*Study area*

This study was conducted in Beef Basin, which is in San Juan County, Utah. It is in the Monticello District of the Bureau of Land Management (BLM), and located on the Colorado Plateau. It can be found just to the south of Canyonlands National Park, and to the north of the Abajo Mountains, which are also locally known as the Blue Mountains. Beef Basin is an area characterized by flat plains of deep sandy soil covered in grass, and interspersed and surrounded by shallow rocky outcrops with pinion pine and juniper. The average precipitation of the study area is approximately 20.5mm during the winter and 28.4mm during the summer, with the average winter temperature ranging from 5.4˚C to -7.7˚C, and average summer temperature ranging from 30.2˚C to 13.2˚C (1981-2010 PRISM data, Daly et al. 2008).

This study focused primarily on North Plain and South Plain which are the two southernmost plains in the basin, but a larger view of the whole basin was also conducted using data collected by and in collaboration with the United States Geological Survey (USGS). Recreation and cattle grazing are the primary uses for the area.

*Sampling design*

The North Plain and South Plain plots were selected using ArcGIS to randomly sample across the two basins based on the three dominant soil types (Begay, the Ignacio/Leanto complex, and Mido) (Utah AGRC) and 4 vegetation classes which were assigned using a quartile break based on September 2011 NDVI values (2011 NAIP 1m 4-band imagery from Utah AGRC). They were buffered a minimum of 50-m from roads, the edge of the study basins, and other sample points. The USGS plots were selected from the whole of Beef Basin using condition Latin Hyper Cube (cLHC). These selected plots were then subject to elimination or minor adjustment based on certain on the ground criterion. Sites had to be within one vegetation type, safely accessible (ie. not on a cliff face), and buffer requirements set above using ArcGIS were confirmed on the ground. A total of 99 plots were sampled within North Plain and South Plain, with an additional 37 USGS plots added to the dataset for a total of 136 sampled sites. 6 of the USGS plots were located within North Plain or South Plain. Sites were sampled from May to August in 2013. Additional sagebrush leaf samples were collected in early June 2014.

In 2013 line-point-intercept (LPI), shrub density, and soils data were collected from each site. Sagebrush leaf samples were collected from each site that had sufficient sagebrush from which to collect a viable sample. Five 30-m transects spaced 7-m apart were positioned parallel to the hillslope contour, with the middle transect centered 2-m above the soil pit. In the absence of a discernible slope, transects were oriented on an east-west axis with the center transect offset to the north. Plot photos were taken at the four cardinal directions and at the beginning and end of each transect. LPI was collected on all five transects beginning at 0.5-m and collected every half meter thereafter to the 30-m point, resulting in 60 points per line and 300 points per plot. Shrub density was collected in a 2-m belt, 1-m on either side of lines 1, 3, and 5. Each shrub was tallied and placed in one of five height classes: <15cm (Juvenile), <15cm (Mature), 15-50cm, >50-100cm, and >100cm. A soil pit was located at the center of each plot, and augered to the depth of bedrock or up to 2-m in depth. Where the soil was too rocky to use an auger, a sharpshooter was used to dig a soil pit. Sagebrush leaf samples collected were the interior winter persistent leaves, and not the exterior early ephemeral leaves. They were collected twice, once in 2013, and once in 2014. In 2013 leaves were collected and weighed at night between midnight and 5:30 a.m. Because of the limited timeframe and poor visibility only 16 viable sites were sampled. Where possible a total of four sagebrush were sampled at each plot, with ten leaves collected from each plant, otherwise all sagebrush present were sampled. Samples were kept on ice while transferred to the lab, and leaf area was measured within 12 hours of collection. They were then dried and measured again. From this the percent dry weight (PDW) in grams, and the specific leaf area (SLA) in centimeters was obtained. The 2014 leaves were collected during the day, dried, and weighed. They were then wrapped in a square of tin foil and ran through a LECOS machine which provided nitrogen and protein percentages for 67 sites.