Cottonwood Restoration & Monitoring in the Upper Missouri River Breaks National Monument

2019 Cottonwood Monitoring Report

This report was prepared by the Friends of the Missouri Breaks Monument on behalf of NorthWestern Energy. During the summer of 2019, the Friends of the Missouri Breaks Monument (FMB) monitored and assessed the eight cottonwood planting sites located throughout the Upper Missouri River Breaks National Monument (UMRBNM). The following report explains project rationale, methods, and findings.

Friends of the Missouri Breaks Monument
Submitted November 2019

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Project Overview

Why do we need to plant cottonwoods?

Cottonwood trees are an iconic and keystone species throughout the Missouri River watershed. They provide critical habitat and food for birds and wildlife, and their presence is directly associated with higher species richness and overall biodiversity.[1] Cottonwood roots help stabilize river banks during high and erosive flows. Thick trunks and branches also offer windbreaks, shelter, and shade for travelers; from the native tribes that roamed the northern Great Plains, to the explorers of the Lewis and Clark expedition, to present-day recreationalists paddling the Upper Missouri River Breaks National Monument (UMRBNM).

Bald eagles are frequently seen nesting in cottonwood trees. Here, two chicks poke their heads out of a nest in the UMRBNM.

Photo Credit: Taylor Mudford

The dependence of the monument's ecosystems on cottonwoods is similar to the overall dependence cottonwoods have on river conditions for completing their life cycle. Cottonwood regeneration is highly reliant on spring flooding, as the trees' reproductive strategies depend upon bare alluvial soil for successful germination of their seeds.[4]

Unfortunately due to the modification of natural flow regimes in the UMRBNM (the magnitude of peak flows has been reduced 40% by upstream dams[2]) cottonwoods are no longer regenerating at a sustainable rate. Approximately 62% of cottonwood trees are over 60 years old, and only 14% have been established in the last 25 years.[3] In addition, there are very few areas suitable for natural establishment.[2] If the current trend of dying cottonwoods is left unchecked, wildlife that depends upon them for habitat will be lost and much of what makes the UMRBNM a naturally wonderful place will vanish.

In an effort to mimic natural regenerative forces the Friends of the Missouri Breaks Monument, in partnership with the Bureau of Land Management (BLM), has been planting plains cottonwood (*Populus deltoids,* subsp. monilifera). Since 2013 we have planted 645 cottonwood cuttings within imperiled riparian zones along the Wild and Scenic stretch of the Missouri River. By planting and tending to cottonwood saplings in the UMRBNM we hope to establish the future generation of thriving cottonwoods.

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Why is it important to monitor cottonwood restoration?

Monitoring the mortality of our cottonwood plantings on short and long time-scales is an imperative way to evaluate project success, justify program costs, and assess future planting sites. Ecosystems are complex and sensitive. They typically change on slower time-scales, and monitoring them can alert us to future problems and trends – leading to more adaptive management.

Throughout the summer of 2019 the Friends of the Missouri Breaks Monument (FMB) conducted the first thorough monitoring assessment of cottonwood trees at our eight planting sites. Our 2019 Big Sky Watershed Corps members, Lacey Gunther and Tori Hill, were in charge of developing and implementing the assessment.

Top: Tori Hill (left) and Lacey Gunther (right), Big Sky Watershed Interns for the Friends.

Bottom right: Lacey and volunteer McKenzie Schessl measure and record tree height.

Bottom left: Tori measures the DBH of a young cottonwood planting.

Photo Credits: Lacey Gunther

Although FMB gathered tree mortality data in 2017, the 2019 monitoring assessment was the first time that information was assembled beyond whether a tree was alive or dead. Our 2019 BSWC members collected quantitative and qualitative data on 549 cottonwood plantings, which were identified by the presence of restoration materials including a protective wire cage and PVC pipe for watering. Each planting was determined to be dead or alive, and tree height, caliper, and diameter at breast height (DBH) were measured. Additionally, the presence and type of invasive species and/or pests were noted. For a more detailed explanation of what data was collected, please see methods (below).

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Monitoring Methods

Quantitative Data Collected

- **GPS Coordinates** – each tree's location was mapped and recorded with a Garmin GPS unit.
- **Tree Height** – length of tree from ground/base to top tips of leaves or branches. Measured with height staff or measuring tape for dead and alive trees.
- **Tree Caliper** – the diameter of the trunk at 1ft above the ground/base. Measured with diameter tape. Only recorded for live trees.
- **Diameter at breast height (DBH)** – the diameter of the trunk at 4.5ft above the ground/base. Only recorded for live trees which measured >4.5ft tall.
- **Tree Numbers** – all live trees were given a tree tag with a unique ID number, which will help track growth for individual trees.

Qualitative Data Collected

- **Tree Vigor Rating** – cottonwood plantings were assessed for their mortality and vigor, determined to be dead or alive, and then rated on a scale of 0-4.
  - 0: Missing – tree is absent but previous presence was detected by old restoration materials (typically PVC pipe).
  - 1: Dead – tree is dead, no leaves. Inner cambium bark is also dead when cut into (no green present).
  - 2: Poor – tree is struggling to survive, observable by signs such as sparse crown density, grazing or pest damage, a majority of dead branches with no leaves, the presence of chlorotic (yellow or orange) and necrotic (brown, black) leaves that indicate desiccation, and heavy competing vegetation that is threatening to overrun the planting.
  - 3: Average/Fair – tree has normal crown density, majority of branches are alive, and leaves are in decent condition with minimal signs of desiccation or pest damage.
  - 4: Great – tree is thriving, with dense crown density, above average height and caliper compared to the surrounding plantings, and minimal dead bark or branches.
- **Crown Density** – a visual assessment of how dense the leaf canopy is (i.e. how much light is being let through).
  - Sparse – tree is generally lacking leaf cover with several dead branches; two trunks are present but only one has leaves.
  - Normal – tree has an average amount of leaf canopy.
  - Dense – tree has lots of leaves that create a thick canopy.

- **Competing Vegetation** – the presence of competing vegetation and invasive plant species (within or close to the protective wire cage around each planting) which may be competing for sunlight, water, etc. were identified and recorded.

Left: a dead planting is overrun by competing vegetation.

Right: Leafy spurge and Russian knapweed cozy up to an otherwise healthy cottonwood sapling.

Photo Credits: Lacey Gunther

Common invasive species identified at planting sites:

- Leafy spurge
- Russian and spotted knapweed
- Canada thistle
- Cocklebur
- Russian Olive
- Sweet Clover

- **Pests** – insect presence or damage was recorded (sometimes observed as holes or spotting in leaves). Ants were the most common insect observed, however their presence is not thought to be particularly harmful. See photos below.

- **Necrotic and Chlorotic Leaves** – dead or dying leaves were noted. See photo below.

Left: unidentified grubs on a cottonwood leaf.

Top right: ants (feeding on aphids) on a cottonwood planting.

Bottom right: a necrotic (dead) cottonwood leaf.

Photo Credits: Lacey Gunther

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Research Findings

Summary of Monitoring Data

Since 2013 the Friends of the Missouri Breaks Monument have planted 645 cottonwood trees across eight planting sites. Our Big Sky Watershed Corps members, with the generous help of summer volunteers, **monitored and assessed 549 plantings** total throughout the field season.

Left: volunteers David Gans, Steve Berkram, and John McEwen plant a new cottonwood cutting during the 2019 fall planting event.

The PVC pipe will be used to water plantings in the summer, and the wire cage will protect young trees from being grazed on by cattle or wildlife.

Photo Credit: Alexander Newby

As of summer 2019 **the average cumulative survival rate across our eight planting sites is 54%.** This has decreased considerably from the survival rating collected in 2017, which was 79.5%. Tree mortality rates varied across the eight planting sites, with some doing well (75% of trees still alive at Little Sandy) and others faring less fortunately (only 32% still alive at Terry Ranch and Dark Butte). Table 1 showcases survival rates for each site.

Planting Site	Planting Date	Trees Planted	Trees Alive (as of Winter 2017)	Trees Alive (as of Summer 2019)	Cumulative Survival Rate
Judith Landing	Mar-13	30	21	19	63%
Dark Butte	Mar-14 & Mar-15	100	59	32	32%
ABN Ranch	Mar-15	65	54	43	66%
Eagle Creek	Mar-16	89	74	56	63%
Slaughter River	Mar-16	64	62	40	63%
Little Sandy	Mar-17	77	66	58	75%
Terry Ranch	Apr-17	71	56	23	32%
Bailey Hazlewood	May-18	149	N/A	57	38%
Total/Average:		**645**	**392**	**328**	**54%**

Table 1: Cumulative Survival Rates for Planting Sites

FMB monitored 549 trees, but over the last 6 years we have planted 645. What happened to the other trees? The 96 trees that were unable to be located are presumed dead – with possible scenarios being 1) they were planted too close to the river and subsequently scraped away by ice flows, or 2) restoration materials were removed previously from dead trees and any remaining evidence was overgrown with vegetation and hidden from sight.

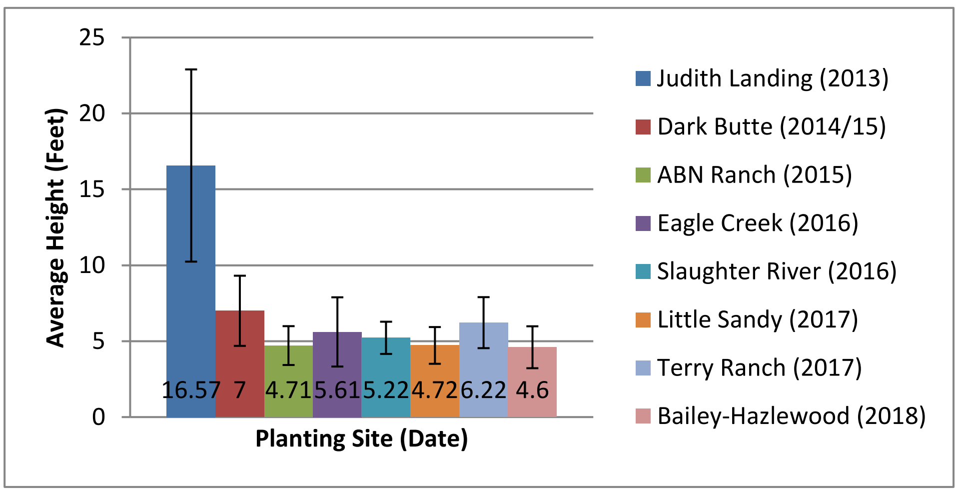
How are the trees faring?

Because baseline monitoring data (ex. height of the planting) was not collected when cottonwood cuttings were initially planted, we are unfortunately unable to calculate accurate growth rates. Instead, we have compared living tree measurements from site to site. The table and graphs below showcase our findings, with Judith Landing (our oldest planting) expectably having the largest trees.

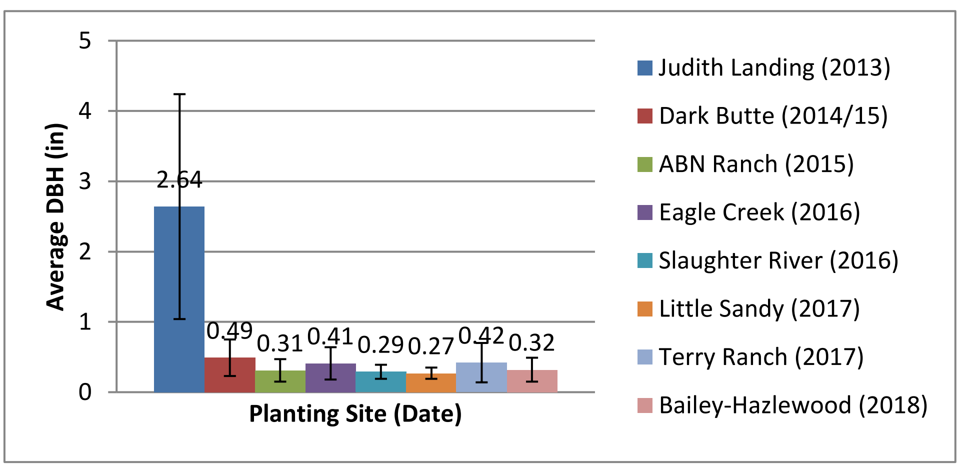
Planting Site	Average Height (feet)	Average Caliper (in)	Average DBH (in)
Judith Landing (2013)	16.57	3.52	2.64
Dark Butte (2014/15)	7	0.98	0.49
ABN Ranch (2015)	4.71	0.62	0.31
Eagle Creek (2016)	5.61	0.74	0.41
Slaughter River (2016)	5.22	0.67	0.29
Little Sandy (2017)	4.72	0.6	0.27
Terry Ranch (2017)	6.22	0.83	0.42
Bailey-Hazlewood (2018)	4.6	0.56	0.32

Table 2: Average Height, Caliper, and DBH

There is a significant difference in height and DBH between Judith Landing (planted 2013) and all other planting sites, shown in the graphs below.



Graph 1: Average height (measured in feet) by planting site.



Graph 2: Average DBH (measured in inches) by planting site.

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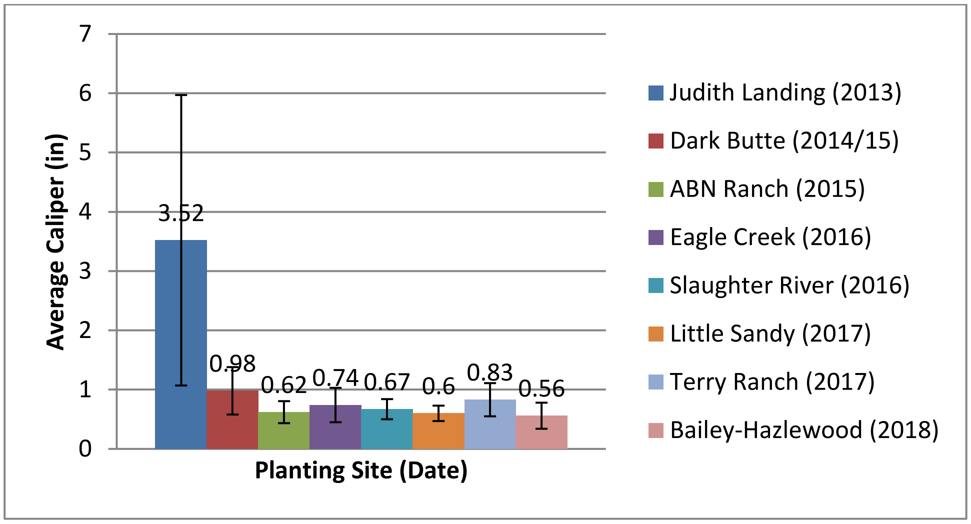
Judith Landing also had the significantly largest tree caliper compared to the majority of our planting sites, with the exceptions of the Dark Butte (planted 2014/15) and, surprisingly, Terry Ranch (2017) planting sites.



Graph 3: Average tree caliper (measured in inches) by planting site.

Unexpected Results

Given the tree height and size of cottonwood plantings at Judith Landing, which are 6 years old, we expected to find a somewhat step-wise decrease in height, DBH, and caliper among the other planting sites. This was not the case. With the exception of Judith Landing, none of the planting sites had significantly different tree height, DBH, or caliper from each other. Dark Butte, the second oldest planting site, had higher caliper, height, and DBH, but it was not significantly different from younger sites. Future monitoring efforts will keep a closer eye on Dark Butte to see if the plantings gain significant height in the next 1-2 years.

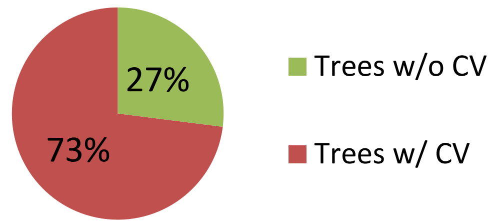
Cottonwoods are one of the fastest growing trees in North America, but one possible explanation for why we aren't seeing larger differences among the younger planting sites is related to root development. Because we plant cottonwoods as pole cuttings, they have to grow their root systems first to access water and nutrients before devoting more energy to above-ground growth. This helps anchor and stabilize them and ensures that future growth will be supported. We would expect to see more above-ground growth after 2-3 years. Additionally, pole cuttings ranged in size (height and caliper) when initially planted.

Left: Volunteers plant a cottonwood pole cutting at the 2019 planting event.

Photo Credit: Alexander Newby

Competing Vegetation (CV) and the Presence of Invasive Species

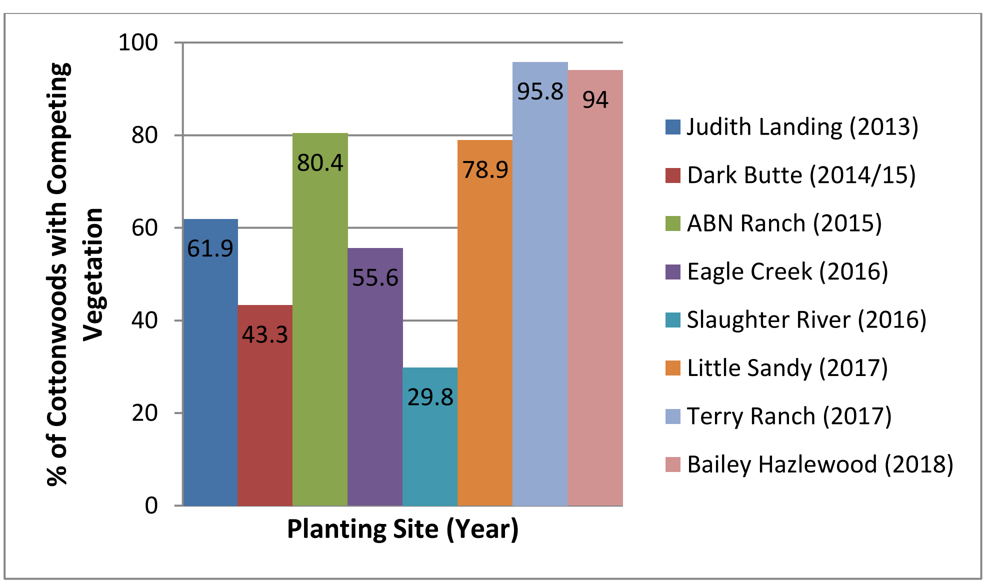
While surveying cottonwood plantings and collecting measurements, our field team noted the presence of competing vegetation. When possible, invasive plant species were identified and recorded. Competing vegetation (noted as CV in the following graphs and tables) was the most common qualitative observation we made at planting sites, **occurring at 73% of cottonwood plantings.**



Planting Site	# Trees Monitored	# Trees w/o CV	# Trees w/ CV	% Trees w/ CV
Judith Landing (2013)	21	8	13	61.9%
Dark Butte (2014/15)	67	38	29	43.3%
ABN Ranch (2015)	51	10	41	80.4%
Eagle Creek (2016)	72	32	40	55.6%
Slaughter River (2016)	47	33	14	29.8%
Little Sandy (2017)	71	15	56	78.9%
Terry Ranch (2017)	71	3	68	95.8%
Bailey Hazlewood (2018)	149	9	140	94.0%
Total/Average	**549**	**148**	**401**	**73.0%**

Table 3: Competing vegetation (CV) across all planting sites

Planting sites with the highest occurrences of competing vegetation were 1) Terry Ranch, 2) Bailey Hazlewood, and 3) ABN Ranch. These planting sites are all located on private property. The other planting sites are located at primitive and developed BLM campgrounds, which may be influenced by BLM weed control measures (they typically treat most campgrounds with herbicides once per year).



Graph 4: Percentages of trees with competing vegetation by planting site.

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What were the most common invasive species present?

Leafy spurge (*Euphorbia esula)* was the most common invasive plant (also known as a noxious weed) that FMB encountered throughout the summer field season, **found at 40% of cottonwood plantings**. Leafy spurge is considered a Priority 4 weed species by the BLM, meaning it is abundant and widespread in the UMRBNM. Management criteria will require containment and long term management. Out of the 401 cottonwood plantings with competing vegetation present, it was present at 55% of them.

Top right: a close-up of leafy spurge.

Left: Cottonwood plantings at Bailey Hazlewood planting site are accompanied by a thick field of leafy spurge. A Russian olive tree (also nonnative) stands in the background.

Photo Credits: Lacey Gunther

Other common invasives were Russian knapweed (*Centaurea repens*), spotted knapweed (*Centaurea stoebe),* Canada thistle (*cirsium arvense*), sweetclover (*melilotus officinalis*) and wild licorice (*Glycyrrhiza lepidota*). With the exception of cheat grass, invasive grasses were not identified to species, however many are present throughout the UMRBNM.

Left: Wild licorice *Middle: Russian knapweed* *Right: Canada thistle*

Photo Credits: Lacey Gunther

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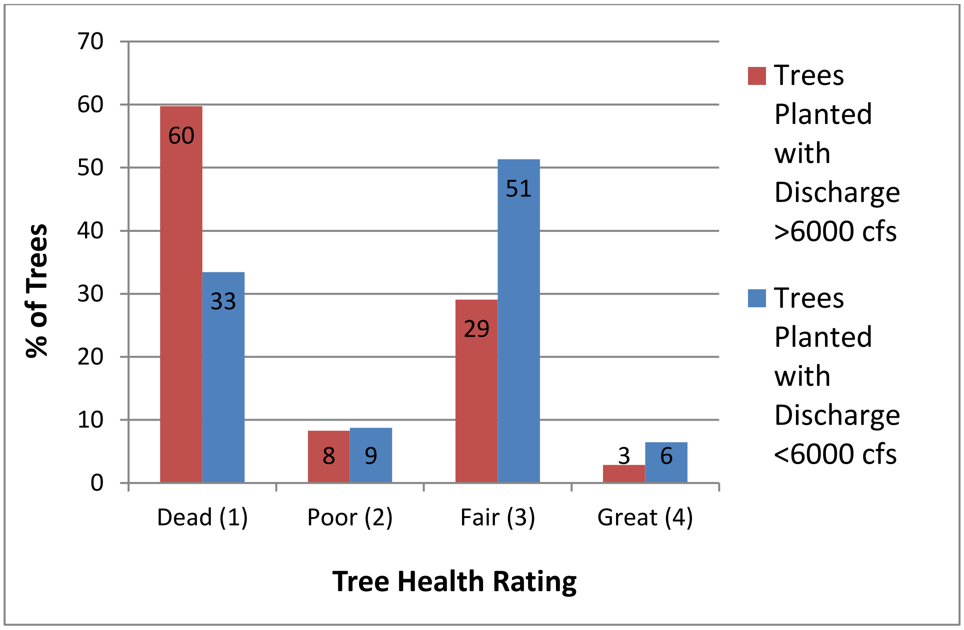
Discharge Data

The window to plant cottonwoods is a narrow one due to ice breakup and cottonwood bud break. If it's too early, ice and blown out roads make planting sites impossible to access. If it's too late in the year, the plantings will invest the majority of their energy into growing new leaves instead of roots, leading to increased mortality. Additionally, it appears that when trees are planted during months with higher discharge (flows in cubic feet per second) related to spring snowmelt, they have higher mortality rates.



Graph 5: Tree survival when planted during high (>6000 cfs) vs. low (<6000 cfs) monthly flows.

Planting Site	Planting Month-Year	Monthly Discharge (cubic ft/sec)	% of Trees dying per year
Bailey Hazlewood	18-May	23420	61.7%
Little Sandy	17-Mar	5635	12.3%
Terry Ranch	17-Apr	8247	33.8%
Slaughter River	16-Mar	4616	12.5%
Eagle Creek	16-Mar	4616	12.4%
ABN Ranch	15-Mar	6169	8.5%
Dark Butte	Mar-15/14	6169/7670	17.0%
Judith Landing	13-Mar	5478	6.1%

Table 4: Monthly discharge during time of planting and annual tree mortality rate. Discharge data provided by USGS National Water Information System, taken at the Fort Benton gage.

Bailey Hazlewood (2018), experienced an unprecedented die-off following the first year, with 61.7% of trees dying. It also coincided with extremely high flows greater than 23,000 cfs (taken at the Fort Benton gage), which was nearly 13,000 cfs greater than the 30-year mean for the month of June. When trees were planted several holes already had water in them, and we strongly believe that the above-average flows caused the unprecedented mortality.

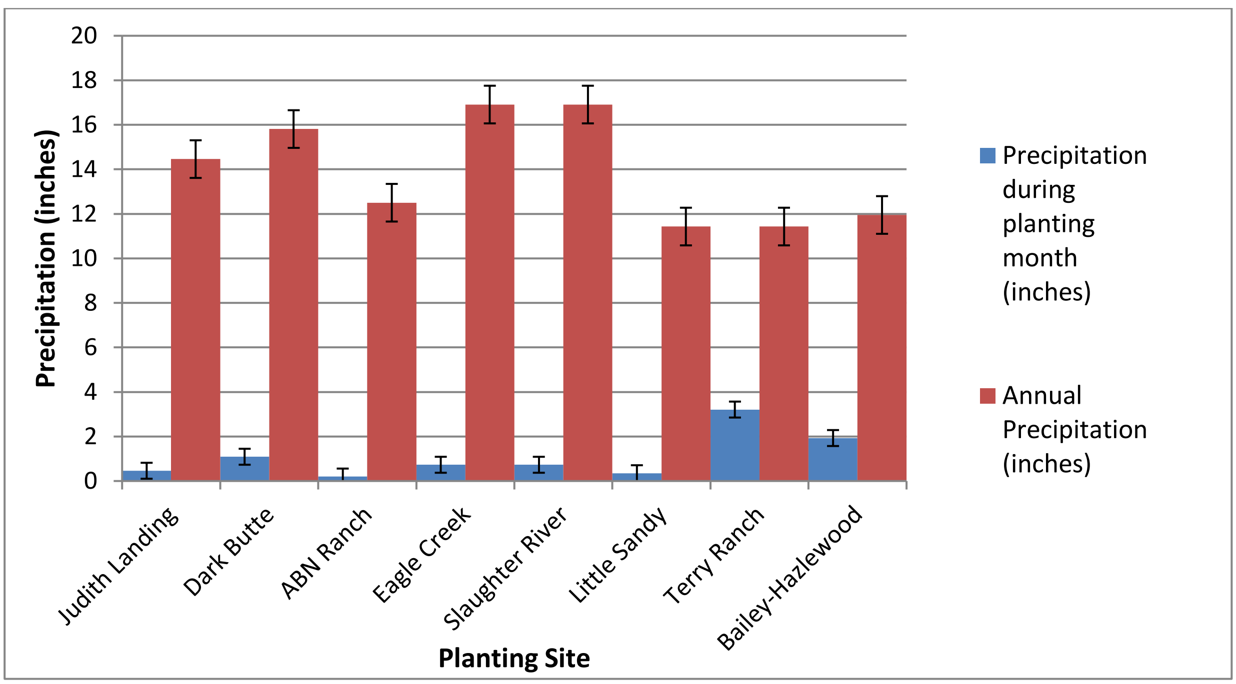
Precipitation Data

We also decided to take a brief look into monthly and yearly precipitation data; however nothing significant has popped out yet. Trees planted later in the year (spring) typically received higher amounts of precipitation, and annual precipitation varied from 11.43 to 16.91 inches at our planting sites.

Planting Site	Planting Date	Precipitation during planting month (inches)	Annual Precipitation (inches)	Survival Rate
Judith Landing	Mar-13	0.46	14.46	63%
Dark Butte	Mar-14/15	1.09/0.2	15.81/12.5	32%
ABN Ranch	Mar-15	0.2	12.5	66%
Eagle Creek	Mar-16	0.73	16.91	63%
Slaughter River	Mar-16	0.73	16.91	63%
Little Sandy	Mar-17	0.35	11.43	75%
Terry Ranch	Apr-17	3.21	11.43	32%
Bailey-Hazlewood	May-18	1.93	11.95	38%

Table 5: Monthly and annual precipitation. Precipitation data was provided by the US Climate Data and the USDA Natural Resources Conservation Service.

Graph 6: Monthly and annual precipitation by planting site.



Planting sites that had the highest precipitation values were 1) Terry Ranch, 2) Bailey Hazlewood, and 3) Dark Butte. Perhaps coincidentally, these are also sites that had the worst survival ratings. Spring precipitation and how quickly air temperatures warm to encourage bud break and growth may play a key role, but further analysis will be needed to determine any significant trends.

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Recommendations for Future Work

Given that the critical watering time for cottonwood plantings is in the first 2-3 years (which is why FMB waters trees for the first 2 summers), we would recommend that future monitoring efforts take place at 2 and 4 years after the original planting. After this period the plantings should be well established, and monitoring could commence once every 5 years. We recommend continuing to monitor tree height, DBH and the presence of competing vegetation. Given that the six year old trees at Judith Landing were significantly taller and larger than trees at all other planting sites, we also recommend that the plantings at Dark Butte be evaluated in the next 1-2 years to see if growth spikes after 5 years of age.

Another parameter that would be helpful to evaluate during future monitoring efforts is tree height above annual bankfull. Cottonwoods are planted on terraces which range in elevation, and the height above the water may be more important than the distance from the water's edge. Cost permitting, it would also be interesting to evaluate soil types at each of the planting sites, which could be done by assessing soil texture and testing the acidity of the soil using pH probes.

The protective wire caging placed around cottonwood pole cuttings is important for preventing grazing and wildlife damage. For example, damaged cages at Judith Landing led to 2 trees being killed by beavers. However, outside pressures such as wind, high floods, and wildlife can warp cages and impede tree growth. Summer fieldwork should continue to place an emphasis on fixing damaged cages, and in cases of rapid tree growth the cages will need to be expanded.

Left: Volunteer Mark Werley begins to expand the protective wire cage around a flourishing cottonwood planting.

Photo Credit: Tori Hill

Our findings related to tree mortality and river discharge indicate that spring planting events should take place no later than April. Higher flows during spring snow melt and runoff may negatively impact cottonwood plantings, and if planted too late trees will invest more energy into leaf development than roots.

The Upper Missouri River Breaks National Monument is a wild and remote place. There are many uncontrolled factors that are extremely difficult to account for. Floods, droughts, and wildlife can all have unpredictable impacts on cottonwood planting efforts. One thing is clear – cottonwoods are an iconic and stunning tree along the river corridor, and the UMRBNM would not be the same without them. With continued care and stewardship of the plantings and favorable climate conditions, we hope that the 328 living cottonwood trees continue to grow, ultimately replacing the aging stands of mature cottonwoods. In another 200 years, we hope for cottonwoods in the UMRBNM to still be alive and flourishing.

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2019 Cottonwood Planting

The Friends of the Missouri Breaks Monument completed their 2019 cottonwood planting on October 19th at the Bailey-Hazlewood site previously planted at in the preceding year. This was the first year that the Friends' planting event took place in the fall. The change in planting time was necessitated by an unusually wet spring that caused the planned sites to be inaccessible before bud-break, therefore threatening the survival of the project's trees.

While the change in planting time was a significant departure from previous plantings, the Friends feel confident that the trees should remain as viable as those from past year's plantings. This belief is informed from consultation with professionals in the horticulture field around the Intermountain-West (*see appendix*). According to multiple horticulturists, many cottonwood pole planting operations are conducted in the fall because of issues associated with need for summer watering, suitable planting conditions and changing climatic systems. Therefore it was concluded there should be little impact upon the overall survival rates of cottonwoods planted in the fall when compared with those planted in the spring.

Above: The Friends planting crew for the 2019 cottonwood planting event. *Photo Credit: Alexander Newby*

In total, the Friends planted 129 new cottonwoods during their 2019 planting event with the help of 24 volunteers from across the state. The cottonwood poles for the planting were harvested from a ranch located in the Arrow Creek drainage adjacent to the monument. Along with the new trees, volunteers also put up fencing to protect 27 naturally deposited young cottonwood trees, under .75" in DBH, in the planting area to protect them from grazing and beavers.

Despite the 2019 change in planting, the Friends will return to a spring planting in 2020 and will do so for the following year as well. The trees planted in 2019 will be watered throughout the summer months in 2020 and 2021, during that time they will continue to be monitored for survival rates and overall growth. Following the two year period after planting, the Friends expect to make a decision regarding future fall plantings. If the 2019 cottonwoods perform well the Friends anticipate moving future plantings to the fall due to ease of transport and more favorable weather conditions.

Acknowledgements

The Friends of the Missouri Breaks Monument would like to thank the Bureau of Land Management for partnering with us on our continuing cottonwood project. Special thanks go to the following BLM employees for their assistance with this monitoring effort: Bonny Richard, Kenneth Keever, Kathryn Lloyd, and Zane Fulbright.

We would also like to thank the landowners who have made planting cottonwoods on private land a possibility. Conservation would not be possible without partnerships, and the ranchers we have worked with are proof of that.

Lastly, we would like to thank our project funders at NorthWestern Energy. The Cottonwood Planting & Monitoring Program would not be possible without your support over the last five years. We are forever grateful for the financial assistance and faith you have given us.

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Appendix

1. Data sheet for 2019 Cottonwood Monitoring

FMB Cottonwood Assessment 2019								
Planting Site:				Year Planted:		Date:		Sheet #:
Surveyors:				Topography:		Weather:		
Tree #								Comment Codes / Notes
	DBH (in):		Tree Caliper (inches):		Tree Height (ft):		Tree Vigor: 0 1 2 3 4	
	___Dead/Damaged bark ___Necrotic Leaves ___Desiccation ___Compt. Veg ___Wildlife ___Pests							
	___Grazing ___Flood/Ice Damage ___Damaged Wire Crown Density: Sparse / Normal / Dense							
	GPS:							
Tree #								Comment Codes / Notes
	DBH (in):		Tree Caliper (inches):		Tree Height (ft):		Tree Vigor: 0 1 2 3 4	
	___Dead/Damaged bark ___Necrotic Leaves ___Desiccation ___Compt. Veg ___Wildlife ___Pests							
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	GPS:							
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	___Grazing ___Flood/Ice Damage ___Damaged Wire Crown Density: Sparse / Normal / Dense							
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Tree #								Comment Codes / Notes
	DBH (in):		Tree Caliper (inches):		Tree Height (ft):		Tree Vigor: 0 1 2 3 4	
	___Dead/Damaged bark ___Necrotic Leaves ___Desiccation ___Compt. Veg ___Wildlife ___Pests							
	___Grazing ___Flood/Ice Damage ___Damaged Wire Crown Density: Sparse / Normal / Dense							
	GPS:							

2. Contacts for fall cottonwood planting events:

Confluence Consulting, Hoag Riparian and Wetland Restoration, Biomimicry Institute, Montana State, Tizer Gardens

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