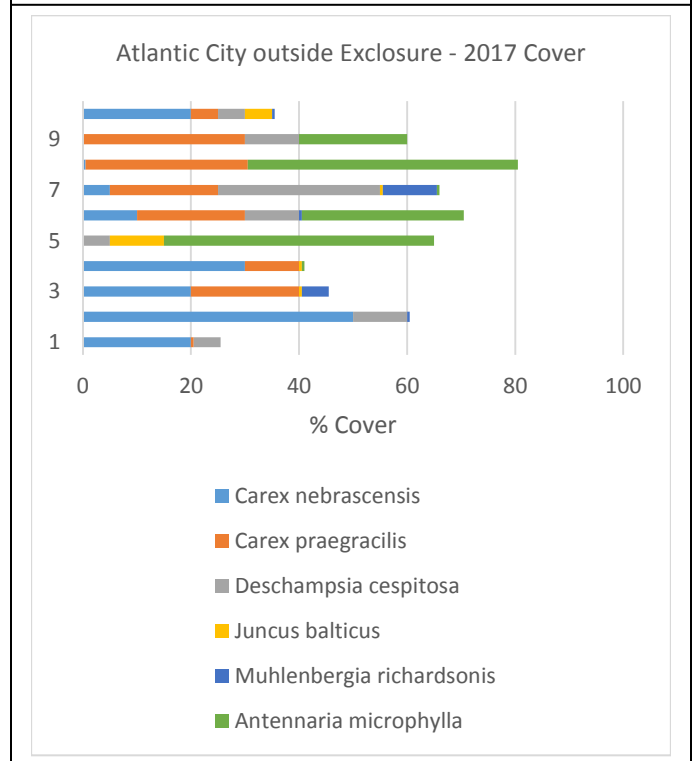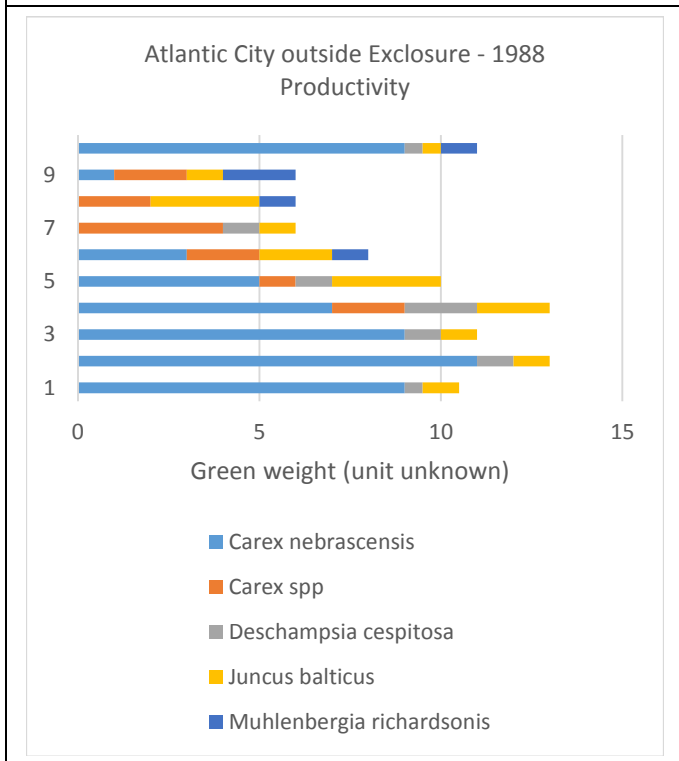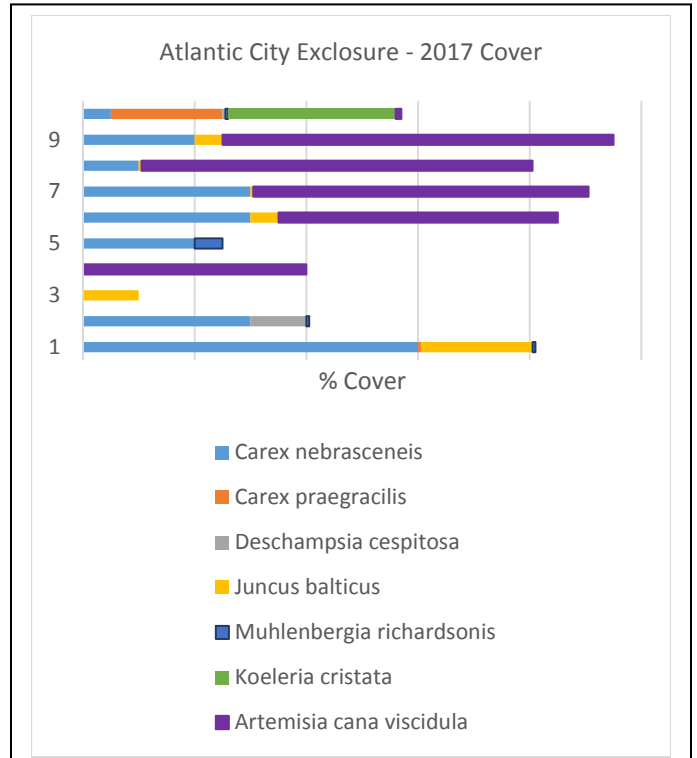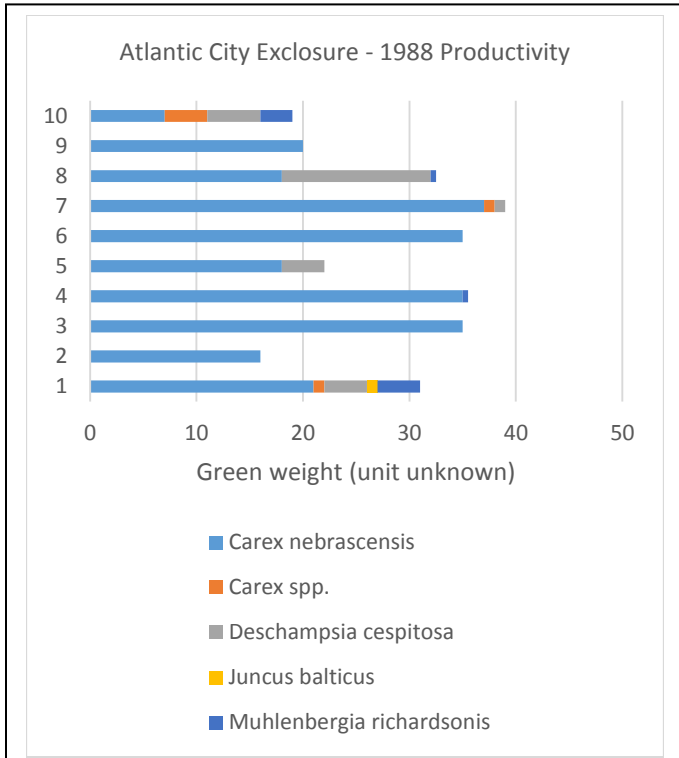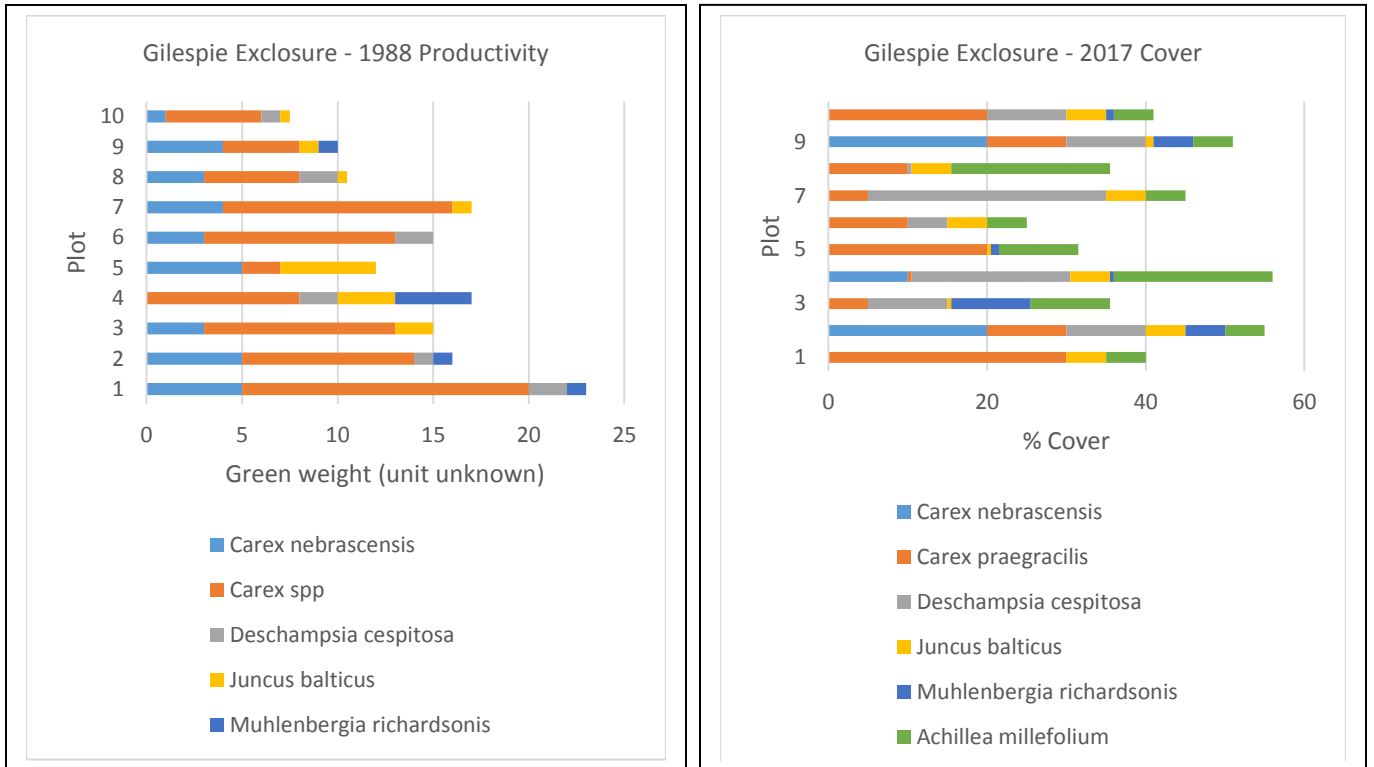
Figure 6. 1988 productivity and 2017 cover data from three transects (continued)



Comparison between 1988 and 2017 datasets provides preliminary evidence of vegetation change in the 30 intervening years, including cover type conversions that generally signify a shift from wetland species to facultative wetland or non-wetland species (Figure 6). These include:

1. Reduction in *Carex nebrascensis* component, the only wetland obligate among the nine species.

2. Appearance of four upland or facultative upland species that apparently were not present, or were not recorded as major components in 1988, including *Achillea millefolium*, *Antennaria microphylla*, *Artemisia cana* var. *viscidula* and *Koeleria cristata*.

One of the most important unanswered questions was whether the four upland or facultative upland plants noted with high cover in 2017 were deliberately excluded from 1988 data-collecting because they have limited forage value, or whether they have in fact increased over time. There were only 13 unique species recorded in the BLM productivity datasets (including *Calamagrostis* spp., *Carex* spp., *Erigeron* spp. and *Poa* spp.) whereas the preliminary checklist for the exclosures has close to 70 species (Appendix B). Tabular data for these graphs are presented in Appendix C.

**DISCUSSION**

The 2017 revisit to the BLM Exclosures recent visit does not replicate the 1983 and 1988 work because productivity was not measured. However, if all major species contributions to productivity were recorded in 1988, then there are four new species components over time (*Achillea millefolium, Antennaria microphylla, Artemisia cana* var. *viscidula* and *Koeleria cristata*), and declines in the number of plots in which *Carex nebrascensis* is present, if not in its productivity. The 2017 data provide a snapshot of cover-based composition for comparison.

The 30 years between 1988-2017 have included periods of prolonged dry conditions or drought, and it is noteworthy that vegetation transect data outside the Atlantic City Exclosure suggest possible vegetation shifts, not just vegetation transect data inside the Exclosure. The data from outside the Exclosure suggest possible decline in *Carex nebrascensis*, and appearance of *Antennaria microphylla* over the years.

Comparisons between 1983-1988 Atlantic City transects data inside/outside the Exclosure are also a study in contrast. They were not necessarily placed for direct comparison, but the 1988 data, collected only six years after Exclosure construction in 1982, showed three-fold greater productivity inside vs outside the Exclosure along the productivity transect. The current cover inside the Atlantic City Exclosure is distinctly higher than outside it, although these cover differences are not necessarily as great as productivity differences. This cover data and prior productivity results provide context for the disappearance of *Antennaria arcuata* along the frequency transect, where it dropped from 75% to 0% in only five years and has not reappeared.

The original study designs had excellent records, while the most basic matters of relocating transects and replicating measurements were challenges that might have been addressed if there had been more chance for BLM consultation, searches for additional records in the BLM files, or more time searching for answers at the study sites. There were an assortment of details that complicated productivity replication. In one place, dry weight was mentioned and in another, green weight was mentioned. Units of measurement (gram?) were not recorded. All species abbreviations on the original forms were clear but there were other acronyms (e.g., AAFF) that could not be deciphered.

The high microhabitat heterogeneity as represented in Figure 5 is reason to question the merit of using a small size sampling frame, when the alignment, angle of view, and presence/absence of vegetation on the hummock "sidewall" make it difficult to get consistent readings. In this particular frame, only half of the frame has hummock vegetation and the other half is devoid of vegetation between hummocks. It is possible that the hummock dimensions have changed, and any change in the size of "hummock heads" would obscure vegetation changes.

A recent study suggested that grazing increases the surface roughness of wetland habitat (Booth et al. 2015). This study included vegetation sampling at the Atlantic City Exclosure, both inside/outside of it, among six study sites. Booth et al. (2015) hypothesized that hummocked wetlands loose water more rapidly than non-hummocked wetlands. Curtailment of grazing as found in the Exclosure does not necessarily ameliorate roughness, but the increased biomass

within the Exclosure potentially draws greater quantities of water from the soil, while also losing greater amounts to evapotranspiration.

An earlier Colorado study sought to analyze hummock origin using all permutations of climate, soils, topography, soils and vegetation, and test whether there might be cases of hummock formation associated with freeze-thaw cycles apart from grazing (Smith 2011). Results were inconclusive. In an even earlier study, Bayer (1992) analyzed soils from six populations of *Antennaria arcuata*, four in Wyoming, and most sites were found to be high in organic content, ranging between 3-20%. Two of Bayer's four sites included the two Exclosure areas. High organic soils tend to accumulate at very slow rates, may be differentially prone to hummock formation with grazing, and may represent vestigial conditions of organic accumulation under colder climates.

Surveys of *Antennaria arcuata* in the BLM Pinedale FO, Wyoming documented peatland inclusions in *A. arcuata* occupied habitat, raising questions about whether or not the species is a relict species and even has the potential to colonize new habitat or recolonize suitable local habitat. Of the three spots where *A. arcuata* persists in the Exclosures, two are dryer than monitoring transects, and one in the northeastern corner of Gilespie Exclosure is wetter than monitoring transects, located near a spring. It is not known if *A. arcuata* can routinely produce viable seed, in which case its unique vegetative growth of stolons would constrain maintenance and spread of the species to the immediate vicinity of established plants.

When monitoring was replicated at the Atlantic City Exclosure in 1988, these results were interpreted to mean that *Antennaria arcuata* disappears in the absence of grazing. It definitely showed drastic decline in the exclosure over the first five years, and no rebound in the ensuing 25 years. The relocation of *A. arcuata* inside the exclosure seems more likely to represent trace vestiges of the local numbers than recolonization. There were pronounced hummocks before the exclosure was constructed, they have environmental changes associated with them in ameliorating competition, weather or climate conditions, and successional changes.

In order to better evaluate *Antennaria arcuata* long-term trends, population viability and species' vulnerability or resiliency, the following steps are recommended:

- Seek context on the completeness of the species composition list recorded in the 1988 dataset to determine whether or not the appearances of species since then mark changes to composition or just reflects taxa that were originally excluded.
- Seek 2013 *Antennaria arcuata* frequency transect data outside the exclosures for comparison with 1983 and 1988 frequency transect data to evaluate trends apart from the idle conditions inside the exclosures.
- Seek photo records and any other exclosure file records that provide context.
- Consult and exchange trend data with Idaho and Nevada land managers and botanists.
- Evaluate the merit and options for evaluating long-term trends of *Antennaria arcuate* in light of this pilot report and steps above.

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