

Abella SR. Cover-biomass relationships of an invasive annual grass, *Bromus rubens*, in the Mojave Desert. *Invasive Plant Sci Manag*

Supplementary Appendix S1. Descriptions of three study sites where equations were developed relating cover to aboveground biomass of an invasive annual grass, red brome (*Bromus rubens* L.), in the Mojave Desert, USA.

Grand Canyon-Parashant National Monument

The 424,000-ha Grand Canyon-Parashant National Monument, in northwestern Arizona, is a publicly held conservation area administered by the Bureau of Land Management and National Park Service. On the Bureau of Land Management portion, the study site (36°29'34"N, 114°0'29"W; elevation of 1,060 m) was within the 1,351-ha Jacob Fire, a July 2006 wildfire. The site burned at high severity, mostly eliminating shrub cover, which was previously dominated by creosote bush (*Larrea tridentata* (Sessé & Moc. ex DC.) Coville), blackbrush (*Coleogyne ramosissima* Torr.), Joshua tree (*Yucca brevifolia* Engelm.), and Nevada jointfir (*Ephedra nevadensis* S. Wats.). A weather station 30 km northwest of the site and at a lower elevation (480 m) reported averages of 18 cm year⁻¹ of precipitation and temperatures of -1/16°C (daily minimum/maximum) for January and 20/41°C for July (Mesquite, Nevada; National Oceanic and Atmospheric Administration, Asheville, North Carolina). Soil at the site developed from limestone parent material and is classified as loamy-skeletal, mixed, thermic, shallow Typic Paleorthids of the Yurm family (DeWall 2004). *Bromus rubens* data were collected at the site within a 5 m × 50 m area. Within this area, 72 quadrats (each 0.5 m × 0.5 m, 0.25 m²) were located 1.5 m from each other, positioned as three rows of 24 quadrats each. Each year, aboveground *B. rubens* material was harvested within a 0.50 m × 0.25 m (0.125 m²) area within each quadrat. The harvest area was rotated clockwise across years to avoid harvesting the same location in successive years.

Lake Mead National Recreation Area

The study site, which provided a controlled environment for *B. rubens* growth, was the experimental plant nursery within Lake Mead National Recreation Area (hereafter Mead), administered by the National Park Service. The nursery (36°03'30"N, 114°49'26"W, 381 m in elevation) is 16 km east of Las Vegas, Nevada. Vegetation surrounding the nursery was predominately *L. tridentata*-white bursage (*Ambrosia dumosa* (Gray) Payne) shrubland. Climate reported in Las Vegas included averages of 14 cm year⁻¹ of precipitation and temperatures of 1/14°C (daily minimum/maximum) for January and 25/40°C for July (McCarran Airport station at an elevation of 659 m; Western Regional Climate Center, Reno, Nevada). At the study site within a 20 m × 25 m (0.05 ha) area enclosed by a fence (1.25 m tall with mesh openings 0.6 cm in diameter and aluminum flashing to a height of 45 cm) to deter herbivory, 30 quadrats (each 2 m × 2 m) were randomly located at least 0.5 m apart. Soil within quadrats was excavated to a depth of 0.25 m and replaced with a standard mixture of sandy loam soil low in organic carbon (< 0.5%) typical of desert soils. In September 2009, *B. rubens* was broadcast seeded in quadrats at a density of 700 seeds/m² from collections around the site that exhibited 50% germination in greenhouse conditions (daily watering and constant 24°C temperature).

Goodsprings

The study site was 3 km north of the town of Goodsprings, Nevada on land administered by the Bureau of Land Management (35°51'03"N, 115°26'50"W; elevation 1,190 m). The site was in a broad valley and contained mature shrubland dominated by *L. tridentata*, *A. dumosa*, littleleaf ratany (*Krameria erecta* Willd. ex J.A. Schultes), Mojave yucca (*Yucca schidigera* Roezl ex Ortgies), and *Y. brevifolia*. Soil formed in alluvium from limestone and is classified as loamy, mixed, superactive, thermic, shallow Typic Petrocalcids of the Irongold series (Lato et al. 2006). A weather station 60 km southeast of the site but at a comparable elevation (1,079 m) reported averages of 20 cm year⁻¹ of precipitation and temperatures of 2/12°C (daily minimum/maximum) for January and 22/36°C for July (Searchlight, Nevada; 1914 through 2019 records; Western Regional Climate Center, Reno, Nevada). In May 2020, 30 quadrats (each 0.5 m × 0.5 m, 0.25 m²) were randomly located along a 100 m × 20 m transect in which *B. rubens* cover data and biomass were collected.

References

- DeWall AA (2004) Soil survey of Shivwits Area, Arizona, part of Mohave County. Washington, D.C.: U.S. Government Printing Office. 271 p
- Lato LJ, Merkler D, Lugo J, Harrington K (2006) Soil survey of Clark County area, Nevada. Washington, D.C.: U.S. Government Printing Office. 1801 p

Supplementary Appendix S2. Examples of cover classes and aboveground biomass of an invasive annual grass, *Bromus rubens*, at the Goodsprings site, Nevada, USA, in the Mojave Desert. A general site photo is below, with *B. rubens* constituting most of the beige-purplish senescing plant material. All photos by S.R. Abella, May 2020.





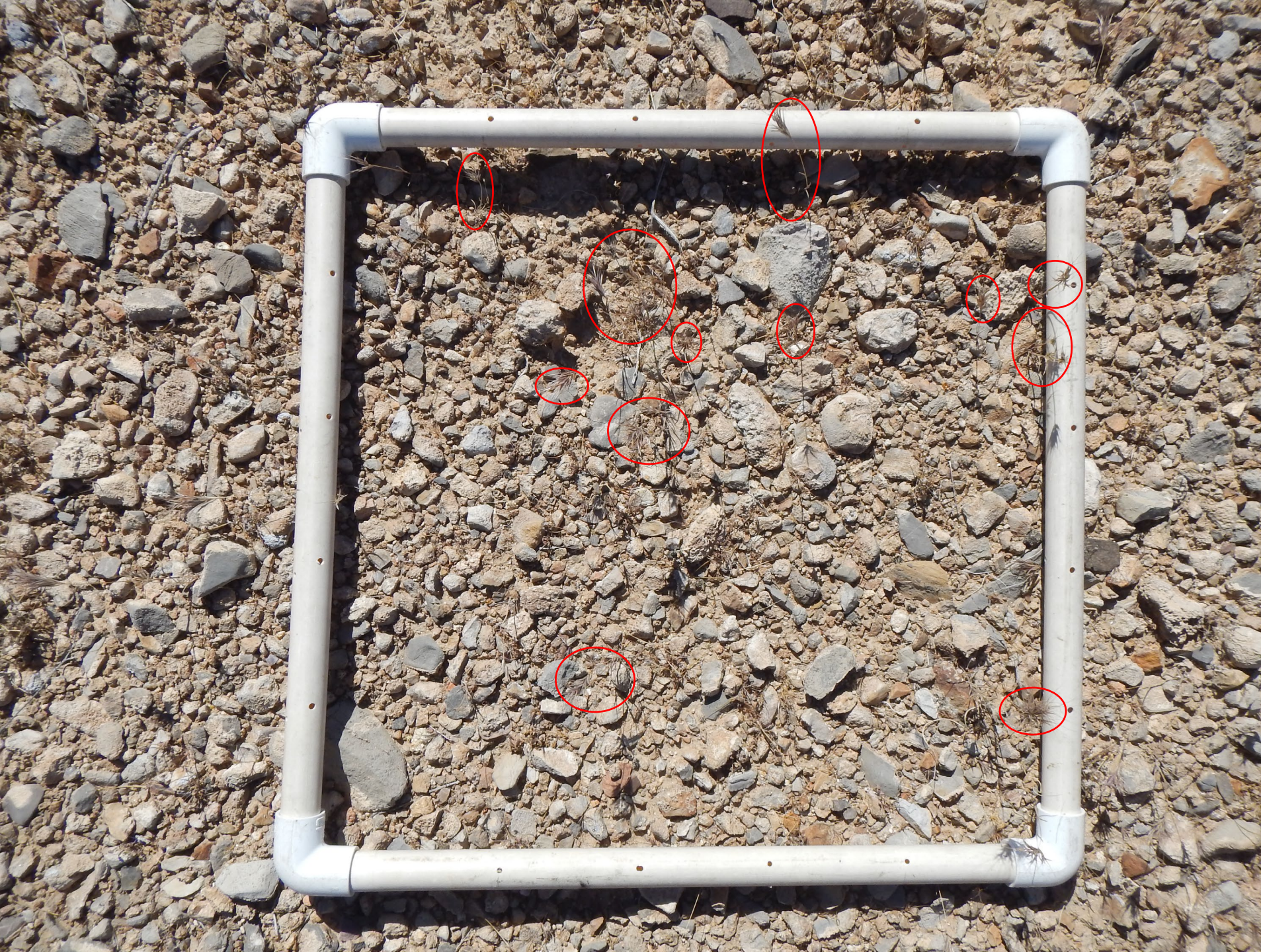
Bromus rubens

Cover: 0.1%

Biomass: 1.6 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#5 in Table S1)

For this low-cover
quadrat, *B. rubens*
individuals are circled.



Bromus rubens

Cover: 0.5%

Biomass: 2.8 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#9)

For this low-cover
quadrat, *B. rubens*
individuals are circled.



Bromus rubens

Cover: 1.5%

Biomass: 15.5 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#8)



Bromus rubens

Cover: 3.5%

Biomass: 42.4 g m⁻²

Quadrat is 0.5 m × 0.5 m

(#3)



Bromus rubens

Cover: 7.5%

Biomass: 78.3 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#25)



Bromus rubens

Cover: 17.5%

Biomass: 151.3 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#6)



Bromus rubens

Cover: 37.5%

Biomass: 178.1 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#10)



Bromus rubens

Cover: 62.5%

Biomass: 236.2 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#20)



Bromus rubens

Cover: 85%

Biomass: 320.6 g m⁻²

Quadrat is 0.5 m × 0.5 m
(#12)

Supplementary Table S1. Cover and aboveground biomass data of an invasive annual grass, *Bromus rubens*, for three sites (including three years at Parashant) in the Mojave Desert, USA.

2011		Parashant 2012		2013		Goodsprings		Mead	
Cover (%)	Biomass (g m ⁻²)	Cover (%)	Biomass (g m ⁻²)	Cover (%)	Biomass (g m ⁻²)	Cover (%)	Biomass (g m ⁻²)	Cover (%)	Biomass (g m ⁻²)
7.5	31.2	17.5	63.2	7.5	16.8	3.5	23.8	7.5	80.9
17.5	39.2	7.5	48.8	17.5	30.4	7.5	70.8	17.5	58.4
37.5	126.4	3.5	5.6	7.5	24.0	3.5	42.4	3.5	8.0
37.5	70.4	7.5	10.4	37.5	74.4	0.5	2.8	17.5	73.5
37.5	181.6	37.5	14.4	37.5	22.4	0.1	1.6	3.5	4.2
7.5	16.8	0.5	0.8	3.5	18.4	17.5	151.3	17.5	119.2
37.5	62.4	3.5	5.6	7.5	40.8	17.5	149.4	17.5	102.1
17.5	39.2	17.5	49.6	17.5	152.8	1.5	15.5	3.5	8.2
62.5	122.4	3.5	2.4	7.5	38.4	0.5	2.8	17.5	27.9
7.5	46.4	0.5	1.6	0.1	3.2	37.5	178.1	17.5	31.8
37.5	98.4	17.5	39.2	17.5	51.2	3.5	27.3	7.5	19.9
37.5	100.0	37.5	44.0	17.5	44.8	85	320.6	85	315.2
7.5	41.6	3.5	8.8	3.5	29.6	7.5	51.4	17.5	57.7
37.5	79.2	37.5	68.0	17.5	40.0	0.1	0.9	17.5	27.5
62.5	105.6	17.5	26.4	7.5	10.4	3.5	16.4	7.5	25.2
37.5	40.8	17.5	58.4	17.5	19.2	3.5	42.3	17.5	103.0
17.5	32.8	17.5	40.8	17.5	26.4	7.5	46.4	7.5	14.2
7.5	41.6	3.5	2.4	1.5	3.2	17.5	62.9	37.5	185.1
62.5	182.4	7.5	10.4	17.5	17.6	17.5	91.2	7.5	64.7
7.5	55.2	7.5	28.0	17.5	28.8	62.5	236.2	1.5	6.6
17.5	84.0	37.5	24.0	37.5	60.0	3.5	16.2	3.5	11.5
85	220.0	62.5	253.6	62.5	314.4	7.5	75.2	7.5	11.6
37.5	49.6	3.5	3.2	1.5	8.8	17.5	102.3	17.5	107.4
62.5	64.8	17.5	17.6	37.5	72.0	62.5	297.9	7.5	13.4
37.5	99.2	7.5	28.0	7.5	49.6	7.5	78.3	37.5	160.2
37.5	94.4	37.5	106.4	7.5	17.6	37.5	202.3	17.5	76.2
17.5	25.6	1.5	4.0	3.5	8.8	0.5	3.1	17.5	27.6
17.5	18.4	37.5	85.6	17.5	35.2	85	237.5	1.5	2.4
17.5	32.8	3.5	22.4	7.5	16.0	7.5	43.4	1.5	1.0
37.5	48.8	3.5	7.2	7.5	16.0	37.5	189.6	1.5	1.5
37.5	64.0	17.5	36.0	7.5	1.6				
37.5	59.2	17.5	16.8	37.5	79.2				
7.5	45.6	7.5	7.2	7.5	75.2				
7.5	40.8	7.5	16.8	37.5	113.6				
62.5	81.6	37.5	56.0	37.5	68.0				
37.5	76.8	1.5	0.8	1.5	3.2				
17.5	40.8	17.5	45.6	17.5	24.8				
7.5	87.4	3.5	22.4	7.5	14.4				
3.5	58.4	3.5	25.6	7.5	13.6				
85	237.6	62.5	72.8	62.5	85.6				
17.5	55.2	37.5	47.2	17.5	46.4				
17.5	48.0	1.5	3.2	3.5	13.6				
37.5	37.6	3.5	5.6	17.5	19.2				
17.5	73.6	1.5	3.2	1.5	1.4				
17.5	48.8	37.5	48.8	17.5	32.8				
7.5	86.4	3.5	3.2	3.5	4.0				
62.5	154.4	62.5	26.4	37.5	28.0				
37.5	26.4	17.5	11.2	17.5	38.4				
37.5	71.7	37.5	70.4	37.5	41.6				
17.5	86.4	7.5	17.6	17.5	32.8				
17.5	116.3	17.5	26.4	7.5	18.4				
62.5	51.2	37.5	103.2	37.5	68.0				
17.5	78.4	17.5	47.2	17.5	25.6				
7.5	71.2	1.5	2.4	0.1	0.8				
62.5	102.4	62.5	282.4	17.5	64.8				
37.5	41.6	37.5	58.4	7.5	26.4				
7.5	60.8	7.5	8.0	1.5	8.0				
37.5	60.0	3.5	7.2	7.5	36.0				
7.5	44.0	0.5	1.6	3.5	15.2				
17.5	49.6	1.5	0.8	3.5	9.6				
62.5	100.8	7.5	24.8	37.5	36.0				
3.5	8.0	1.5	4.0	1.5	1.6				
3.5	12.8	1.5	4.0	1.5	4.0				
17.5	21.6	7.5	14.4	3.5	8.0				
37.5	86.4	17.5	32.8	37.5	45.6				
7.5	34.4	7.5	11.2	3.5	9.6				
7.5	29.6	17.5	59.2	7.5	23.2				
7.5	121.0	3.5	23.2	7.5	97.6				
62.5	90.4	37.5	80.0	37.5	82.4				
7.5	26.4	1.5	1.6	3.5	15.2				
7.5	20.0	7.5	26.4	7.5	25.6				
37.5	48.8	37.5	259.2	17.5	65.6				