

Bacteria Contamination of Surface Waters Due to Livestock Grazing in the Stanislaus National Forest, California

(Third Year of Study)

Summary of 2011 Results

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Surface waters were tested for pathogenic bacteria indicators (i.e., *E. coli*, fecal coliform bacteria, and total coliform bacteria) for the third consecutive year within commercial cattle grazing allotments in the Stanislaus National Forest. Water samples were collected from three allotments that had commercial livestock grazing during the summer of 2011 and from four allotments that did not. Similar to the results from the first two years of sampling (2009 and 2010), the results showed that individual and average concentrations of fecal coliform bacteria in surface waters were below regulatory thresholds at all sites before cattle presence or where no livestock grazed during the season. Shortly after cattle were released to graze in allotments, fecal coliform concentrations were much higher, and in places exceeded state standards. *E. coli* and total coliform concentrations followed the same pattern. The 2009 and 2010 reports focused on the violations of state standards for fecal coliform concentrations in recreational contact waters. This summary highlights the difference in *E. coli* and fecal coliform concentrations detected in waters when cattle were not present against the *E. coli* and fecal coliform concentrations when cattle were present in the Stanislaus National Forest.

Field Site Selection

Four sites that were exposed to commercial livestock grazing during the summer of 2011 were sampled within the Stanislaus NF. Three of these sites were also sampled during the summer of 2010 and the fourth was also sampled during the summer of 2009. These sites are described below, and Table 1 provides location (i.e., latitude, longitude) coordinates for each site, using datum NAD 83.

Boggy Meadow 1 & 2 (Bog 1 & Bog 2)

Bog 1 sample site: 1,694 meters (5,558 feet) elevation

Bog 2 sample site: 1,695 meters (5,561 feet) elevation

Two samples were collected from an unnamed tributary stream of Jawbone Creek where it flows out of Boggy Meadow (which is within the Rosasco Range Allotment). Jawbone Creek is entirely within the Tuolumne River watershed and flows directly into the Tuolumne River. Boggy Meadow is used as a gathering area for cattle at the end of the permitted grazing season in October. Boggy Meadow is fenced to exclude cattle for most of the summer; however, the fence was not up when cattle were released into this allotment in 2011. Cattle trespass inside the fence was observed on Saturday, June 18,

2011, prior to the first water sample collected. The meadow was subsequently fenced and the cattle removed before the first sample was taken on Tuesday, June 21, 2011. The meadow was fenced during the time period when most of the samples were collected from the unnamed tributary of Jawbone Creek that flows from the meadow. Three samples were collected at the end of the summer when the meadow was used to gather cattle for removal from the allotment. Two samples were collected from this stream to provide a “before vs. after livestock arrival” comparison. The first sample was collected 100 feet downstream/outside of the Meadow fence (where livestock have unrestricted access to the stream); the second sample was collected 4 feet inside the fence (where livestock did not have access to the stream or meadow). The majority (7 of 12) of the samples collected inside the fence took place when cattle were not present within the fenced meadow. 5/12 samples collected inside the fence were taken when there was cattle trespass or cattle were gathered into the meadow for removal. After the winter snowpack receded from this area, there was no flowing water entering Boggy Meadow. The stream flowing from Boggy Meadow is spring-fed, discharging from within the fenced meadow. Twelve “inside fence/before” and “outside fence/after” grazing water samples were collected between June 21, 2011 and October 3, 2011.

Bull Meadow Creek (BM) – sample site: 1,145 meters (3,757 feet) elevation
The samples were collected from Bull Meadow Creek a short distance below Bull Meadow (which is within the Jawbone Range Allotment). Bull Meadow Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. Cows were already present at the time of the first visit to this site but did not appear to have been there for long. Accordingly, no “before” grazing samples were collected at this site. Sixteen “after cattle arrival” samples were collected between May 25, 2011 and October 3, 2011. Bull Meadow Creek was also sampled in 2010, with all samples collected after cattle presence.

Upper Cottonwood Creek (CMUS & CMUS2)
CMUS sample site: 2,160 meters (7,087 feet) elevation
CMUS2 sample site: 2,194 meters (7,198 feet) elevation
Samples were collected upstream of Cottonwood Meadow from Cottonwood Creek (which is within the Rosasco Range Allotment). Cottonwood Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via Cherry Creek. Like Boggy Meadow, two samples were collected from this stream to provide a “before vs. after livestock arrival” comparison. The first sample was collected 30 feet downstream/outside of a meadow fence (where the livestock have unrestricted access to the stream); the second sample was collected 90 feet inside the fence (where livestock did not have access to the stream or meadow while these samples were collected). After the winter snowpack receded from this area, there was no flowing water entering the headwaters of Cottonwood Creek inside the fenced area. The headwaters of Cottonwood Creek are spring-fed, discharging from within the fenced meadow. Six “outside fence/after cattle arrival” water samples were collected between August 5, 2011 and October 3, 2011. Five “inside fence/before cattle” water samples were collected between August 9, 2011 and October 3, 2011.

Lower Round Meadow – sample site: 1,932 meters (6,338 feet) elevation

Samples were collected from a tributary stream of Bell Creek, where it flows through Lower Round Meadow (which is within the Bell Meadow/Bear Lake Range Allotment). Bell Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. One “before livestock” grazing water sample was collected July 19, 2011 from the same sample site that the “after livestock arrival” samples were collected. Twelve “before livestock” samples were collected upstream of the meadow from two sample sites located in the forest between July 19, 2011 and September 7, 2011 (cattle and/or evidence of cattle were not observed near either upstream sample site). Eleven “after livestock arrival” water samples were collected between July 26, 2011 and September 22, 2011. Cattle were not visibly present in the Lower Round Meadow area from August 10, 2011 through September 22, 2011.

In addition to the four grazed sites described above that were sampled multiple times over the course of the summer in 2011. Samples were also collected from the following five sites that were not grazed in 2011, four of which were grazed and sampled in previous years. The other was sampled in previous years, but not grazed.

Sheep Meadow (SM2 & SM3)

SM2 sample site: 2,634 meters (8,642 feet) elevation

SM3 sample site: 2,640 meters (8660 feet) elevation

Two samples were collected from an unnamed tributary of Elbow Creek below Sheep Meadow in the Mokelumne Wilderness (which is within the Highland Lakes Range Allotment). The unnamed tributary is entirely within the North Fork Mokelumne River watershed and flows into the North Fork Mokelumne River via Elbow Creek. The unnamed tributary of Elbow Creek has several confluences with tributaries and seeps that drain into the stream from Sheep Meadow. The two sample sites are located 80 feet apart on the main stream below separate confluences with water flowing from Sheep Meadow. These sites were sampled in 2010, but only when cattle were present; accordingly, no “before cattle” data is available from 2010. These sites were sampled twice on August 31, 2011 so that the ungrazed results could be compared with the six “after cattle arrival” samples that were collected between August 2, 2010 and August 23, 2010

Bourland Meadow (control site, not grazed) – sample site: 2,225 meters (7,299 feet) elevation

Samples were collected below Bourland Meadow from Bourland Creek. Bourland Meadow lies within a designated research natural area (RNA). Bourland Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. This site was sampled in both 2009 and 2010 as an “ungrazed/control” site. Sampling at this site in 2009 and 2010 occurred during the same general time period as the “after cattle arrival” samples that were collected those years. The same site was sampled once in 2011 on September 29, 2011.

Upper Fiddlers Green Meadow – sample site: 1,966 meters (6,450 feet) elevation

Samples were collected at the lower end of Upper Fiddlers Green Meadow from a tributary stream of Herring Creek (which is within the Herring Creek Range Allotment). Herring Creek is entirely within the Stanislaus River watershed and flows into the South Fork of the Stanislaus River. This site had “before” and “after” grazing samples

collected during the summer of 2009. Eight “before” grazing water samples were collected between June 11, 2009 and July 9, 2009. Six “after livestock arrival” grazing water samples were collected between July 16, 2009 and August 13, 2009. Cattle did not graze this allotment during 2011. Three samples were collected in 2011 during the same time period that cattle would have been present if the allotment had been grazed in 2011.

Bull Run – sample site: 2,022 meters (6,634 feet) elevation

Samples were collected below Bull Run Meadow from a major tributary of Cow Creek (which is within the Herring Creek Range Allotment). Cow Creek is entirely within the Stanislaus River watershed and flows into the Lower Middle Fork of the Stanislaus River. This site had “before” and “after” grazing samples collected during the summer of 2009. Seven “before” samples were collected between June 9, 2009 and July 1, 2009. Seven “after livestock arrival” grazing water samples were collected between July 9, 2009 and August 13, 2009. Cattle did not graze this allotment during 2011. Three samples were collected in 2011 during the same time period that cattle would have been present if the allotment had been grazed in 2011.

Barn Meadow - sample site: 2,273 meters (7,458 feet) elevation

Samples were collected below Barn Meadow from a tributary stream to Niagara Creek (which is within the Long Valley/Eagle Meadow Range Allotment). Niagara Creek is entirely within the Stanislaus River watershed and flows into Donnell Lake via the Middle Fork of the Stanislaus River. This site had “before” and “after” grazing samples collected during the summer of 2009. Seven “before” grazing water samples were collected between June 11, 2009 and July 1, 2009. Thirteen “after livestock arrival” grazing water samples were collected between July 9, 2009 and August 5, 2009. Cattle did not graze this allotment during 2011. Four samples were collected from Barn Meadow in 2011 during the same time period that cattle would have been present if the allotment had been grazed in 2011.

Table 1. List of water sample sites (lat/long datum NAD 83).

Site name	County	Latitude	Longitude
Bog 1 (outside fence/after cows)	Tuolumne	37.89369444	-120.05788889
Bog 2 (inside fence/before cows)	Tuolumne	37.98830556	-119.96372222
BMC	Tuolumne	37.89369444	-120.05788889
CMUP (outside fence/after cows)	Tuolumne	37.99208333	-119.94273333
CMUP2 (inside fence/before cows)	Tuolumne	37.99241666	-119.94275000
LRM	Tuolumne	38.15877200	-119.95698600
LRM upstream sample site 1	Tuolumne	38.16985000	-119.95798333
LRM upstream sample site 2	Tuolumne	38.17751666	-119.94798333
Barn Meadow (BM-09)	Tuolumne	38.29252616	-119.86239033
Bull Run Meadow (BR-09)	Tuolumne	38.249194	-119.96369200
Upper Fiddlers Green (UFG-09)	Tuolumne	38.22421197	-119.96850279
SM2	Alpine	38.56216667	-119.85891667
SM3	Alpine	38.56238889	-119.85883333
BoM (Control site)	Tuolumne	38.10920712	-119.91242115

Results

Comparison of Data From Areas With Livestock Grazing in 2011

There was a rapid rise in the fecal coliform (FC) and *E. coli* concentrations immediately after the onset of cattle grazing at all four sample sites.

At Boggy Meadow, (sample sites on the same stream 100' apart) the average *E. coli* concentration inside the fence when cattle were not present was 6 (n=7, see footnote), with six samples of 8 or less [mean FC=7, n=7]. Downstream/outside the fence where cattle had unrestricted access to the water, the average *E. coli* concentration was 549 (n=12), with four samples of 900 or more [mean FC=570, n=12].

Boggy Meadow was also sampled in 2010; see Figure 1 for a comparison of *E. coli* results between 2010 and 2011. See Figure 2 for a comparison of fecal coliform results between the two years.

At Upper Cottonwood Creek, (sample sites on the same stream 120' apart) the average *E. coli* concentration “inside the fence/cattle not present” was 9 (n=5), with three samples of 8 or lower [mean FC=10, n=5]. Downstream/outside the fence where cattle had unrestricted access to the water, the average *E. coli* concentration was 280 (n=6), with three samples of 300 or higher [mean FC=328, n=6].

At Lower Round Meadow, the average *E. coli* concentration before cattle presence was 6 (n=13), with nine samples of 2 or less [mean FC=6, n=13]. The average *E. coli* concentration after cattle presence was 838 (n=11), with six samples of 900 or higher [mean FC=966, n=11].

Lower Round Meadow was also sampled in 2009; see Figure 1 for a comparison of *E. coli* results between 2009 and 2011. See Figure 2 for a comparison of fecal coliform results from the two years.

At Bull Meadow Creek, no “before cattle” presence samples were taken. The average *E. coli* concentration with cattle presence was 443 (n=16), with eight samples of 300 or higher [mean FC=476, n=16].

Note: There were fewer inside the fence samples counted for the “before cattle presence/inside the fence” average (n=7 for inside the fence vs. n=12 for outside the fence) for two reasons. First, due to an unmaintained fence, cattle were observed trespassing in Boggy meadow on June 18, 2011 (three days before the first sample). Accordingly, the first two samples taken inside the fence were not included in the “inside the fence/before cattle presence” average. Second, we continued to sample inside the fence late in the summer when cattle were allowed into Boggy meadow for gathering. Accordingly, cattle were present when the last three samples were taken inside the fence. The average *E. coli* concentration for the five samples taken inside the fence when cattle were also present is 584 (n=5) with two samples of 900 or higher [mean FC=584, n=5].

Comparison of Data From Areas Without Livestock Grazing in 2011

At Sheep Meadow sample site SM2, the average *E. coli* concentration after cattle presence in 2010 was 377 (n=6), with two samples of 900 [mean FC=493, n=6]. In 2011 when the allotment was not grazed, the same site was sampled two times, five minutes apart. Both samples came back with *E. coli* concentrations of less than 2 [mean FC=2, n=2]. See Figure 3 for a comparison of *E. coli* results between 2010 and 2011. See Figure 4 for a comparison of fecal coliform results from the two years.

At SM3, the average *E. coli* concentration after cattle presence in 2010 was 349 (n=7), with two samples of 500 or higher [mean FC=450, n=7]. In 2011 when the allotment was not grazed, the same site was sampled two times, five minutes apart. The average *E. coli* concentration was 3 (n=2), with one sample of 2 and the other 4 [mean FC=3, n=2]. See Figure 3 below for a comparison of *E. coli* results between 2010 and 2011. See Figure 4 for a comparison of fecal coliform results from the two years.

Bourland Meadow was the “control/ungrazed site” in both 2009 and 2010; it was also ungrazed again in 2011. In 2009, the average *E. coli* concentration was 5 (n=8), with six samples of 2 or less [mean FC=6, n=8]. In 2010, the average *E. coli* concentration was 2 (n=6), with five samples of 2 or less [mean FC=3, n=6]. In 2011, this site was sampled once; the *E. coli* concentration was less than 2 [FC=<2].

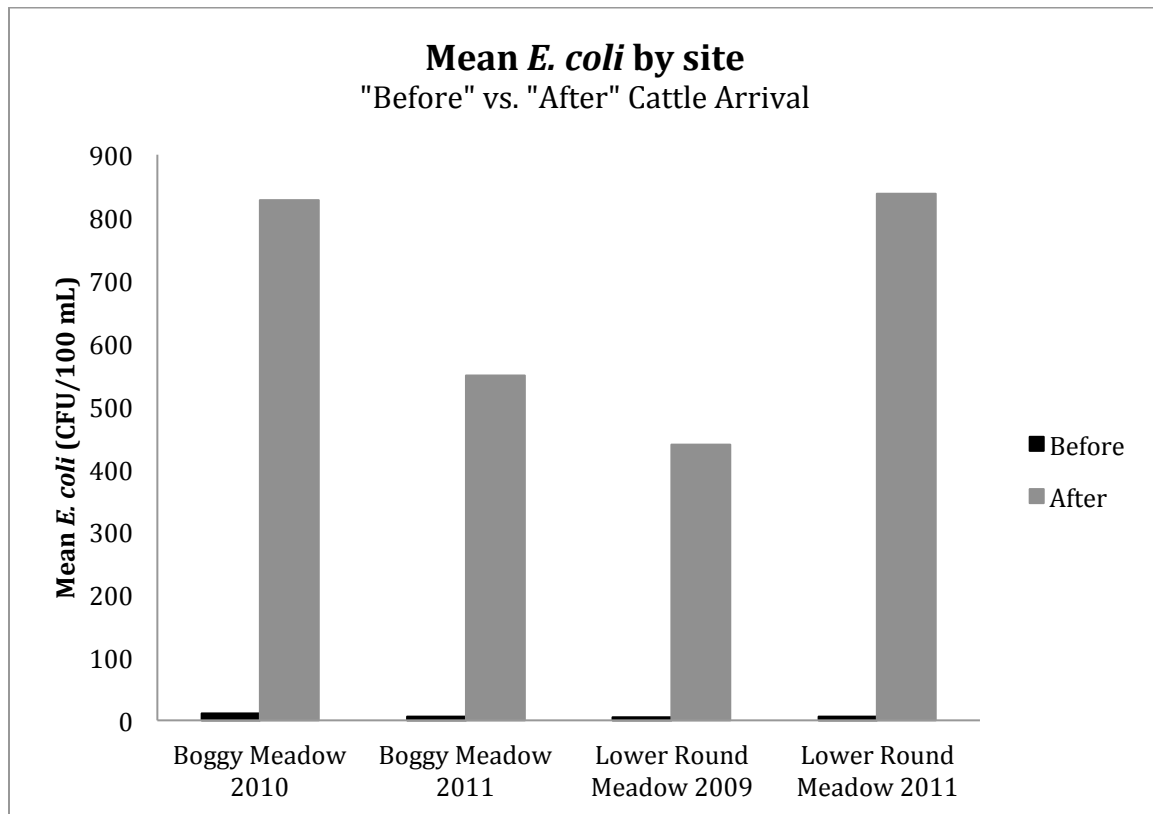
Upper Fiddlers Green Meadow had “before” and “after” livestock sampling in 2009. The average *E. coli* concentration before cattle presence in 2009 was 13 (n=8), with three samples of 8 or less [mean FC=13, n=8]. The average *E. coli* concentration after cattle presence in 2009 was 121 (n=7), with three samples over 100 [mean FC=341, n=7]. In 2011, three “cattle not present” samples were collected during the same time that cattle would have been present if the allotment had been grazed in 2011. The average *E. coli* concentration was 18 (n=3), with two samples of two or less [mean FC=21, n=3]. See Figure 5 for a comparison of the *E. coli* results between 2009 and 2011. See Figure 6 for a comparison of the fecal coliform results from the two years.

Bull Run Meadow had “before” and “after” livestock sampling in 2009. The average *E. coli* concentration “before cattle presence” in 2009 was 10 (n=8), with six samples of 8 or less [mean FC=12, n=8]. The average *E. coli* concentration after cattle presence in 2009 was 127 (n=10), with four samples over 100 [mean FC=141, n=10]. In 2011, three “cattle not present” samples were collected during the same time that the “after cattle presence” samples were collected in to 2009. The average *E. coli* concentration was 41 (n=3) [mean FC=51, n=3]. See Figure 5 for a comparison of the *E. coli* results between 2009 and 2011. See Figure 6 for a comparison of the fecal coliform results from the two years.

Barn Meadow had “before” and “after” livestock sampling in 2009. The average *E. coli* concentration before cattle presence in 2009 was 3 (n=7), with six samples of 4 or less [mean FC=4, n=7]. The average *E. coli* concentration after cattle presence in 2009 was 265 (n=13), with seven samples of 300 or higher [mean FC=392, n=13]. In 2011, three “cattle not present” samples were collected during the same time that cattle would have been present if the allotment had been grazed in 2011. The average *E. coli* concentration was 25 (n=4), with two samples of 4 or less [mean FC=26, n=4]. See Figure 5 for a

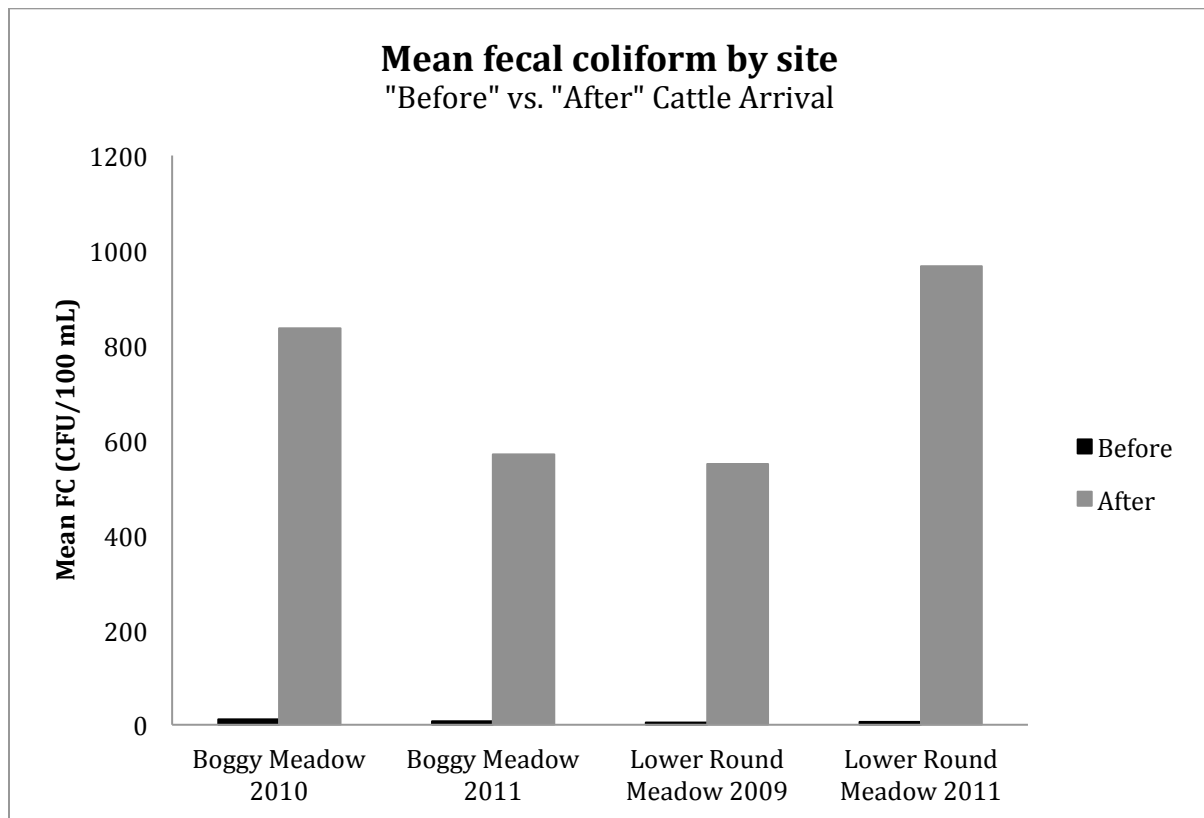
comparison of the *E. coli* results between 2009 and 2011. See Figure 6 for a comparison of the fecal coliform results from the two years.

Figure 1. The graph depicts the results for the average *E. coli* concentrations for the “before grazing” and “after livestock arrival” at Boggy Meadow in 2010 and 2011 and Lower Round Meadow in 2009 and 2011:



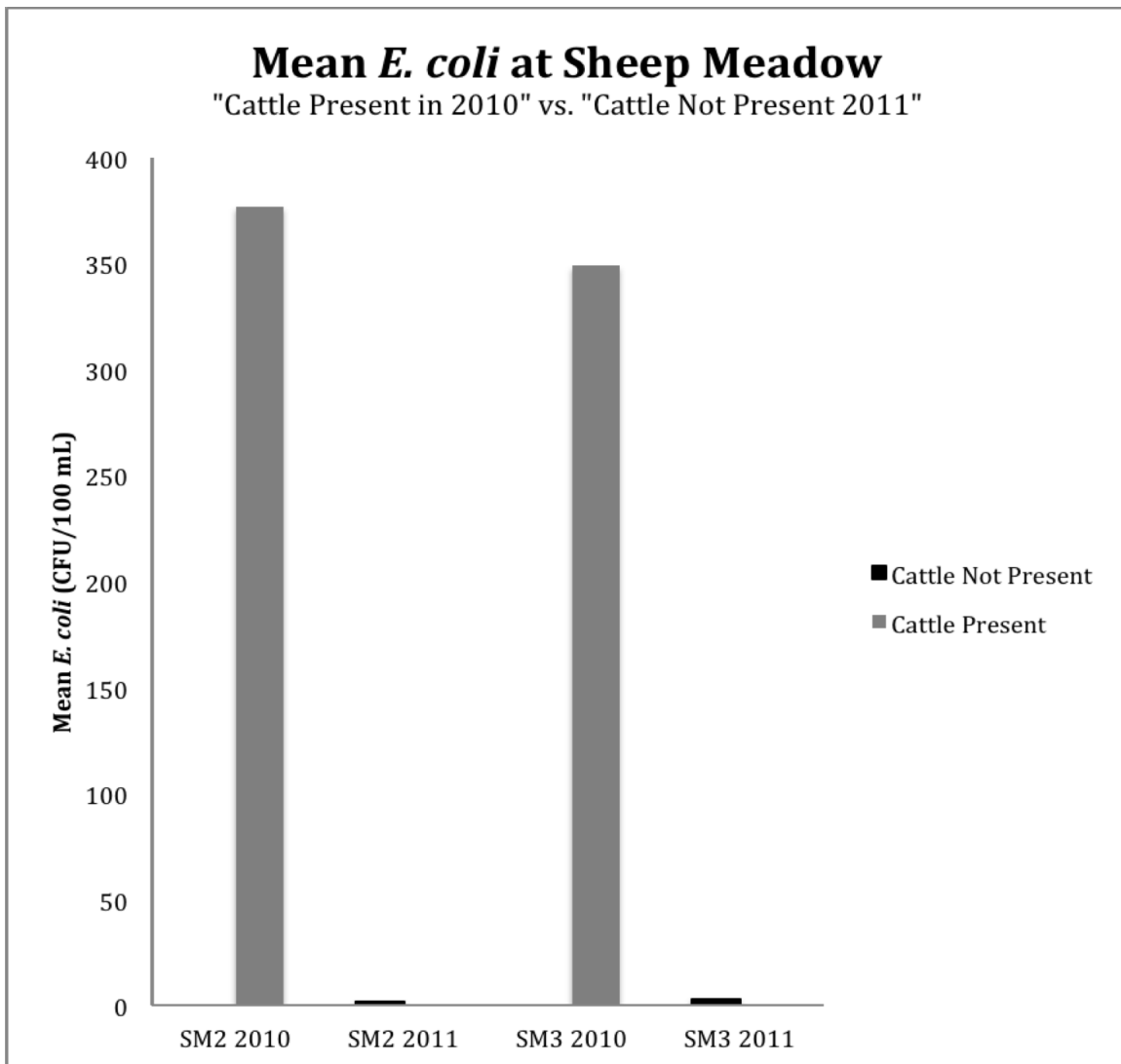
Note: The bar charts above shows the average *E. coli* concentrations “before” and “after” the commencement of grazing for each year sampled for both sites.

Figure 2. This graph depicts the results for the average fecal coliform concentrations for the “before grazing” and “after livestock arrival” at Boggy Meadow in 2010 and 2011 and Lower Round Meadow in 2009 and 2011:



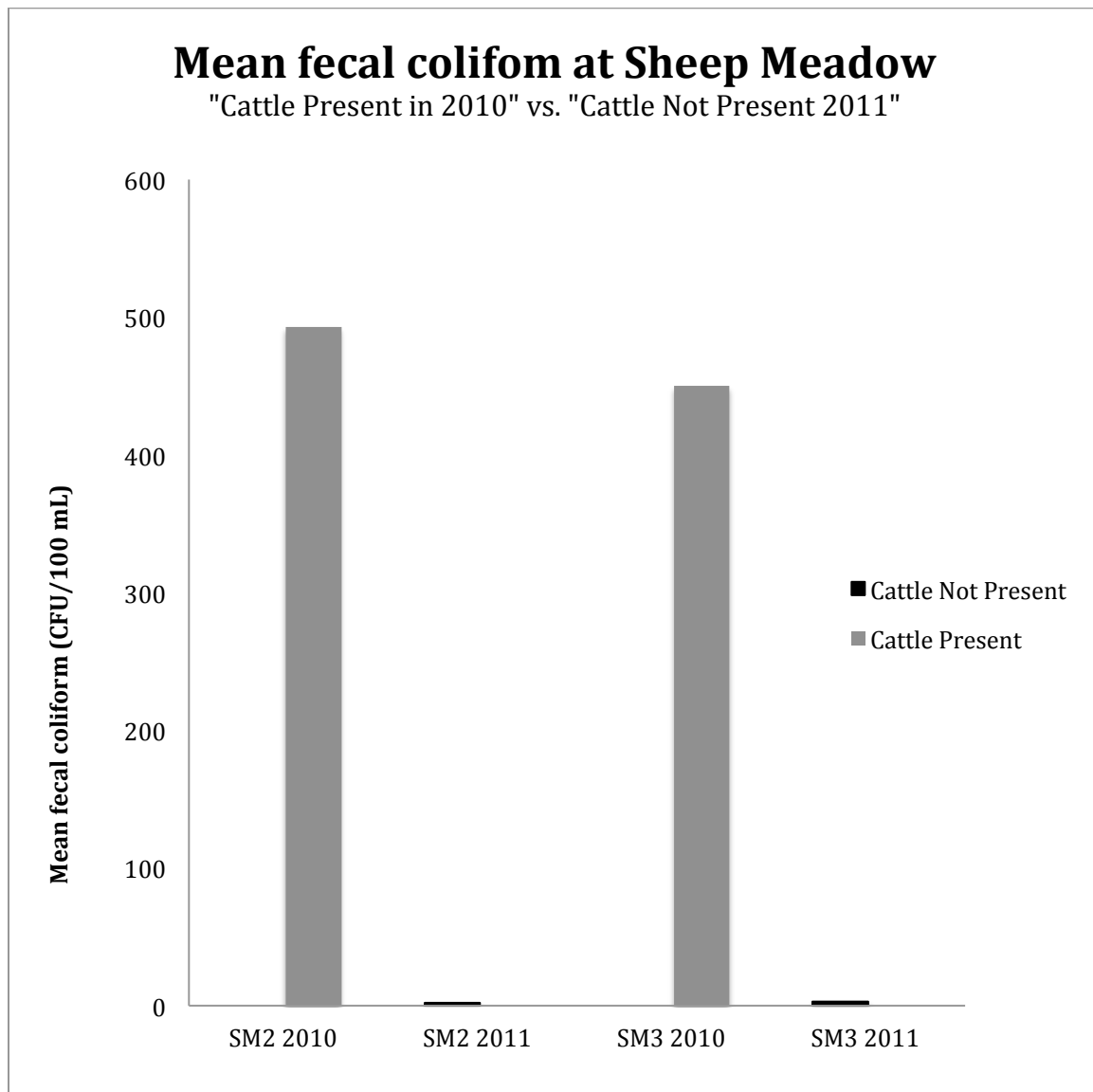
Note: The bar charts above shows the average fecal coliform concentrations “before” and “after” the commencement of grazing for each year sampled for both sites.

Figure 3. The graph depicts the results for the average *E. coli* concentrations for “Cattle Not Present” samples taken in 2011 and for “Cattle Present” samples taken in 2010 at Sheep Meadow:



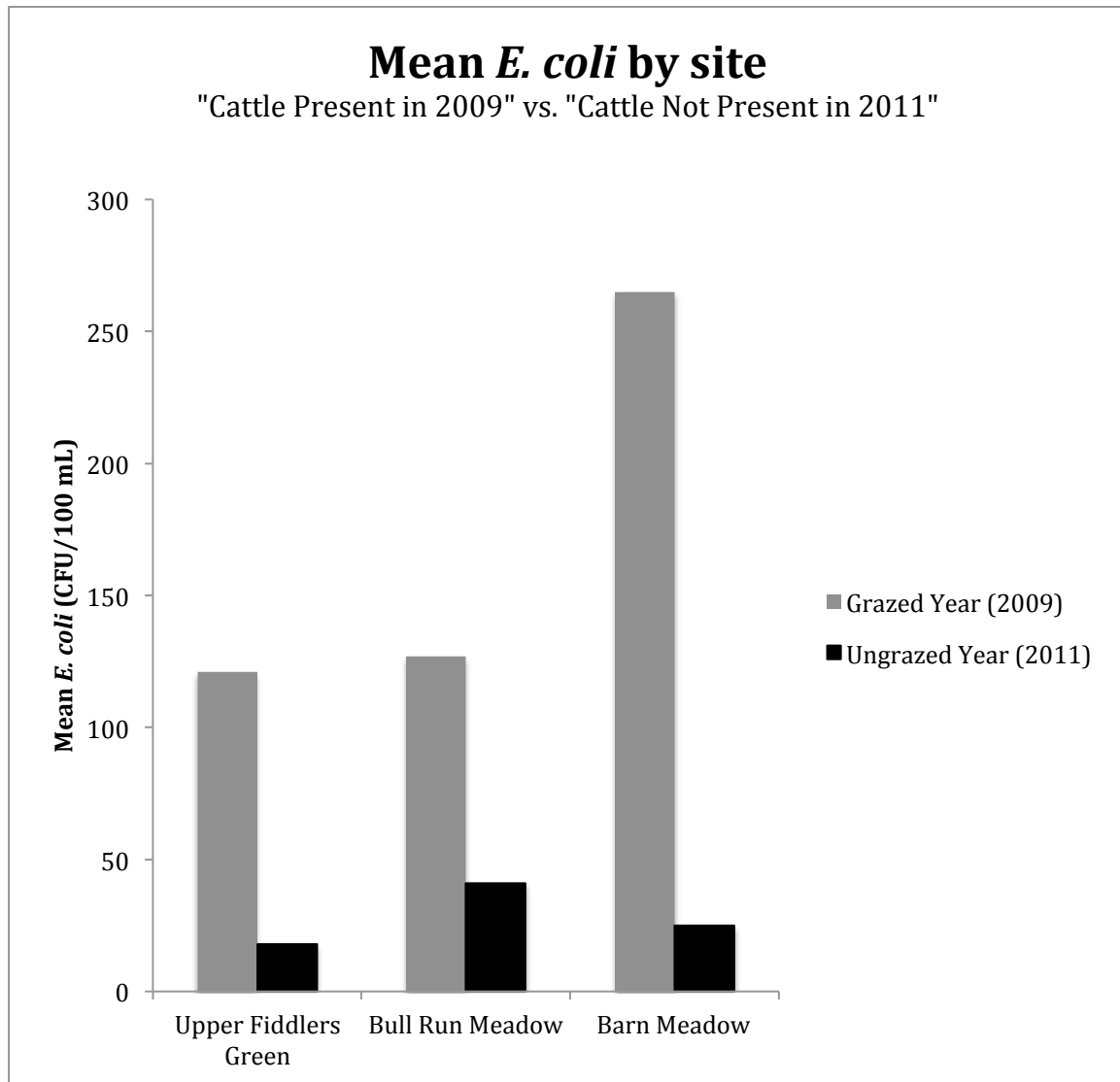
Note: The bar charts above shows the average *E. coli* concentrations for the same two sites for two different years (one year with and one year without livestock presence).

Figure 4. This graph depicts the results for the average fecal coliform concentrations for “Cattle Not Present” samples taken in 2011 and for “Cattle Present” samples taken in 2010 at Sheep Meadow:



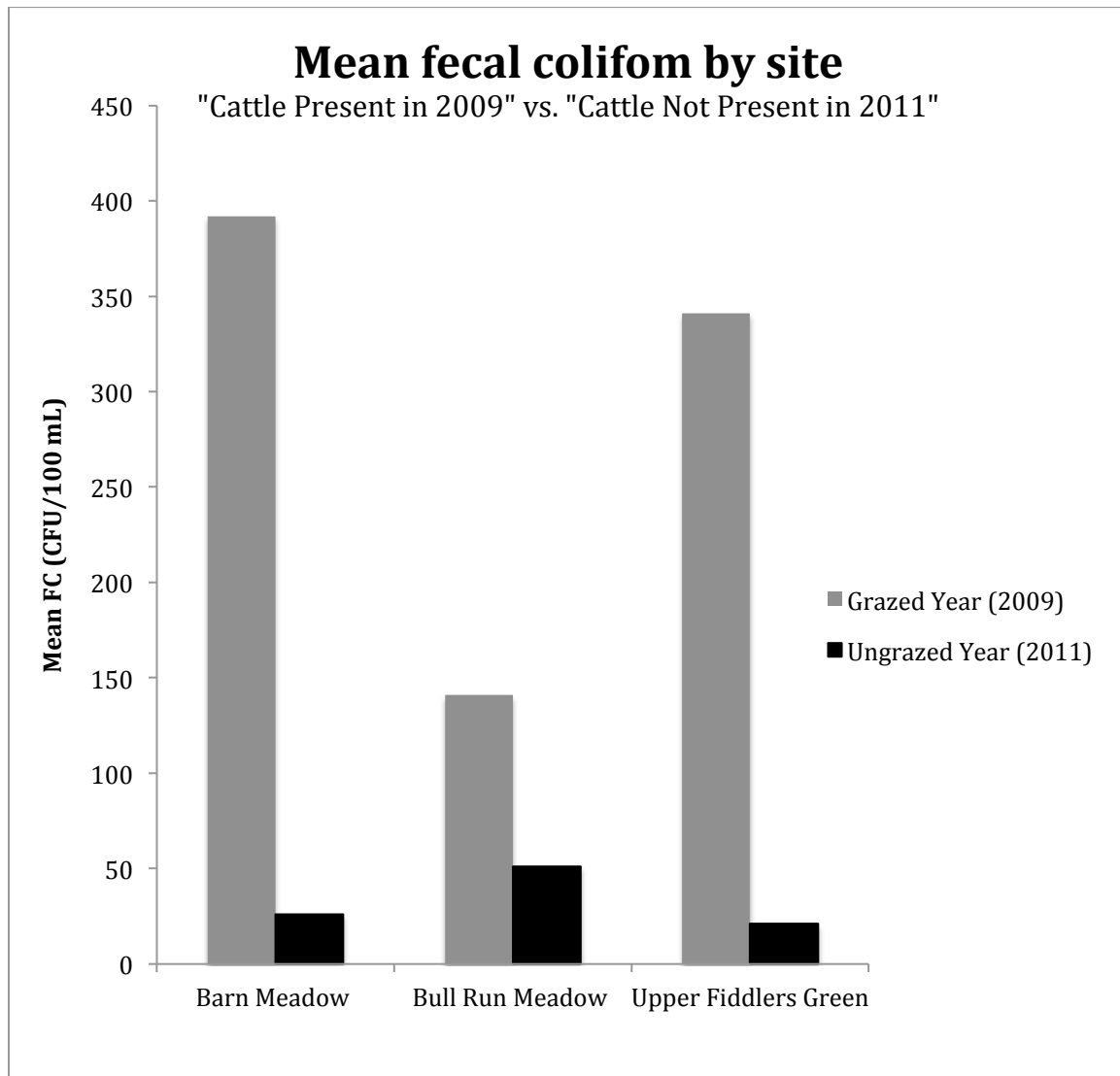
Note: The bar charts above shows the average fecal coliform concentrations for the same two sites for two different years (one year with and one year without livestock presence).

Figure 5. The graph depicts the results for the average *E. coli* concentrations for “Cattle Present/Grazed” samples taken in 2009 and for “Cattle Not Present/Ungrazed” samples taken in 2011 during the same time period at Upper Fiddlers Green, Bull Run Meadow, and Barn Meadow:



Note: The bar charts above shows the average *E. coli* and fecal coliform concentrations at the same sample sites for two different years (one year with and one year without livestock presence).

Figure 6. This graph depicts the results for the average fecal coliform concentrations for “Cattle Present/Grazed” samples taken in 2009 and for “Cattle Not Present/Ungrazed” samples taken in 2011 during the same time period at Upper Fiddlers Green, Bull Run Meadow, and Barn Meadow:



Note: The bar charts above shows the average fecal coliform concentrations at the same sample sites for two different years (one year with and one year without livestock presence).

Conclusion

Study results in 2011 continue to document that significant pollution of surface waters is resulting from cattle grazing as currently permitted and regulated on National Forest System lands.

After three years of collecting water samples for bacteriological testing throughout the Stanislaus National Forest, the results remain consistent. The concentration of indicator bacteria detected in the forest waters is very low until cattle are released into summer grazing allotments. Shortly after cattle are present, the concentration of indicator bacteria rapidly rises and remains high as long as the cattle are present.

Of particular interest are the results from Bourland Meadow (“ungrazed/control site”), where no livestock grazing takes place. For three consecutive years Bourland Meadow has been tested for indicator bacteria; no high concentrations of *E. coli* or fecal coliform have been detected at this site. In comparison to the consistently low concentrations of indicator bacteria found at Bourland Meadow and at sites before cattle are present, the increase of indicator bacteria found in streams when livestock are present is substantial. Excepting livestock, the stream at Bourland Meadow experienced the same general weather conditions, exposure to wildlife use, dispersed recreation, and other environmental influences as the sample streams that experienced rapid rises and high concentrations of indicator bacteria.