

As described in the State of the Watershed Report, in 2019 we initiated our Monitoring and Assessment Framework in the St. Vrain Watershed. While the St. Vrain Watershed is geographically similar to Left Hand, there are differences in watershed area and flows. The St. Vrain Watershed covers a greater area and experiences higher flows in both tributaries (North and South St. Vrain Creeks) and main stem St. Vrain Creek than Left Hand Watershed tributaries. Due to these differences and our limited monitoring data, the purpose of this appendix is to show 2019 results from St. Vrain sites and key take-aways. For further explanation of the parameters, methods, and our adaptive management process see the 2020 State of the Watershed Report.

In 2019, we implemented monitoring from June through October at six restored sites in St. Vrain Watershed (Figure 1). All sample sites were in the Foothills watershed zone but located on three different creeks: St. Vrain, South St. Vrain, and North St. Vrain Creeks (Figure 1). Notably, our sites varied by restoration year, so our results were dependent on time. Therefore, we grouped results for most ecological categories by “year(s) since restoration”. Table 1 below lists each site and monitoring details.

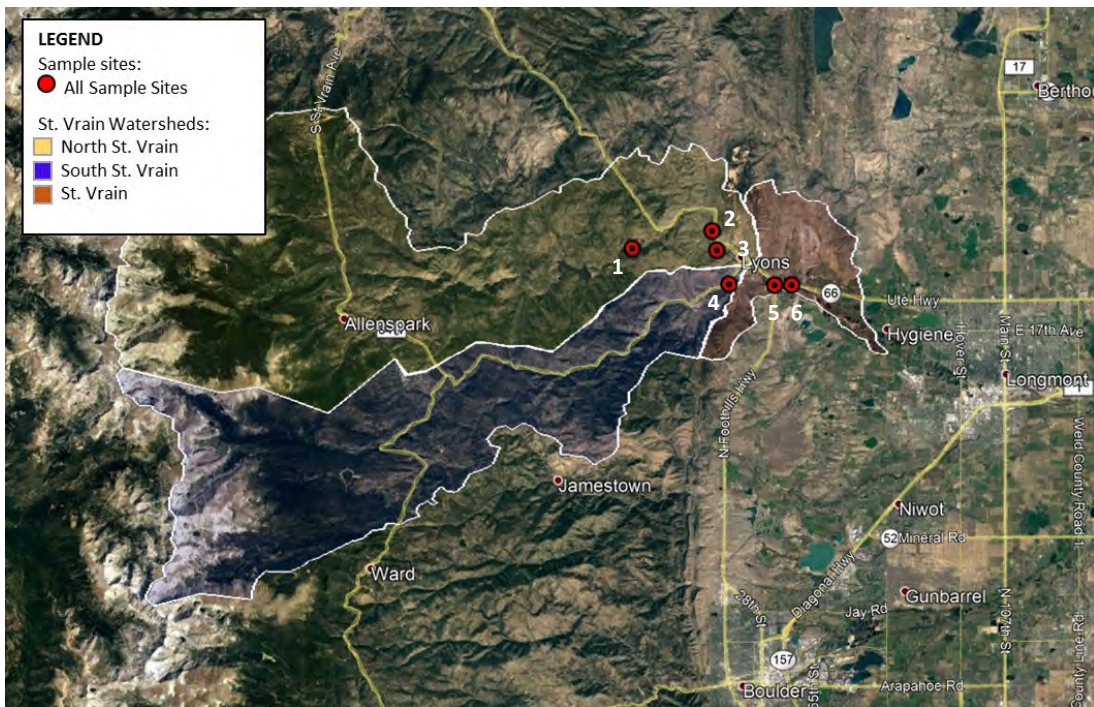


Figure 1. A map of all sites in the St. Vrain Watershed, including North and South St. Vrain sub-watersheds. Watersheds and all sample sites on North St. Vrain, South St. Vrain, and St. Vrain Creeks are indicated by color. Numbers are linked to site names listed in Table 1.

Table 1. The 2019 St. Vrain Watershed restored monitoring sites. Sites are described by Number, Creek Name, Site Name, Year(s) Since Restoration, and applicable monitoring activities. Monitoring activities by ecological category assessed at each site are marked with an “X.” BMI Community data from 2016 were also included in our analysis at X’s marked with an asterisk (\*). Site Numbers are linked to Figure 1.

No.	Creek Name	Site Name	Year(s) Since Restoration	Floodplain Connectivity	Channel Morph. & Habitat	Riparian Condition	BMI Community
1	North St. Vrain	Button Rock	2		X	X	X
2	North St. Vrain	Apple Valley North	1	X	X	X	X
3	North St. Vrain	Apple Valley South	1	X	X	X	X
4	South St. Vrain	Hall Meadows	2		X	X	X*
5	St. Vrain	McConnell	1	X	X	X	X
6	St. Vrain	Bullock	1		X	X	X*

## **Floodplain Connectivity**

In 2019, we monitored floodplain connectivity on 6/21/2019 at three (Apple Valley North, Apple Valley South, and McConnell) of the six sites during peak annual flows to qualitatively assess floodplain inundation of bankfull benches and applicable side channels. Figure 2 below shows peak flow observations used to determine key take-aways.

Key take-aways after one year of monitoring are as follows:

- Annual peak flow in St. Vrain Watershed exceeded bankfull benches (flows surpassed wood/boulder toe revetments at Apple Valley South and willow stands at Apple Valley North and McConnell) (Figure 2), while peak flows at Foothills sites in Left Hand Watershed did not exceed bankfull benches.
- Annual peak flow in St. Vrain Watershed activated the side channel at Apple Valley North (Figure 2).
- Need to increase efforts to monitor more sites and to define peak flow discharge ranges appropriate for designed bankfull benches, side channels, benches, and overflow channels at all sites.
- Need to refine hypotheses to evaluate depth, duration, and timing of peak flows and define what peak flows are flushing flows (promoting scour and sediment transport).





Figure 2. Annual peak flow observations from 6/21/2019 at restored sites in St. Vrain Watershed. Photo description match letter and arrow: A. activated side channel at Apple Valley North, North St. Vrain Creek; B. flows exceeding bankfull bench marked by willows at Apple Valley North, North St. Vrain Creek; C. flows exceeding bankfull bench marked by wood revetment and willows at downstream end of Apple Valley South, North St. Vrain Creek; D. flows exceeding bankfull bench marked by wood revetment at upstream end of Apple Valley South, North St. Vrain Creek; E. flows exceeding bankfull bench marked by willows at McConnell, St. Vrain Creek.

## Channel Morphology and Habitat

In 2019, we conducted habitat surveys from August through October at all six sites. At each site, representative survey reaches were generally 1,000 feet in length and included pebble counts at one or two representative riffles. Tables 2 and 3 below show our habitat survey and pebble count results used to determine key take-aways.

Key take-aways after one year of monitoring are as follows:

- Pool area at all sites attained greater than 20% pool area relative to wetted area except for McConnell (17.1% pool area) (Table 2). This may be due to limited project area and floodplain.
- Residual pool depth at all sites was greater than 1.5 ft, providing habitat for fish (Table 2).
- Percent sands at all sites attained less than 40% threshold, indicating no sedimentation issues (Table 3).
- Percent pool area and sands at St. Vrain Watershed sites were similar to Left Hand Watershed Foothills sites, with the exception of low pool area at McConnell (Table 2; Table 3).

## Tables and Figures

Table 2. The 2019 habitat survey summary for all restored sites and grouped by year(s) since restoration in the St. Vrain Watershed. Metrics for each site include percent pool area relative to wetted area, average residual pool depth and pool count. Year(s) since restoration averages and sample size (n) listed in bold.

	Site	% Pool Area: Wetted Area	Avg. Residual Depth (ft)	Pool Count
One Year Since Restoration	<b>Apple Valley N</b>	38.1%	1.9	10
	<b>Apple Valley S</b>	22.6%	2.3	7
	<b>Bullock</b>	22.8%	2.5	2
	<b>McConnell</b>	17.1%	1.9	3
	<b>Average (n)</b>	<b>25.2% (4)</b>	<b>2.1 (4)</b>	<b>5.5 (4)</b>
Two Years Since Restoration	<b>Button Rock</b>	43.7%	1.9	10
	<b>Hall Meadows</b>	33.6%	1.5	10
	<b>Average (n)</b>	<b>38.7% (2)</b>	<b>1.7 (2)</b>	<b>10 (2)</b>

Table 3. The 2019 pebble count percent sands summary for all restored sites and grouped by year(s) since restoration in the St. Vrain Watershed. Metrics for each site include percent sands (+/- standard error) and pebble count. Year(s) since restoration averages (+/- standard error) and cumulative sample size (n) listed in bold.

	Site	Percent Sands (+/- SE)	Sample Size
One Year Since Restoration	<b>Apple Valley N</b>	8.0% (2.0)	2
	<b>Apple Valley S</b>	8.0% (1.0)	2
	<b>Bullock</b>	13% (na)	1
	<b>McConnell</b>	6.0% (2.0)	2
	<b>Average (+/- SE)</b>	<b>8.0% (1.0)</b>	<b>7</b>
Two Years Since Restoration	<b>Button Rock</b>	9.0% (1.0)	2
	<b>Hall Meadows</b>	14% (5.0)	2
	<b>Average (+/- SE)</b>	<b>12% (3.0)</b>	<b>4</b>

## Riparian Condition

In 2019, we monitored riparian condition in September at all six sites. At each site, riparian plots were surveyed along one cross section. At a minimum, each site had four survey plots that assessed creek edge and upland zones on both banks. Additional riparian zones were assigned plots and surveyed if appropriate. Tables and figures below show our percent cover and native richness results used to determine key take-aways.

Key take-aways after one year of monitoring are as follows:

- Between year two and year one sites, average percent native herbaceous cover type and average native richness were similar and percent native woody cover was greater at year two sites (Table 4; Figure 3).
- While average percent native cover types were similar between creek edge and upland zones, native richness was greater in the creek edge zone at both year one and two sites (Table 5; Figure 4)
- Unlike trends at Left Hand Watershed Foothills sites, St. Vrain Watershed sites showed greater average percent non-native cover at year two sites than year one sites. This suggests need for weed control or presence of more non-native competition in the St. Vrain Foothills (Figure 3).

## Tables and Figures

Table 4. The 2019 average native richness (+/- standard error) and sample size for all restored sites and grouped by year(s) since restoration in the St. Vrain Watershed. Year(s) since restoration averages (+/- standard error) and cumulative sample size (n) listed in bold.

	Site	Richness (+/- SE)	Sample Size
One Year After Restoration	<b>Apple Valley N</b>	5.75 (0.95)	4
	<b>Apple Valley S</b>	5.67 (1.31)	6
	<b>Bullock</b>	4.17 (0.95)	6
	<b>McConnell</b>	6.50 (1.44)	4
	<b>Average</b>	<b>5.40 (0.58)</b>	<b>20</b>
Two Years After Restoration	<b>Button Rock</b>	5.20 (0.37)	5
	<b>Hall Meadows</b>	4.71 (0.86)	7
	<b>Average</b>	<b>4.92 (0.51)</b>	<b>12</b>

Table 5. The 2019 average native richness (+/- standard error) and sample size in creek edge and upland riparian zones for all restored sites grouped by year(s) since restoration in the St. Vrain Watershed.

	Site	Richness (+/- SE)	Sample Size
One Year Since Restoration	<b>Creek Edge</b>	6.62 (0.83)	8
	<b>Upland</b>	4.58 (0.74)	12
Two Years Since Restoration	<b>Creek Edge</b>	5.83 (0.74)	6
	<b>Upland</b>	3.80 (0.66)	5

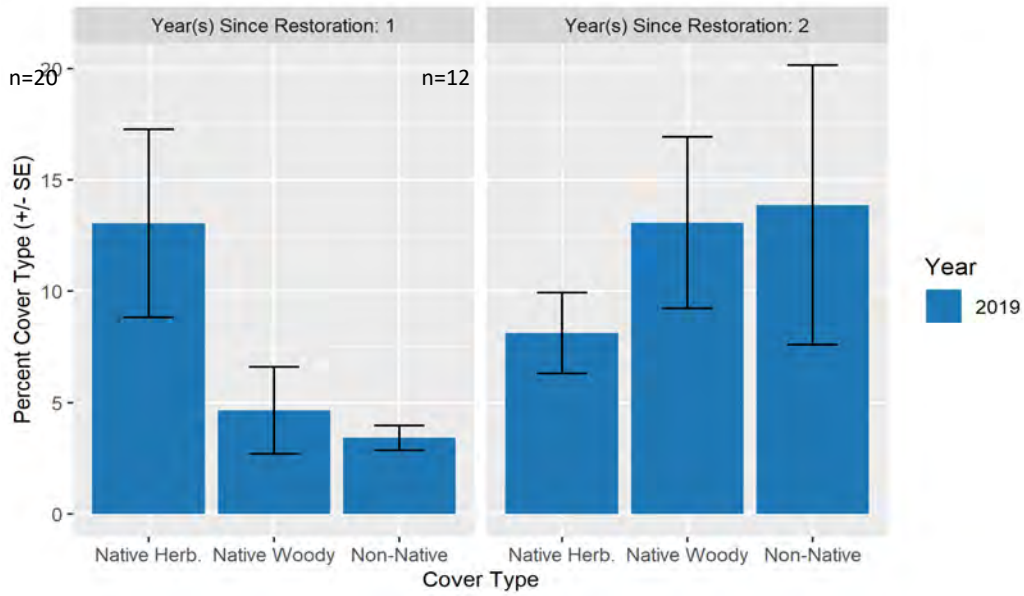


Figure 3. The 2019 average percent cover types (+/- standard error) for sites one or two years after restoration in the St. Vrain Watershed. Cover types are classified as Native Herbaceous, Native Woody, and Non-Native. Sample size indicated by 'n' value.

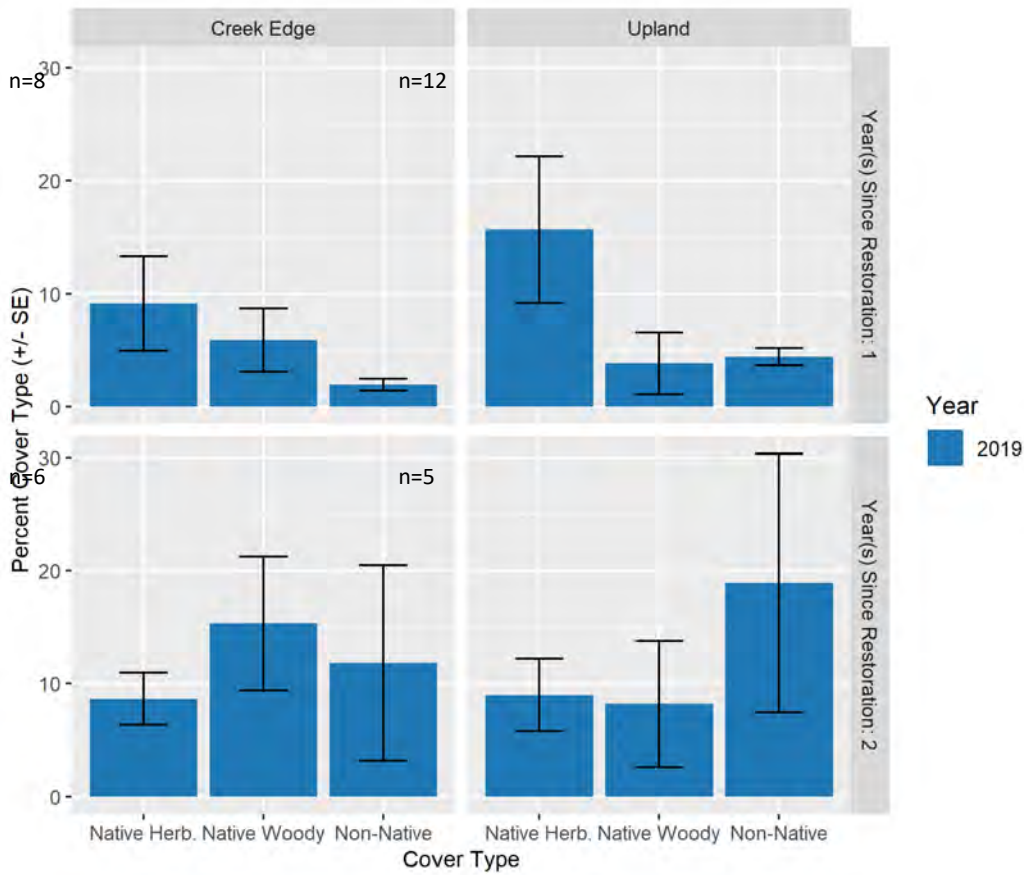


Figure 4. The 2019 average percent of cover types (+/- standard error) in the Creek Edge or Upland riparian zones for all sites one or two years after restoration. Cover types are classified as Native Herbaceous, Native Woody, and Non-Native. Sample size indicated by 'n' value.



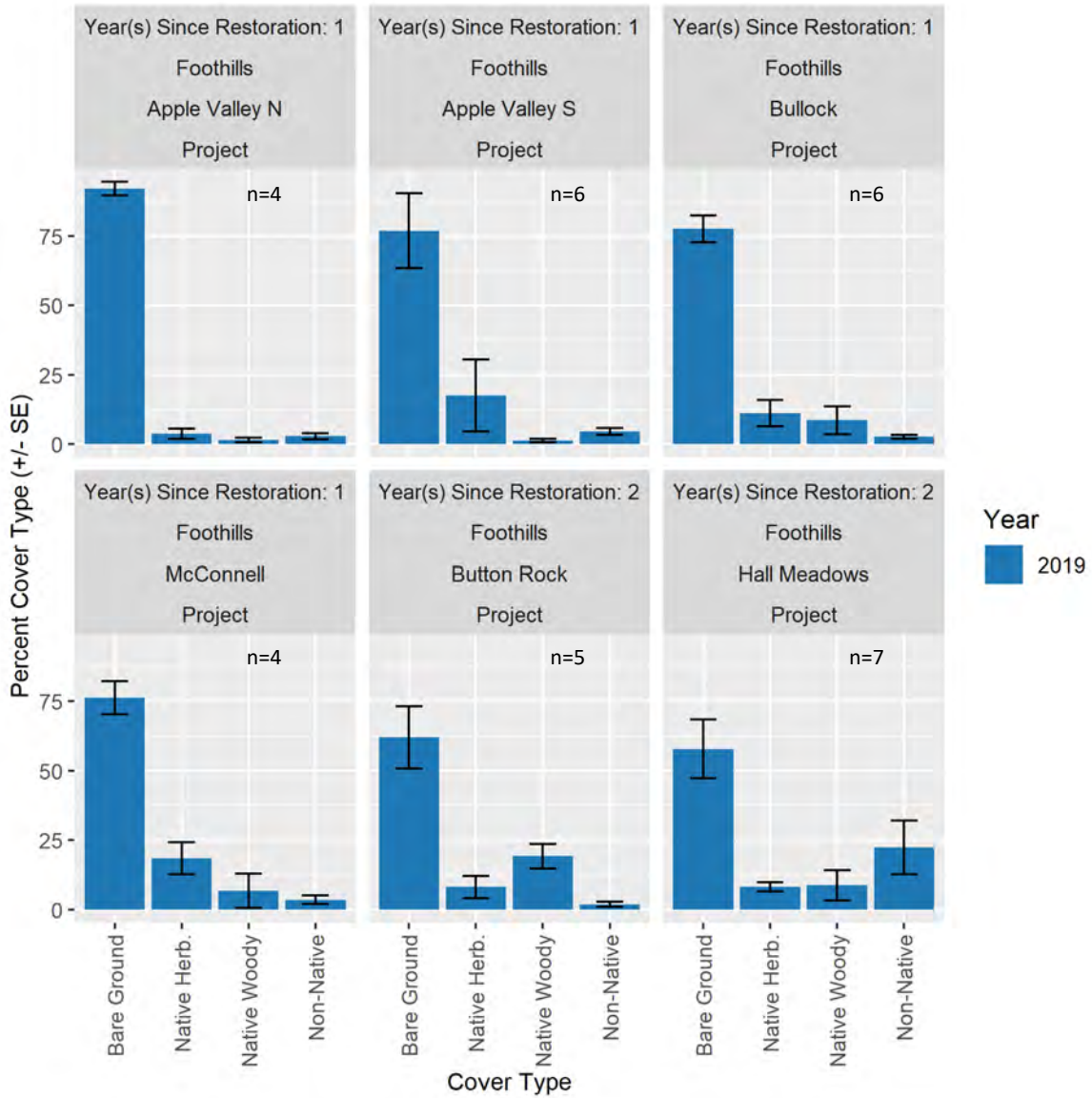


Figure 5. A supplemental figure provided for reference. The 2019 average percent of cover types (+/- standard error) for all sites in St. Vrain Watershed. Sites are described by Year(s) Since Restoration (1, 2), Watershed Zone (Foothills), Site Name, and Site Type (project). Cover types are classified as Bare Ground, Native Herbaceous, Native Woody, and Non-Native. Sample size indicated by 'n' value.

## Benthic Macroinvertebrate Community

In 2019, we collected benthic macroinvertebrate (BMI) samples from one representative riffle at Button Rock, Apple Valley and McConnell sites and obtained 2016 and 2019 samples collected by Boulder County Parks and Open Space (BOCO POS) at Bullock and Hall Meadows. The Watershed Center used CDPHE kick sampling methods, while BOCO POS used Hess Sampling methods. All samples were analyzed using Multimetric Version 4 (and considered applicable sampling methods) and our results are comparable for all sites and samples. Tables and Figures below show our Multimetric (MMI), Diversity, Hilsenhoff Biotic Index (HBI), and Tolerance Indicator Value (TIV) results used to determine key take-aways.

Key take-aways after one year of monitoring, including 2016 and 2019 samples, are as follows:

- All sites attained MMI, Diversity, HBI, and TIV standards, indicating no apparent water quality or sedimentation issues (Table 6; Figures 6-8).
- Compared between 2016 and 2019 samples at Hall Meadows and Bullock: MMI scores were similar, Diversity scores improved in 2019, and HBI scores were slightly higher at Hall Meadows and similar at Bullock (Figures 6-8).
- Need to expand monitoring efforts to assess conditions in Canyons and Plains reaches.

## Tables and Figures

Table 6. Tolerance Index Value (TIV) scores from 2016 and 2019 at sites in St. Vrain Watershed in Sediment Regions 2 and 3. No impairment indicated based on TIV thresholds for Regions 2 (score= 7) and 3 (score= 6.3).

Site	Sediment Region	2016 TIV Score	2019 TIV Score
<b>Button Rock</b>	R2	NA	5.51
<b>Apple Valley</b>	R2	NA	4.31
<b>Hall Meadows</b>	R3	5.05	5.27
<b>McConnell</b>	NA	NA	NA
<b>Bullock</b>	NA	NA	NA

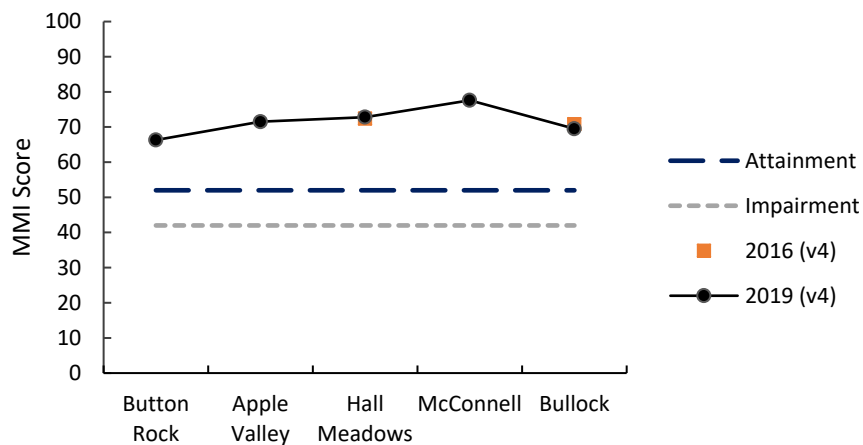


Figure 6. MMI scores from 2016 and 2019 at restored sites in St. Vrain Watershed. Short dotted line indicates impairment threshold and long dotted line indicates attainment threshold for Biotype 1. Impairment indicated by MMI scores below attainment threshold line. MMI version 4 was used to calculate all scores.



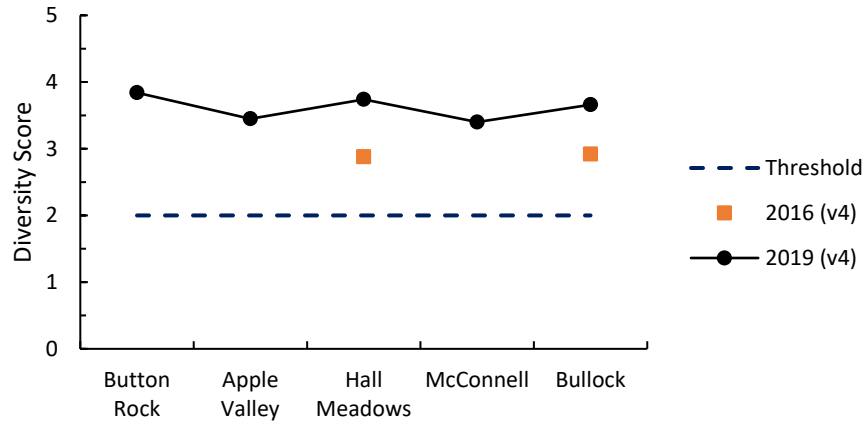


Figure 7. Diversity scores from 2016 and 2019 at restored sites in St. Vrain Watershed. Dotted line indicates impairment threshold Biotype 1. Impairment indicated by diversity scores below threshold line. MMI version 4 was used to calculate all scores.

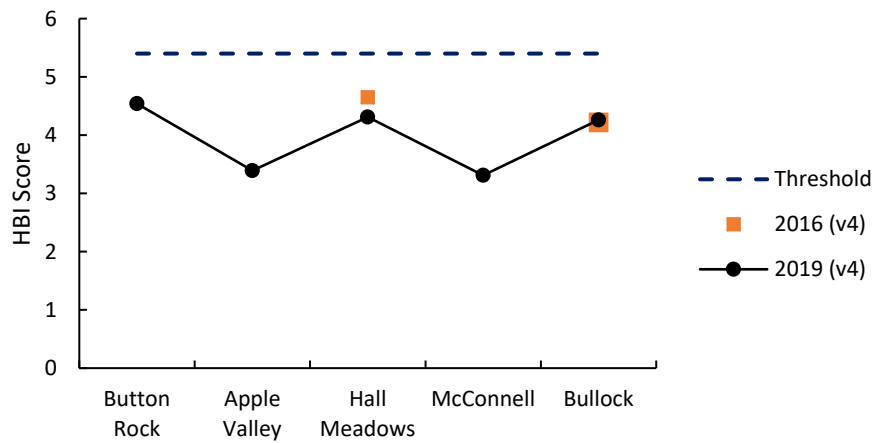


Figure 8. HBI scores from 2016 and 2019 at restored sites in St. Vrain Watershed. Dotted line indicates impairment threshold for Biotype 1. Impairment indicated by HBI scores above threshold line. MMI version 4 was used to calculate all scores.