Materials and Methods S1

List of published studies from which data were extracted. Drought, N addition, increased precipitation, wildfire, grazing, clipping, herbivory, buds, bud bank, bud density.

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**Table S1** The detail information for the 46 publications.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Country | Ecosystem | Moderator | Plant group | Bud type | Basis for classification | Degree/Amount/Concentration | Effect/observation | Reference |
| Southern Brazil | Grassland | Fire | Ungrouped grassshrub | Ungroup bud | Number of fire | 1 | The study showed a decrease in bud bank size in the absence of fire. | Fidelis et al., 2014 |
| Kansas, USA | Tallgrass Prairie | Fire | Ungroupedgrassshrub | Rhizome bud | Number of fire | 3 | The bud bank density in the unburned prairie was significantly lower than aboveground stem densities. | Benson et al., 2004 |
| South African | Tropical savannas | Fire | Grass, forb, shrub | Ungroup bud | Number of fire | 1, 3, 7, 16, 20 | Lower fire frequency was expected to reduce the bud bank density. | Bamboo et al., 2022 |
| South African | Tropical savannas | Fire | Ungrouped | Ungroup bud | Number of fire | 1, 3, 7, 16, 20 | The total bud bank increased at a lower frequency. | Bamboo et al., 2022 |
| Paraguay | Forest | Fire | Ungrouped | Ungroup bud | Number of fire | 1 | In the fire-degraded stand, the density of resprouts increased. | Kammesheidt, 1999 |
| China | Typical steppe grassland | Fire | Ungrouped | Rhizome budtiller bud ungroup bud | Number of fire | 1 | Fire significantly increased bud bank density. | Zhao et al., 2017 |
| Argentina | Forage grass | Fire | Grass | Ungroup bud active buddormant bud, dead bud | Number of fire | 1 | Controlled burning with high fuel loads can severely reduce bud viability in S.tenuis. Plants located in areas of lighter fuel accumulation. | Busso et al., 1993  |
| Texas, USA | Semi-arid savanna | Fire | Grass shrub | Ungroup bud active buddormant buddead bud | Fire frequency | Low, High | Fire energy directly affects bud activity and mortality through soil heating for these two species. | Hiers et al., 2020 |
| La Pampa, Argentina | Perennial grasses | Fire | Grass | Ungroup bud active bud dormant bud dead bud | Number of fire | Low, High | Tillers of plants exposed to fire had more dead buds and fewer metabolically active buds than the tillers of control plants. | Pelaez et al., 1997 |
|  Montana, USA | Semi-arid mixed grass prairie | Fire | Grass | Active bud, dormant bud | Number of fire | 1 | Fall and summer fires reduced total buds per tiller by about 70%. | Russell and Vermeire, 2014 |
|  Montana, USA | Semi-arid mixed grass prairie | Fire | Grass | Active bud, dormant bud, dead bud | Number of fire | 1 | Season of fire directly manipulated bud activity, dormancy, and mortality.  | Russell et al., 2015 |
|  Montana, USA | Semi-arid mixed grass prairie | Fire | Grass | Active bud | Number of fire | 1 | H. comata bud mortality increased immediately following the prescribed fires for summer and fall. | Russell et al., 2019 |
| Southern Brazil | Grassland | Fire | Forbshrub | Ungroup bud | Fire frequency | High | The bud bank of E. ligulaefolium tended to be larger in excluded sites. V. flexuosa showed a larger bud bank in frequently burned sites. | Fidelis et al., 2010 |
| Kansas, USA. | Konza prairie | Fire | Forb | Ungroup bud | Fire frequency | Low | Plants from sites not burned for many years produced 50% more stems than plants from recently burned sites. | Hartnett, 1991 |
| Alberta, Canada | boreal forest | Fire | Grass | Ungroup bud | Fire frequency | Low, High | Vegetative bank assemblages significantly differed between unburned and burned patches but not between lightly and intensely burned patches. | Lee, 2004 |
| Kansas, USA | Perennial grasses | Grazing | Grass | Ungroup bud | Livestock number | 0.06/ha | Grazing decreased grass bud banks compared to ungrazed prairie. | Dalgleish and Hartnett, 2009 |
| Inner Mongolia, China | Perennial bunchgrass | Grazing | Grass | Ungroup bud rhizome bud tiller budroot sprouting bulb bud | Livestock number | 6/ha, 12/ha, 18/ha, 24/ha, 30/ha, 36/ha | The belowground bud bank seems to be tolerant of grazing. | Qian et al., 2017 |
| Inner Mongolia, China | Perennial bunchgrass | Grazing | Grass | Rhizome bud tiller budungroup bud | Livestock number | 6/ha, 12/ha, 18/ha, 24/ha, 30/ha, 36/ha | Species that rely on rhizomes and bulb buds for population regeneration are more sensitive to grazing. | Qian et al., 2017 |
| Loess Plateau, China | Temperate grassland | Grazing | Ungroupedgrassforb | Ungroup bud | Livestock number | 2-3.5/ha | Long-term grazing exclusion significantly increased plant buds and bud bank size. | Zhao et al., 2019 |
| Loess Plateau, China | Typical steppe | Grazing | Ungrouped | Rhizome bud tiller bud root sprouting bud | Livestock number | 2-3.5/ha | Grazing significantly decreased tiller bud bank density. | Zhao et al., 2017 |
| Loess Plateau, China | Grassland | Grazing | Ungroupedgrassforb | Rhizome bud tiller budroot sprouting budungroup bud | Livestock number | 4.6/ha | Compared with grazing, short-term closure significantly increased the total bud bank density and the density of grass bud bank but significantly decreased the density of non-grass bud bank. | Cui et al., 2017 |
| Kansas, USA. | Tallgrass prairie | Grazing | Grassforb | Ungroup bud | Clipping ration  | 42% | Grazing affects their (buds and rhizomes) growth and survival. | VanderWeide and Hartnett, 2015 |
| Northeastern, China | Grassland | Grazing | Ungrouped | Ungroup bud | Clipping ration  | 40% | Simulated moderate grazing increased the bud density of ramets across the years by 52%. | Wang et al., 2021 |
| Dongting Lake, China | Wetland | Grazing | Grass | Ungroup bud, tiller bud | Clipping ration  | Low, High | Compared with the control, bud bank density decreased significantly under HSC. | Chen et al., 2020 |
| Dongting Lake, China | Wetland | Grazing | Grass | Rhizome bud | Clipping ration  | Low | The density and biomass of rhizome buds did not decrease significantly in response to repeated defoliation. | Chen et al., 2016 |
| Texas, USA | Semiarid perennial grasses | Grazing | Grass | Active bud, dormant bud | Livestock number | High | The grazing history of the communities from which the buds were collected did not substantially affect the number of axillary buds. | Hendrickson and Briske, 1997 |
| Kansas, USA. | Tallgrass prairie | Grazing | Grassforb | Ungroup bud | Clipping ration  | 42% | Grazing reduced grass buds per shoot from approximately 7.5 to 5 buds per shoot. | VanderWeide and Hartnett, 2015 |
| South Dakota, USA | Grassland | Grazing | Grass | Ungroup bud | Clipping ration  | Mediate | Clipped tillers had significantly lower numbers of propagules than unclipped tillers. | Ott et al., 2017 |
| Northeastern, China | Grassland | Grazing | Grass | Ungroup bud | Clipping ration  | 50% | Moderate clipping intensities significantly increased the total number of juvenile tillers and buds. | Yuan et al., 2019 |
| Argentina | Perennial bunchgrass | Grazing | Grass | Ungroup bud active buddormant bud, dead bud | Clipping ration  | 50% in 1, 2, 3, 4 or 5 defoliations | The total number of axillary buds per stem base was similar in all defoliation frequencies. | Busso et al., 2011 |
| Argentina | Perennial bunchgrass | Grazing | Grass | Ungroup bud active bud dormant bud dead bud | Clipping ration  | Mediate | Plants of both species that have defoliated late or after internode elongation had a greater number of respiratory inactive buds than undefoliated plants. | Busso et al., 1997 |
| Utah, USA | Bunch grass | Grazing | Grass | Ungroup bud | Clipping ration  | 85% | Long periods of defoliation resulted in reduced tiller number, probably by causing inactivation of axillary buds. | Busso et al., 1989 |
|  Inner Mongolia, China | Steppe | Grazing | Grassforb | Ungroup bud | Clipping ration  | Mediate | Mowing had no significant effect on bud number. | Zhang, 2014 |
| Qinghai-Tibetan Plateau, China | Alpine Meadows | Grazing | Grass | Rhizome bud tiller bud ungroup bud | Clipping ration  | Low | This study showed that disturbance by plateau pikas increased tiller bud number and rhizome bud number per clonal fragment. | Wang et al., 2020 |
| China | Alpine Meadows | Grazing | Ungrouped grass | Rhizome bud tiller bud | Herbivore number | Low | Disturbance by the plateau pika increased the belowground bud density of graminoids but did not affect forbs bud density. | Wang et al., 2018 |
| Inner Mongolia, China | Temperate semiarid steppe | N addition | Ungrouped | Rhizome bud tiller bud roots prouting bulb bud ungroup bud | Amount of N addition | 10g/m2 | In addition, it decreased total bud density but facilitated aboveground productivity, and buds of grasses and forbs responded in the opposite way. | Qian et al., 2021 |
| China | Degraded grasslands | N addition | Grass | Ungroup bud | Amount of N addition | 10g/m2 | N addition increased the bud density of Leymus chinensis ramets by 98 %. | Wang et al., 2021 |
| Inner Mongolia, China | Steppe | N addition | Ungrouped | Rhizome bud tiller bud root sprouting bulb bud ungroup bud | Amount of N addition | 10g/m2 | N addition increased the density of the root sprouting bud and decreased the density of the bulb bud. | Zhang, 2014 |
| Inner Mongolia, China | Desert | N addition | Shrub | Ungroup bud dormant bud | Amount of N addition | 12mmol/L,24mmol/L,36mmol/L,48mmol/L,60 mmol/L | N addition significantly increased the number of total buds and significantly reduced the number of dormant buds. | Zhang et al., 2018 |
| Inner Mongolia, China | Desert | N addition | Shrub | Ungroup bud dormant bud | Amount of N addition | 12g/m2,24g/m2,49g/m2,73g/m2,98g/m2, 122g/m2  | Nitrogen addition significantly increased the bud number of Nitraria tangutorum seedlings and significantly decreased the number of dormant buds. | Zhang, 2017  |
| Inner Mongolia, China | Steppe | N addition | Grassforbshrub | Ungroup bud | Amount of N addition | 10g/m2 | N addition increased the tiller bud density of Stipa krylovii and the root sprouting bud of Potentilla tanacetifolia. | Zhang, 2014 |
| China | Grassland | N addition | Grassforb | Rhizome bud tiller bud ungroup bud | Amount of N addition | 10g/m2 | N addition increased the total bud density of Leymus chinensis by 284.22% and Lespedeza daurica by 57.55%. | Xing, 2019 |
| Kansas, USA. | Tallgrass prairie | N addition | Grass | Ungroup bud | Amount of N addition | 10g/m2 | Nitrogen addition significantly impacted bud bank demography in two subdominant species. | Dalgleish et al., 2009 |
| Kansas, USA. | Tallgrass prairie | Drought | Grass | Ungroup bud | Amount of rainfall intercepted | 886mm | Bud bank density was insensitive to drought. | VanderWeide et al., 2014 |
| Kansas, USA. | Tallgrass prairie | Drought | Grassforb | Ungroup bud | Amount of rainfall intercepted | 408mm |  drought reduced the bud bank density of all taxonomic groups. | VanderWeide and Hartnett, 2015 |
| south-central Nebraska, USA | Restored grasslands | Drought | Grassforb | Ungroup bud | Amount of rainfall intercepted | 629mm | Drought reduced below-ground bud bank density. However, bud bank density recovered, and bud production was higher on previously droughted subplots relative to controls in the year following drought. | Carter et al., 2012 |
| Inner Mongolia, China | Grasslands | Drought | Grass | Ungroup bud | Proportion of rainfall intercepted | 66% | drought reduced belowground bud density. However, drought had no significant influence on belowground buds of the dominant plant growth form in each community. | Qian et al., 2022 |
| Kansas, USA. | Tallgrass prairie | Drought | Grassforb | Ungroup bud | Amount of rainfall intercepted | 408mm | grass bud density remained constant across all drought treatments. Meanwhile, sedge and forb bud density was reduced by drought. | VanderWeide and Hartnett, 2015 |
| Kansas, USA. | Tallgrass prairie | Drought | Grass | Ungroup bud | Amount of rainfall intercepted | 886mm | The number of buds per shoot did not differ among treatments. | VanderWeide et al., 2014 |
| Utah, USA | Bunch grass | Drought | Grass | Ungroup bud | Amount of rainfall intercepted | 368mm, 555mm, 675mm | 6-33% (mean=22%) of the bud pool was active in the drought treatment. | Busso et al., 1989 |
| Bahia Blanca, Argentina | Perennial grass | Drought | Grassforb | Ungroup bud active bud dormant bud | Amount of rainfall intercepted | 200mm | Axillary bud activation is lower under water stress than under higher soil moisture conditions in Stipa clarazii, Stipa tenuis, and Stipa gynerioides. | Flemmer et al., 2002 |
| Northeastern, China | Perennial grass | Drought | Grass | Rhizome bud tiller bud | Proportion of rainfall intercepted | 50%, 70% | Drought decreased the bud bank density by 56%. In addition, drought induced a bud allocation change that decreased by 41% the proportion of buds that developed into shoots and a 41% increase in the buds that developed into rhizomes. | Wang et al., 2019 |
| Northern, China | Temperate grassland | Drought | UngroupedGrassforb | Ungrouped | Proportion of rainfall intercepted | 66% | Belowground bud density was lowest at the highest aridity site for the entire community. Belowground bud density was the lowest for grasses at the high aridity site but the highest for forbs at this site. | Qian et al., 2023 |
| Northern, China | Temperate grassland | Drought | Ungrouped | Ungrouped | Proportion of rainfall intercepted | 100% | Drought increased tiller abundance in the first treatment year and reduced bud banks by the fourth treatment year across grasslands. | Luo et al., 2023 |

Table S2 Basis for the classification of the degree of each moderator.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Moderator | Basis of ranking | Low | Mediate | High |
| Wildfire | Number of wildfires | ≤5 | 5-10 | ≥10 |
| Grazing | Livestock per hectare Clipping proportion  | ≤10/ha≤30% | 10-30/ha30-50% | ≥30/ha≥50% |
| N addition | Amount Concentration | ≤20g/m2≤ 20 mmol/L-1 | 20-50g/m220-40mmol/L-1 | ≥50g/m2≥40mmol/L-1 |
| Drought | Amount of rainfall interceptedProportion of rainfall intercepted | ≤ 200mm ≤30% | 200-500 mm30-60%  | ≥ 500 mm≥60%  |