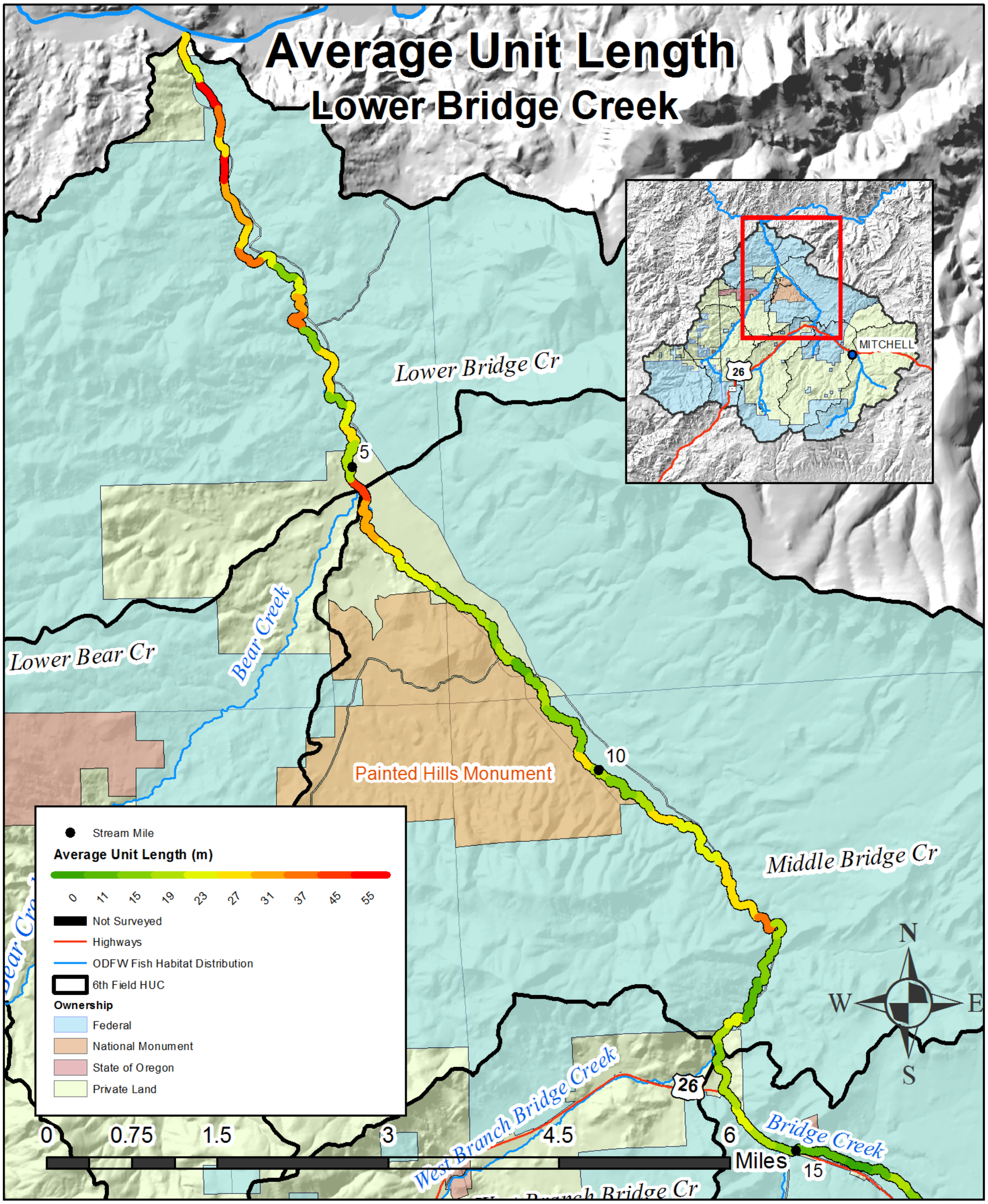

FIGURE 16 - SPATIAL DISTRIBUTION OF AVERAGE UNIT LENGTH (LOWER WATERSHED)

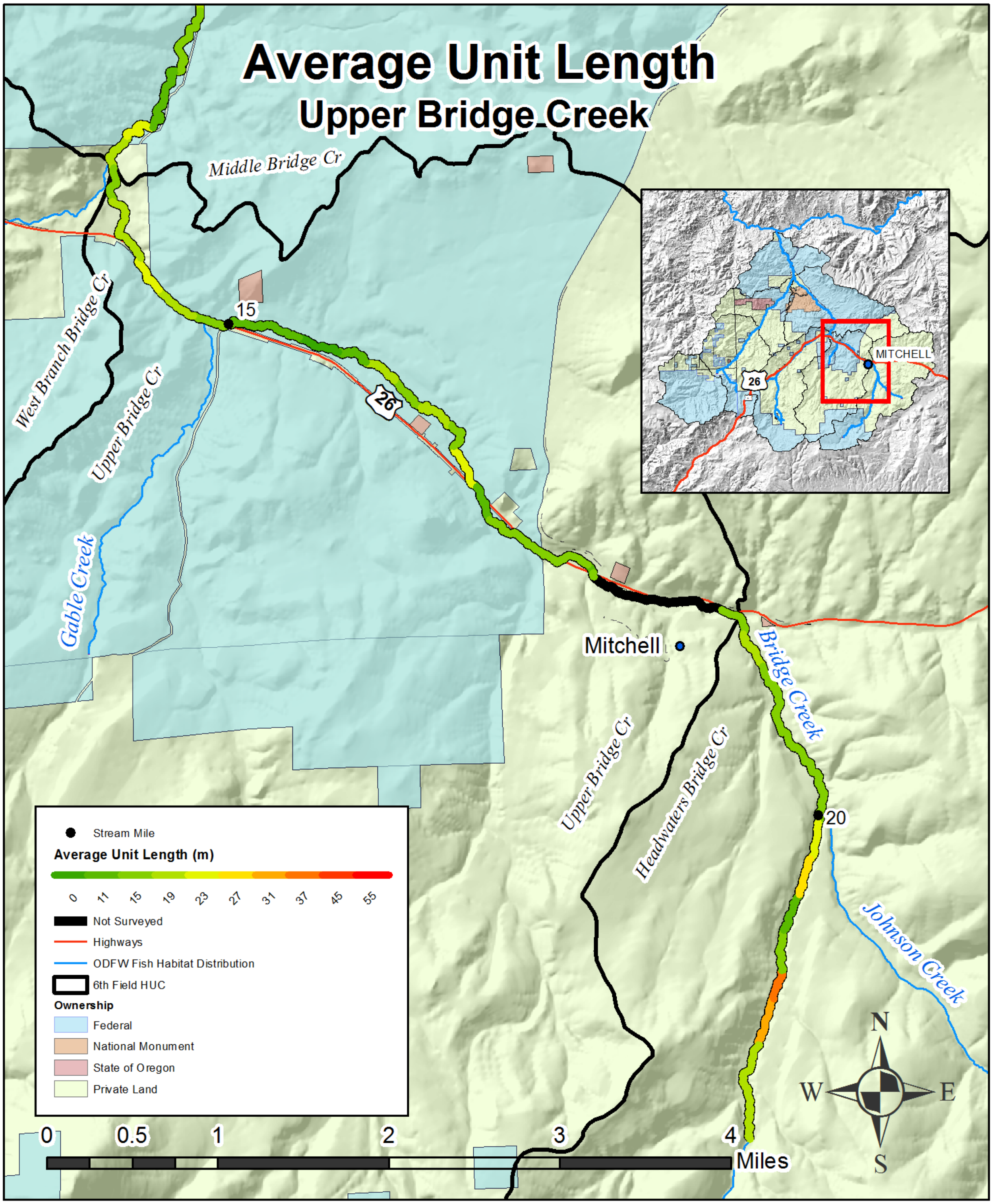

FIGURE 17 - SPATIAL DISTRIBUTION OF AVERAGE UNIT LENGTH (UPPER WATERSHED)

Large Boulder Prevalence

During the field survey, large boulders were identified as boulders with a diameter greater than 0.5 meters. The total boulder count was recorded for each unit. Large boulder prevalence was calculated as the average number of large boulders per 400 meters of stream length using the following formula:

$$Large\ Boulder\ Prevalence = \frac{\sum_{i=1}^{n} Boulder\ Count_i}{\sum_{i=1}^{n} Length_i} \cdot 400 \qquad (4)$$

Boulders serve to disrupt high velocity flows, minimize erosion, and provide low velocity eddies utilized by fish across multiple age classes. The distribution of large boulder prevalence amongst the reaches is shown in Figure 18 and Figure 19. The spatial distribution of large boulder prevalence is shown in Figure 20 and Figure 21. Overall, Bridge Creek is lacking in large boulders. Approximately half of the 400 meter reaches were completely devoid of any rocks larger than 0.5 meters in diameter. Areas that do contain boulders are spread throughout the watershed. The spatial distribution is highly variable with areas with a large amount of boulder scattered amongst areas that are completely devoid.

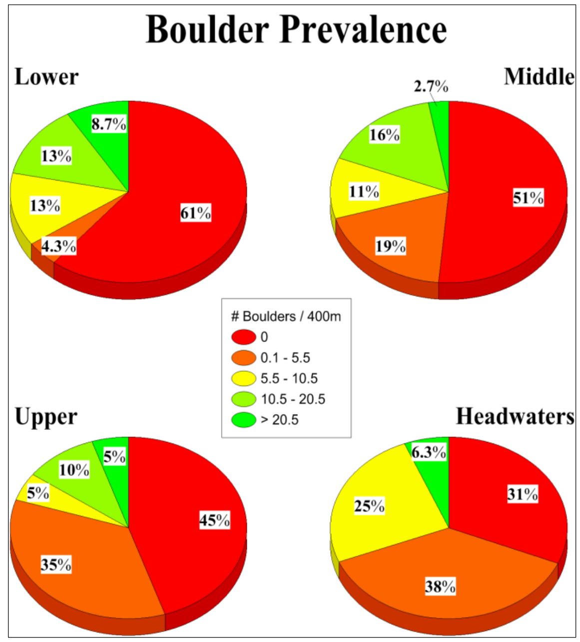

FIGURE 18 - REACH AVERAGED BOULDER PREVALENCE

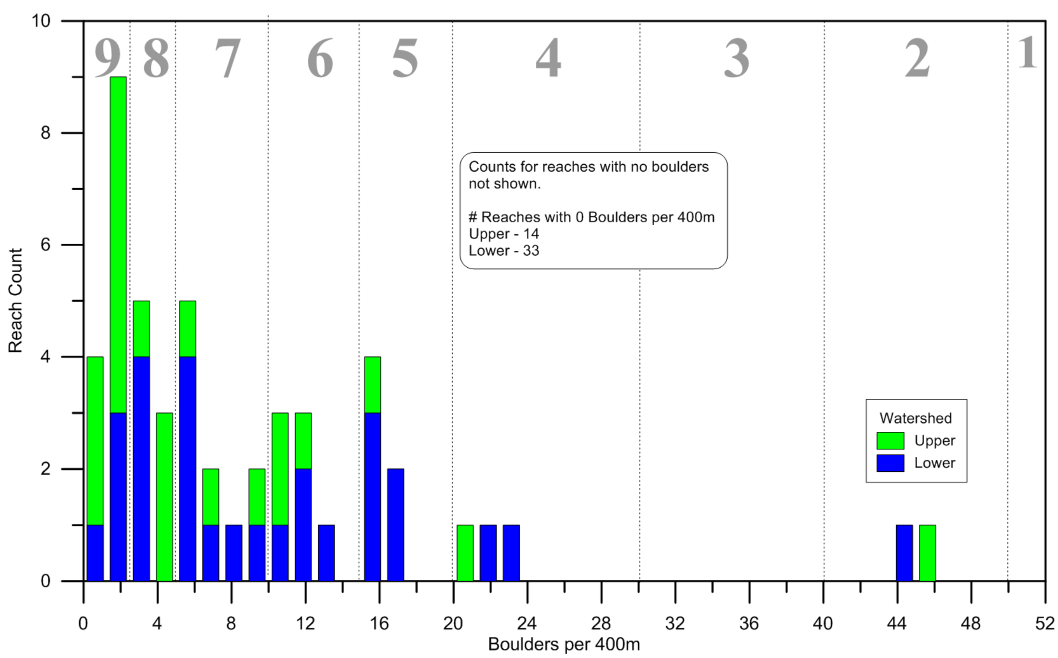

FIGURE 19 - LARGE BOULDER PREVALENCE DISTRIBUTION

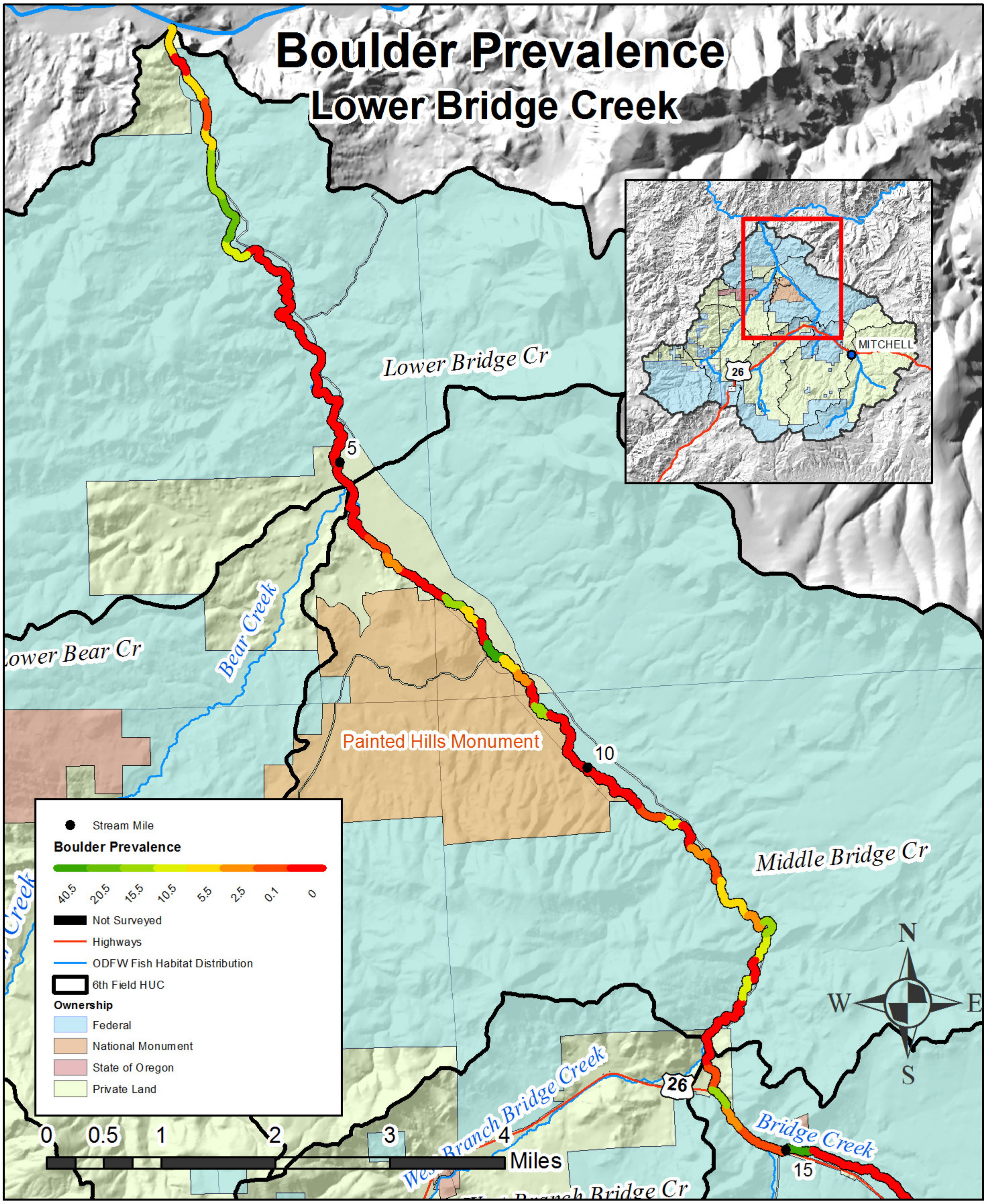

FIGURE 20 - SPATIAL DISTRIBUTION OF LARGE BOULDER PREVALENCE IN LOWER BRIDGE CREEK

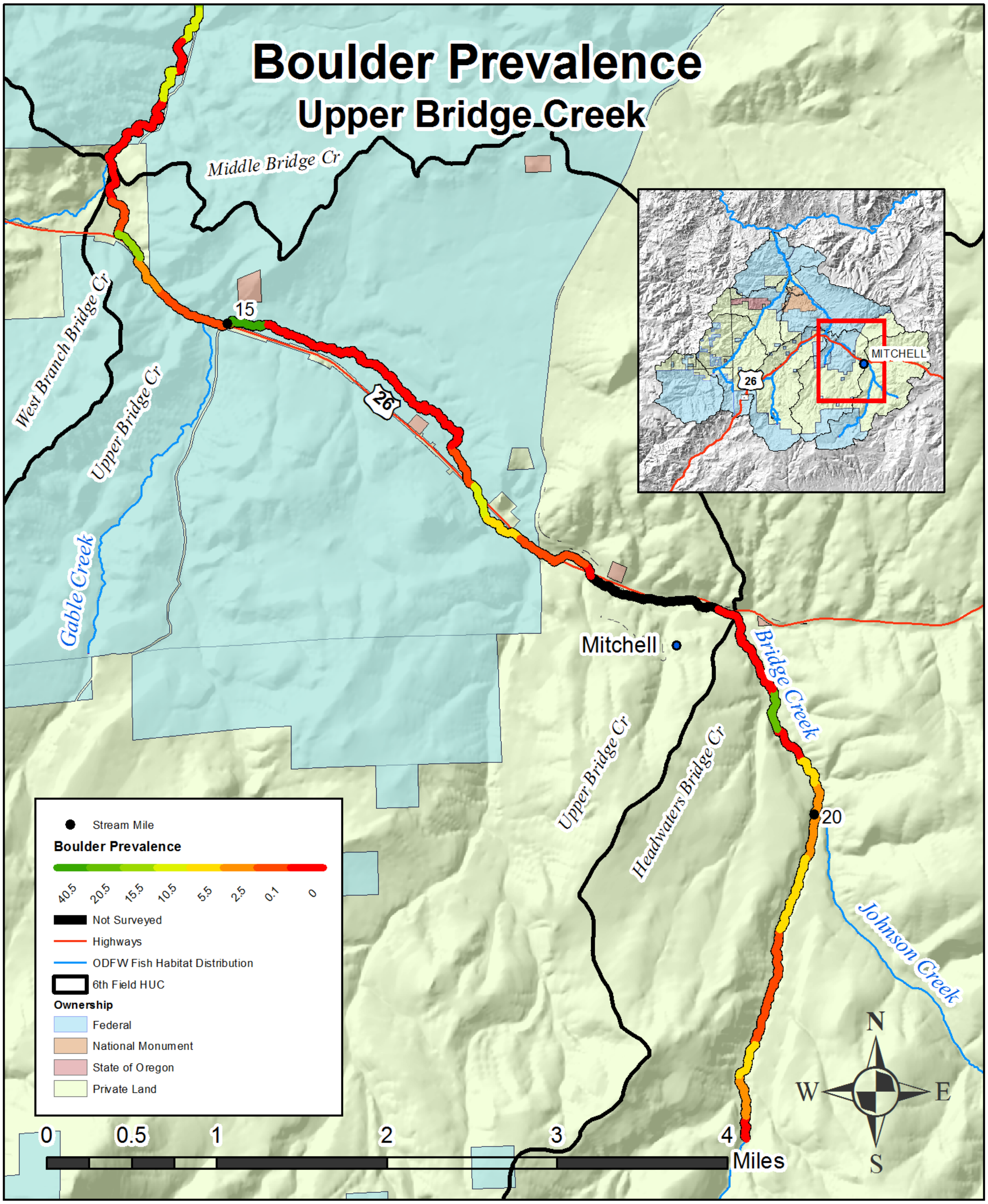

FIGURE 21 - SPATIAL DISTRIBUTION OF LARGE BOULDER PREVALENCE IN UPPER BRIDGE CREEK

Woody Debris Prevalence

Woody debris that were encountered during the survey were divided into three classes (small, medium, large) according to Table 9.

TABLE 9 - WOODY DEBRIS SIZE CLASS CRITERIA

Woody Debris Size Class	Description
Small (S)	15 cm diameter x 3 m length
Medium (M)	30 cm diameter x 6 m length
Large (L)	60 cm diameter x 10 m length

A single metric for woody debris prevalence was established whereby the three size classes were weighted such that a medium piece of woody debris was equivalent to three small pieces and a large piece was equivalent to five small pieces. The average amount of woody debris (*WD*) over a 400 meter reach was calculated for each quarter mile reach using the following formula:

$$Woody\ Debris\ Prevalence = \frac{\sum_{i=1}^{n}(S.WD_i + 3 \cdot M.\ WD_i + 5 \cdot L.WD_i\ )}{\sum_{i=1}^{n} Length_i} \cdot 400 \qquad (5)$$

The distribution of values for woody debris prevalence is shown in Figure 22. The vast majority of Bridge Creek is devoid of woody debris. A total of 19 pieces of woody debris were identified during the survey (all medium size); five of which were in the lower watershed, the other 14 in the upper watershed. Distribution maps are provided in Figure 23 and Figure 24. No pie chart is provided for this metric due to the scarcity of large wood within the watershed.

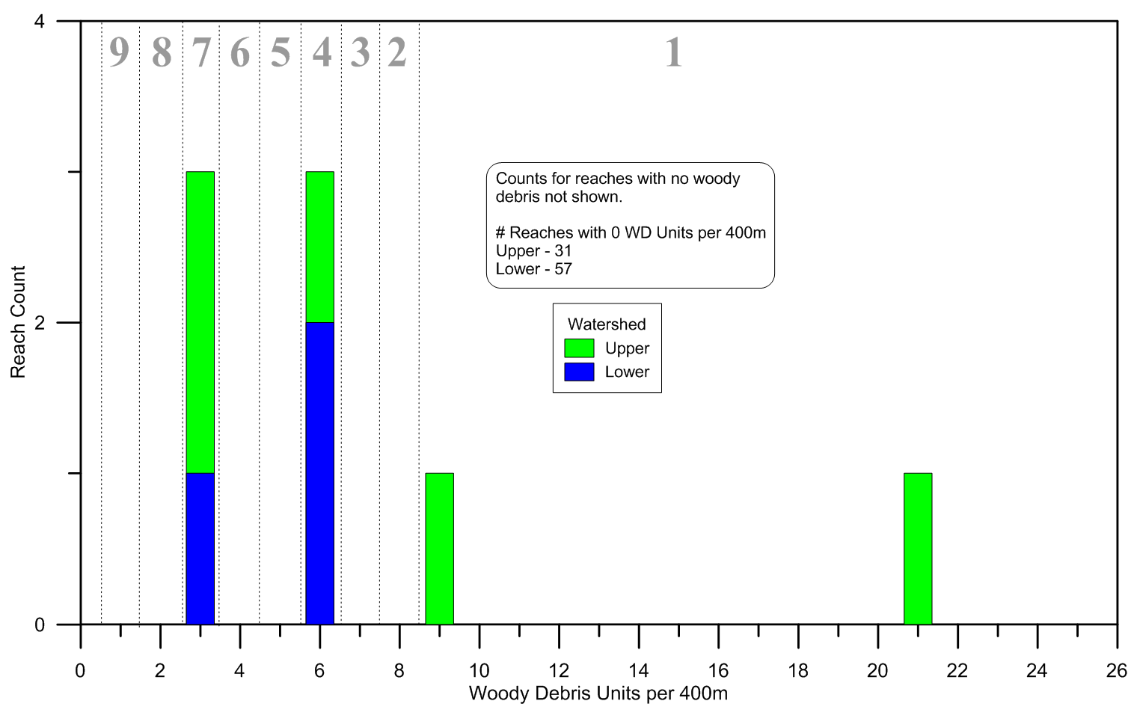

FIGURE 22 - WOODY DEBRIS PREVALENCE VALUE DISTRIBUTION

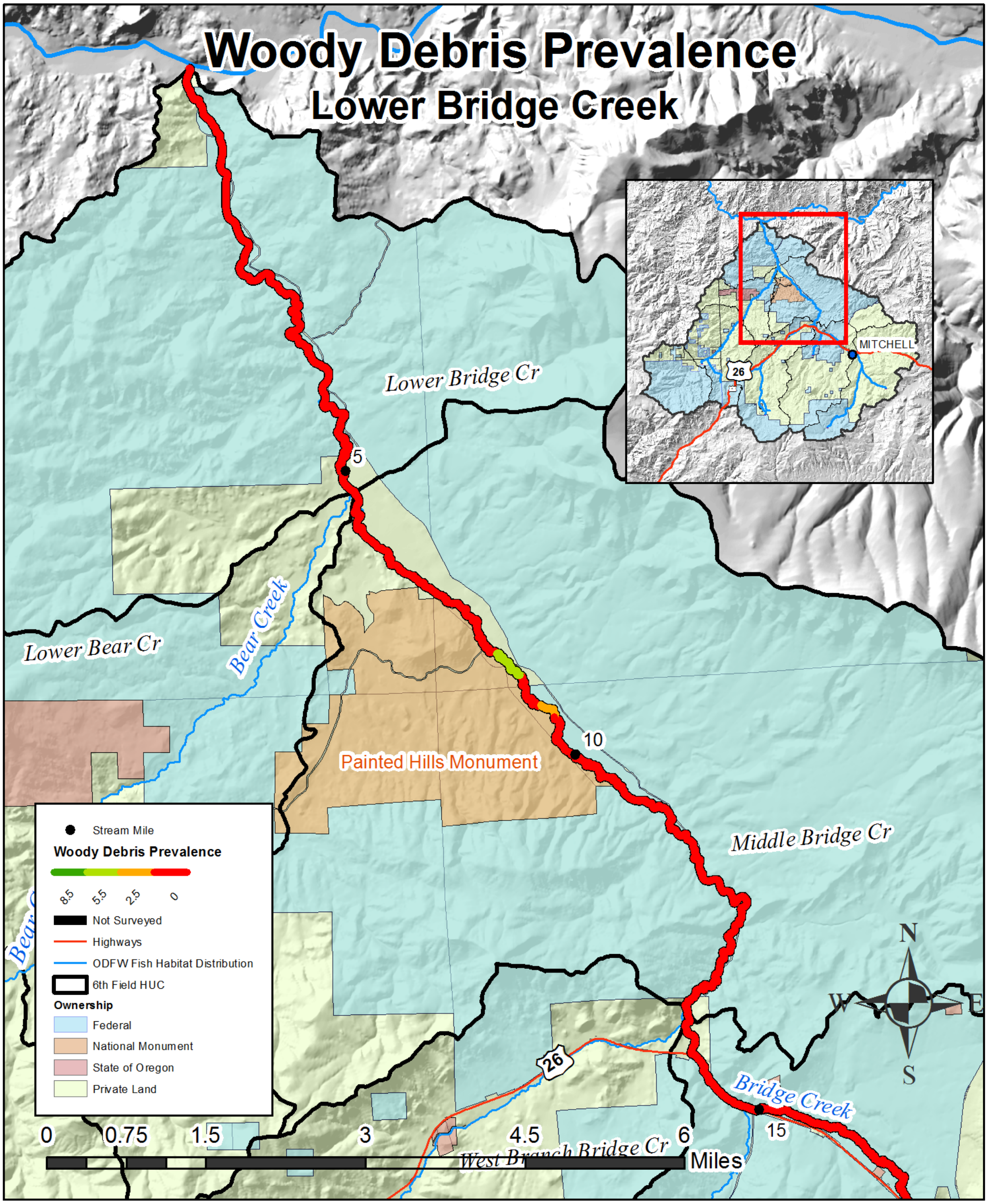

FIGURE 23 - WOODY DEBRIS PREVALENCE IN LOWER BRIDGE CREEK

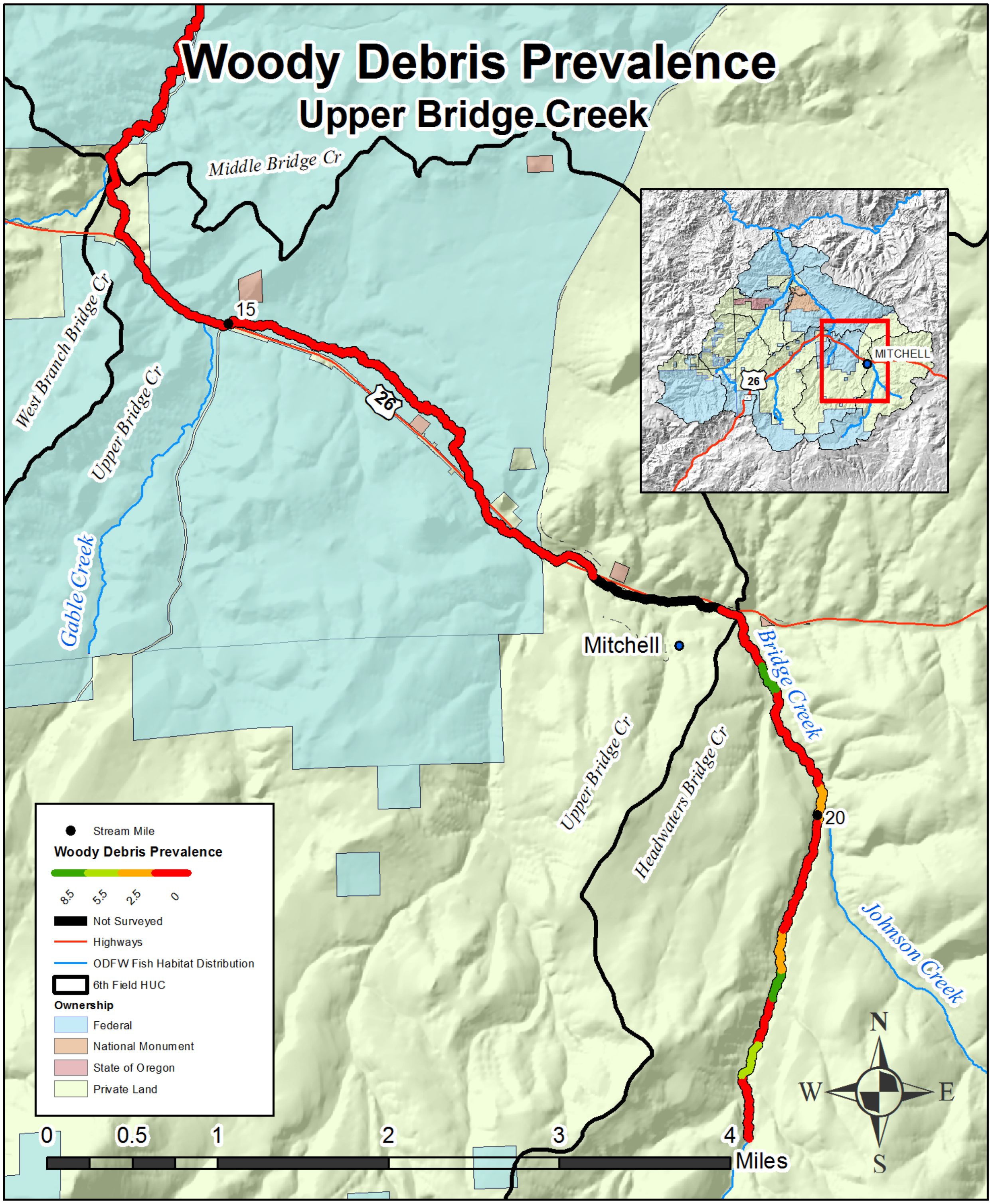

FIGURE 24 - WOODY DEBRIS PREVALENCE IN UPPER BRIDGE CREEK

Substrate Composition

Six distinct substrate types were used for the classification of each unit during the survey. Each of these substrate classes was assigned a rating based on their relative merits. These ratings represent a first attempt at assigning a numerical value to a substrate type. Preference was given to gravel (spawning substrate) and boulders (habitat complexity). Further evaluation will likely lead to different rating numbers. The different classes of substrate identified in the survey along with the ratings are outlined in Table 10.

TABLE 10 - SUBSTRATE DESCRIPTION AND RATING

Substrate (S)	Description	Rating (R)
S/O	Silt and organic material (stays suspended)	0
SND	Sand (settles to bottom when disturbed)	1
GRVL	Gravel (pea to baseball)	4
CBLE	Cobble (baseball to bowling ball)	3
BLDR	Boulder (larger than a bowling ball)	4
BDRCK	Bedrock (solid rock)	0

The percentage of each substrate type was recorded for each unit, providing a detailed inventory of substrate composition. The rating system was necessary to establish a single metric based on the relative abundance of all substrate types. The formula for computing the substrate composition metric of each quarter mile reach uses the percentage of each substrate and the established rating as follows:

$$Substrate\ Composition = \frac{\sum_{i=1}^{n}\left(\sum_{j=1}^{6} \%S_{ij} \cdot R_j\right) Length_i}{\sum_{i=1}^{n} Length_i} \tag{6}$$

where the *i* index represents each unit and the *j* index represents each substrate type. S and R represent the percent abundance of a given substrate type and the substrate rating respectively. A single value that is calculated with this formula is arbitrary, but a relative comparison identifies the reaches with a higher percentage of desirable substrate. The distribution of the values calculated using this formula is shown in Figure 25. Overall the higher ranked substrate types are more prevalent in the upper watershed. There are several reaches with very low ratings that are distributed in the middle and lower reaches of Bridge Creek. These reaches with poor ratings are most likely areas with large pools that are actively aggrading. While these do not provide ideal spawning substrate, the pools are essential habitat for the rearing of young fish.

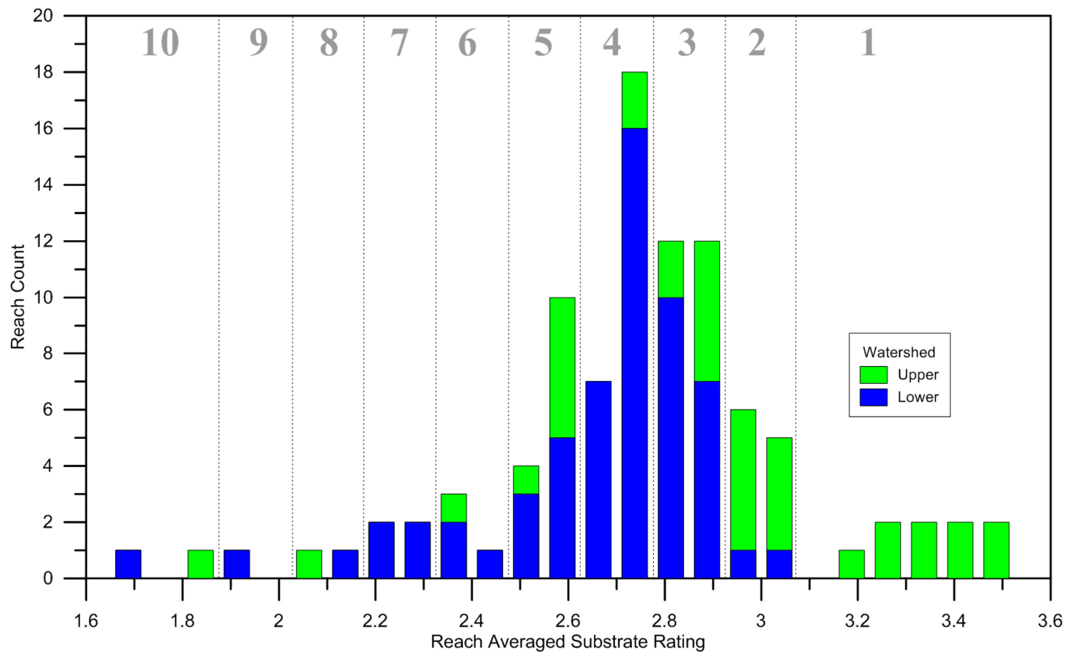

FIGURE 25 - DISTRIBUTION OF SUBSTRATE COMPOSITION VALUES

Using this distribution, a rating table was established as defined in Table 11.

TABLE 11 - SUBSTRATE COMPOSITION RATING

Substrate Composition Score	Rating
> 3.075	1
2.925 - 3.075	2
2.775 - 2.925	3
2.625 - 2.775	4
2.475 - 2.625	5
2.325 - 2.475	6
2.175 - 2.325	7
2.025 - 2.175	8
1.875 - 2.025	9
< 1.875	10

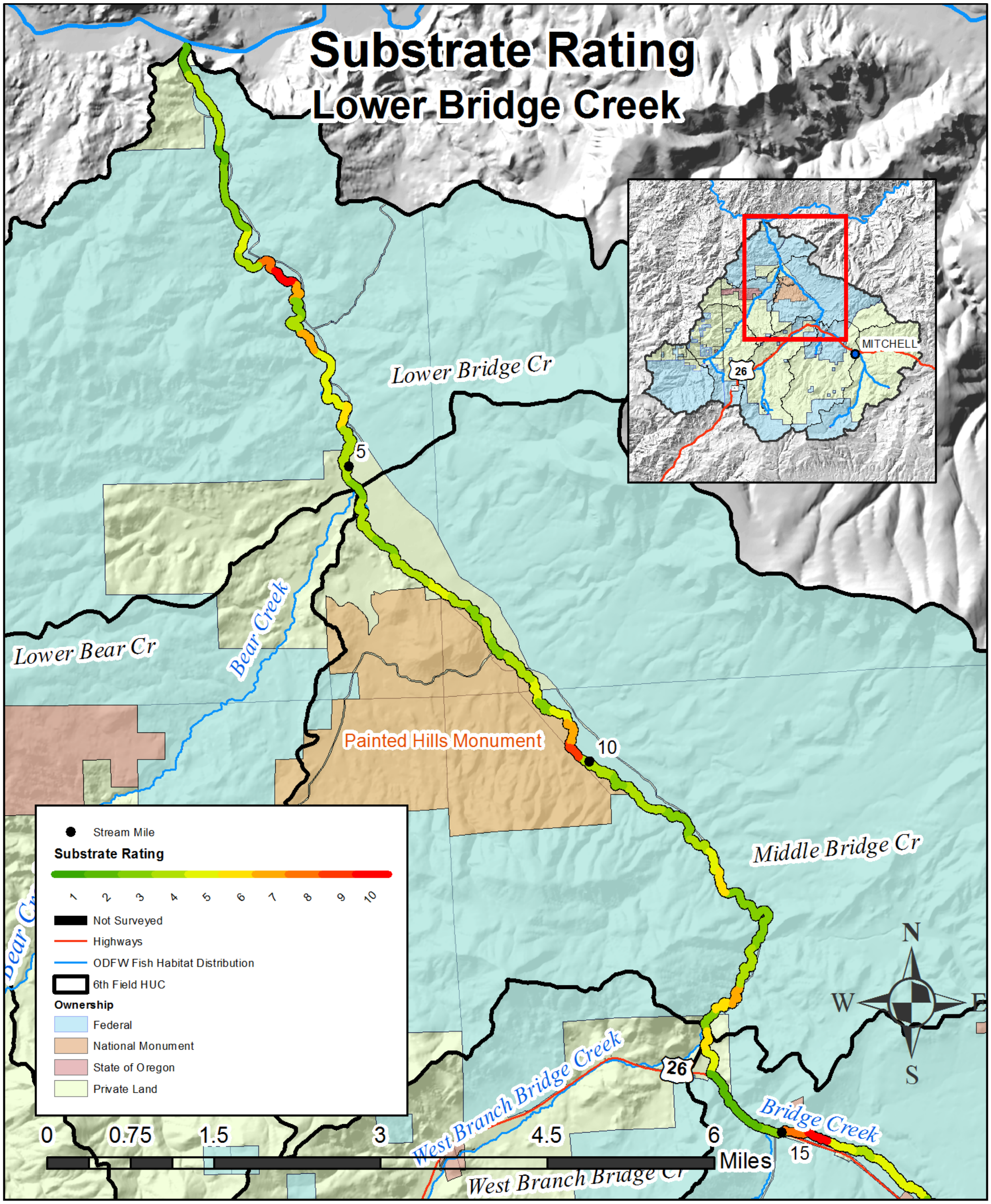

FIGURE 26 – SUBSTRATE RATING OF LOWER BRIDGE CREEK

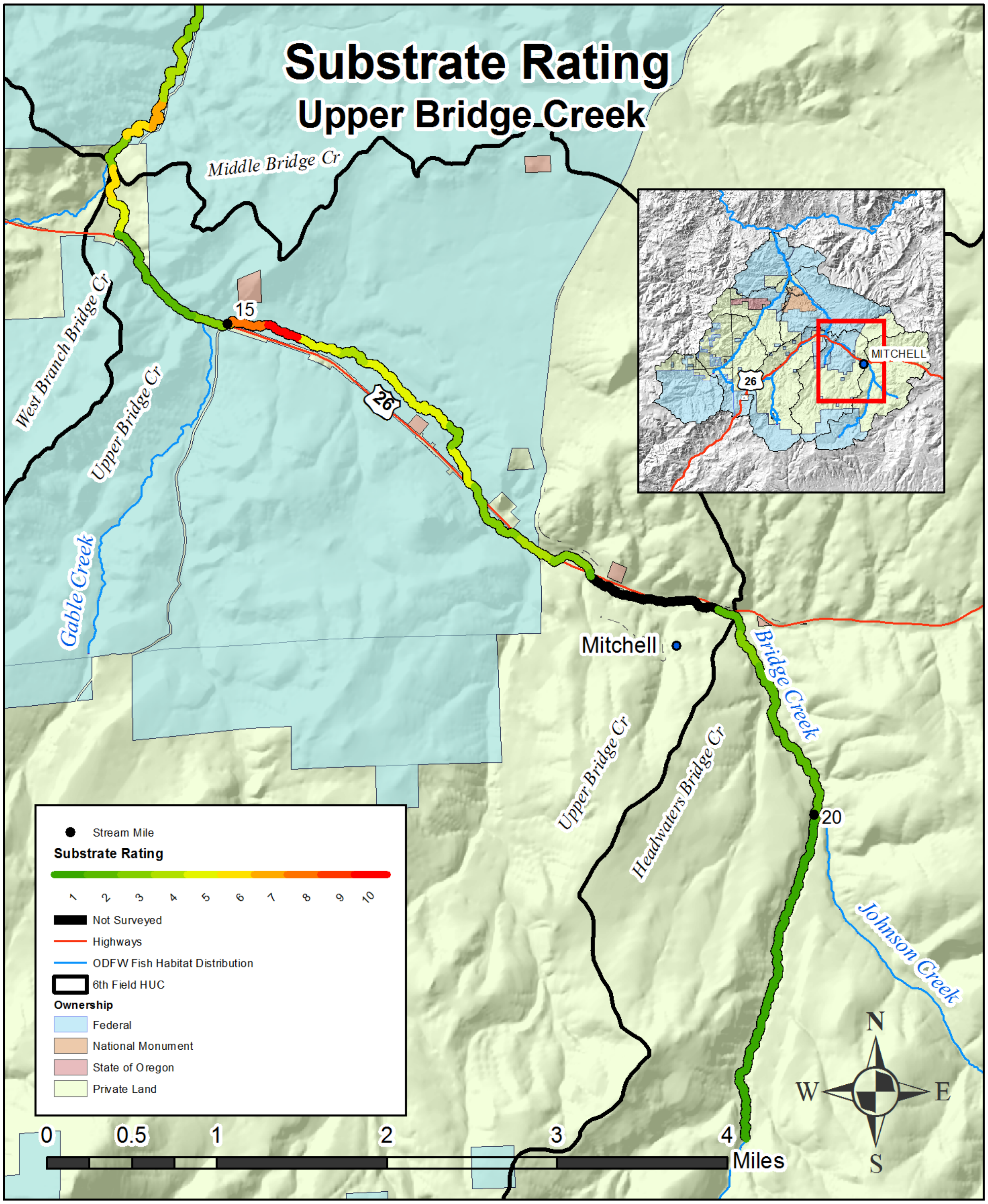

FIGURE 27 – SUBSTRATE RATING OF UPPER BRIDGE CREEK

Gravel Prevalence

In addition to a combined substrate rating, the surveyed reaches were assessed by simply examining the average percent gravel in the substrate. Each unit within a reach was averaged based on the unit length in a similar fashion to the previously discussed metrics. As expected, the gravel distribution follows a very similar pattern as the total substrate composition. Overall there is a large proportion of gravels in Bridge Creek, with median levels near 40% gravel. Higher densities of gravels are more evident higher in the watershed, suggesting more desirable spawning habitat.

Distribution of percent gravel is plotted in pie chart (Figure 28) and bar chart (Figure 29) format. Spatial distribution is shown in Figure 30 and Figure 31.

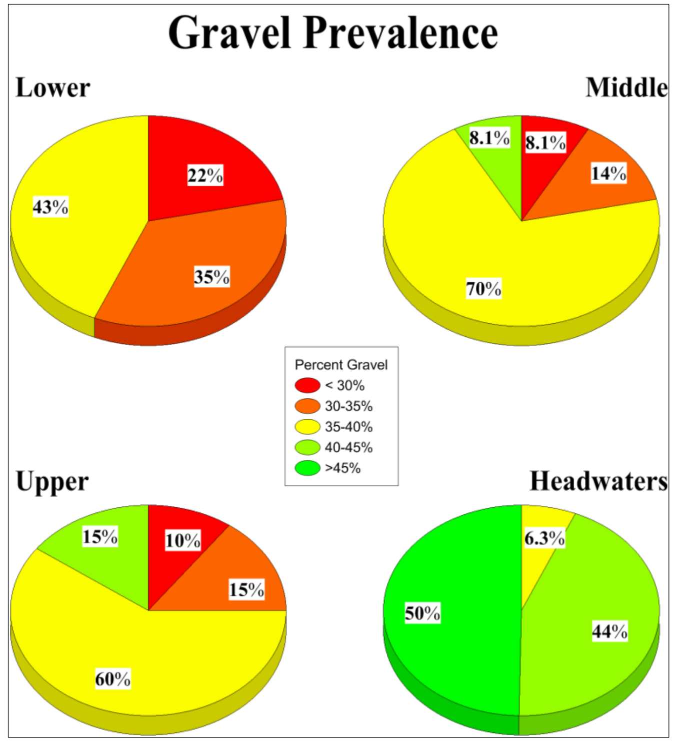

FIGURE 28 - REACH AVERAGED GRAVEL PREVALENCE

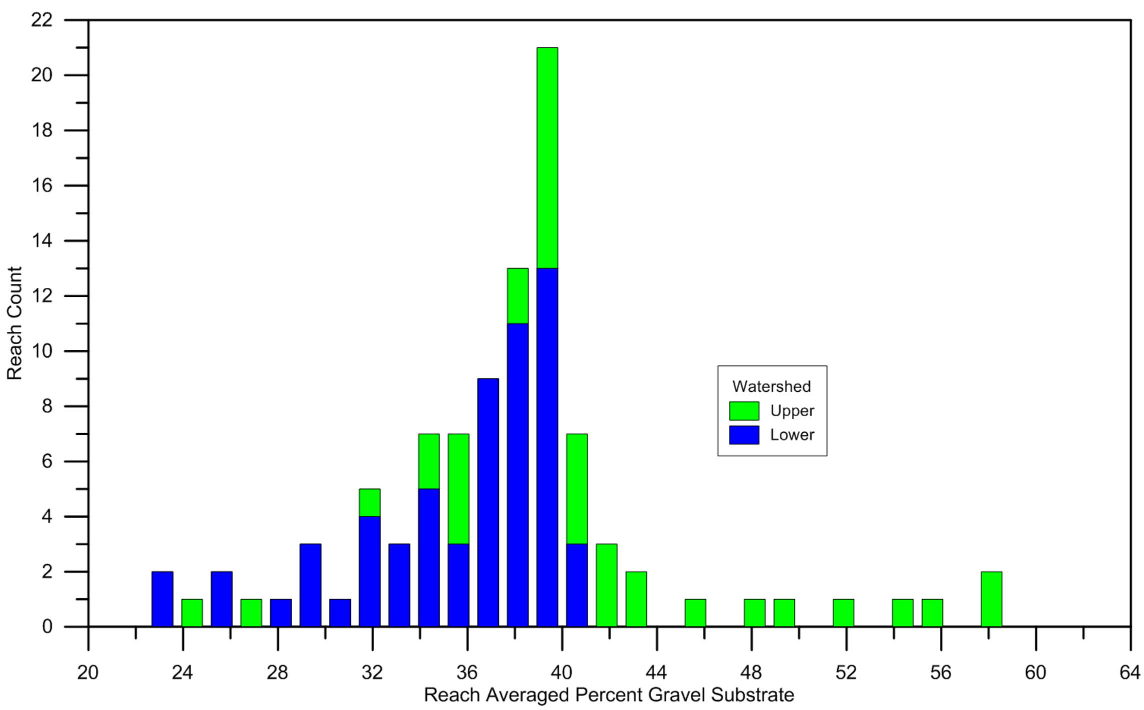

FIGURE 29 - PERCENT GRAVEL DISTRIBUTION ON BRIDGE CREEK

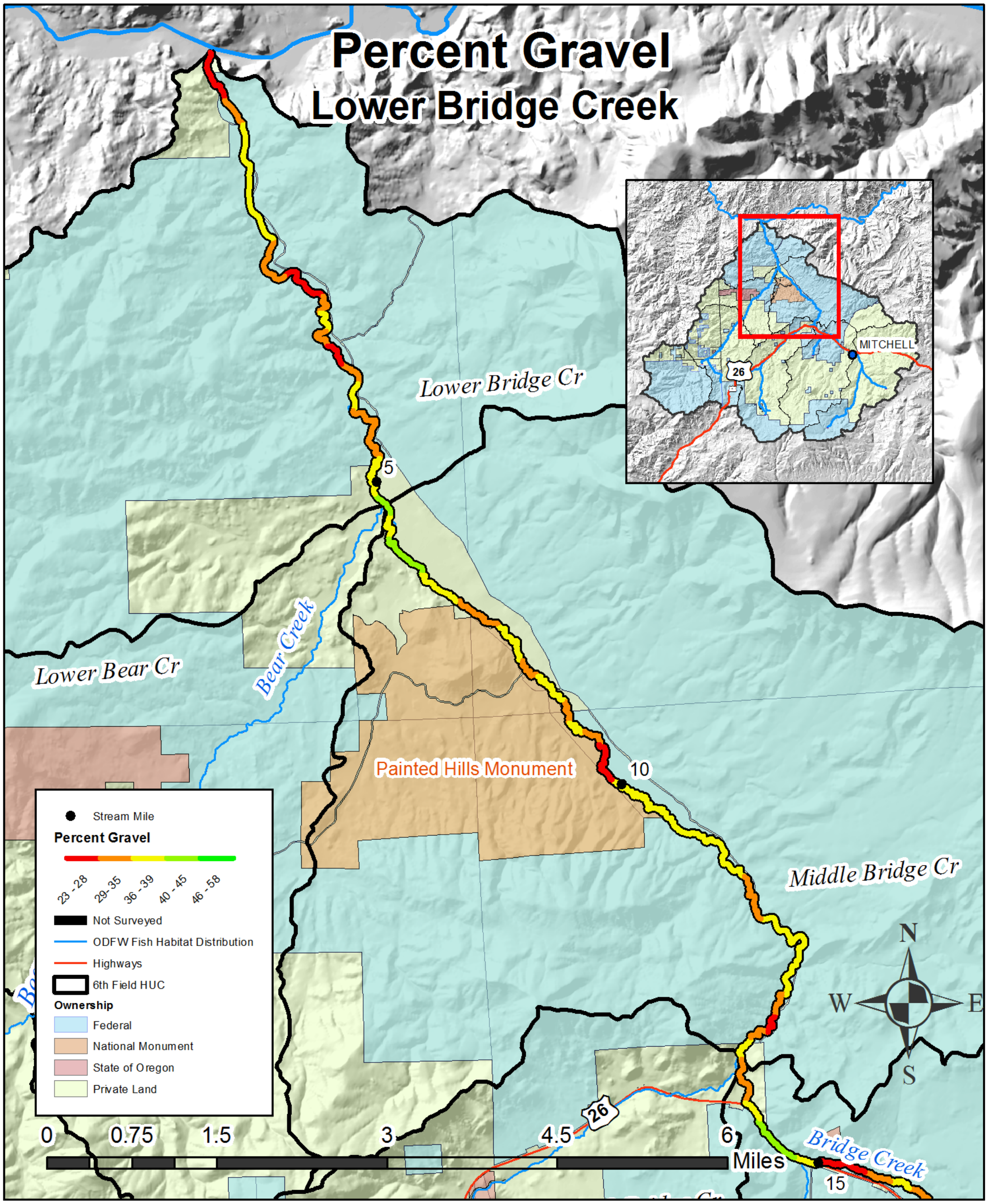

FIGURE 30 - PERCENT GRAVEL SUBSTRATE IN LOWER BRIDGE CREEK

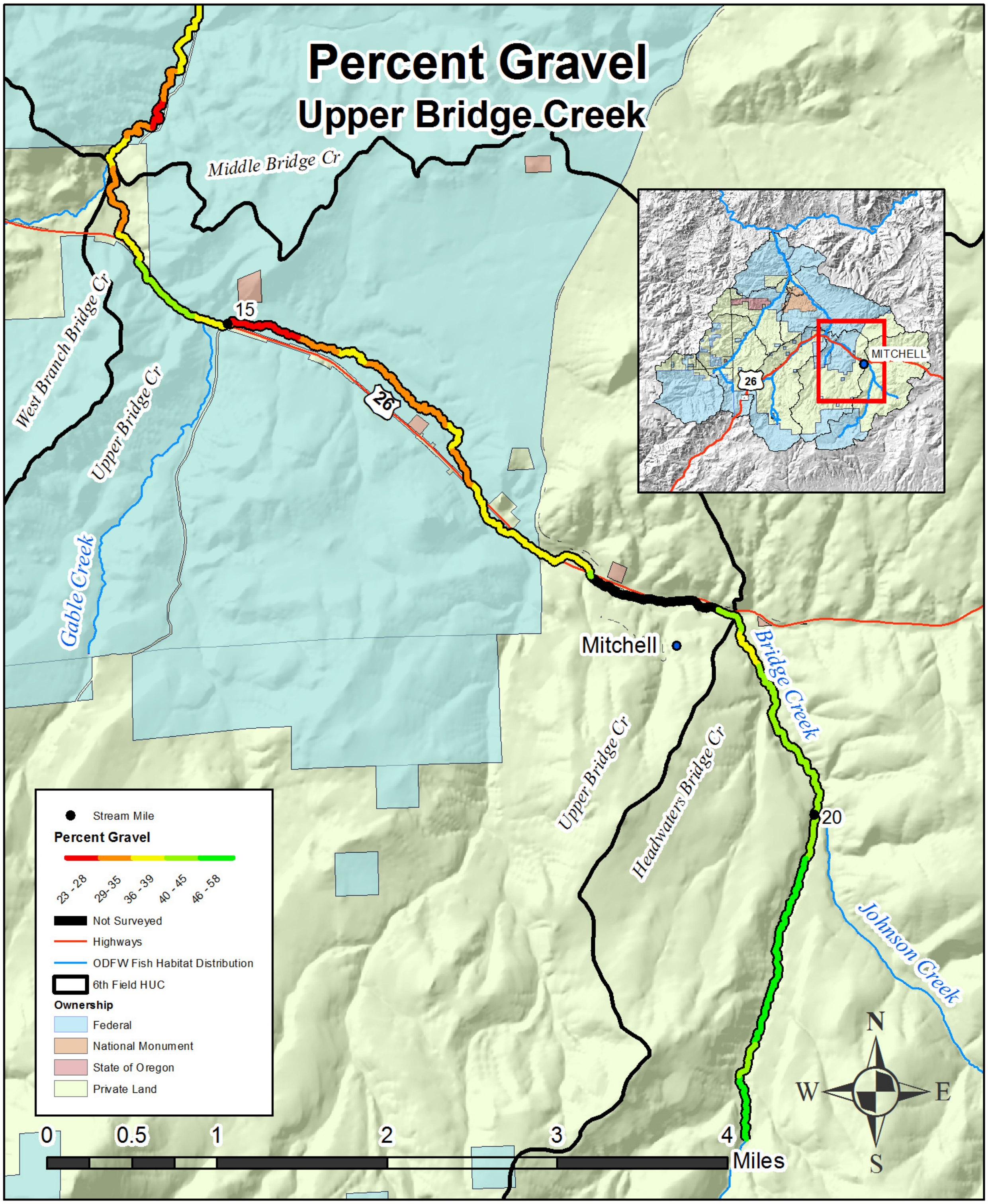

FIGURE 31 - PERCENT GRAVEL SUBSTREATE IN UPPER BRIDGE CREEK

PERCENT POOL HABITAT

The percentage of pool habitat in each reach was examined. Overall, the surveyed section of Bridge Creek contained just over 30% pools by length. These pools were broken down into five distinct types with the distribution shown in Table 12.

TABLE 12 - POOL HABITAT BY POOL TYPE

Code	Description	Percent of Total Surveyed Length
LP	Lateral Scour Pool	11.8%
SP	Straight Scour Pool	8.6%
BP	Beaver Dam Pool	6.2%
PP	Plunge Pool	2.3%
DP	Dammed Pool	1.5%
	Total	30.4%

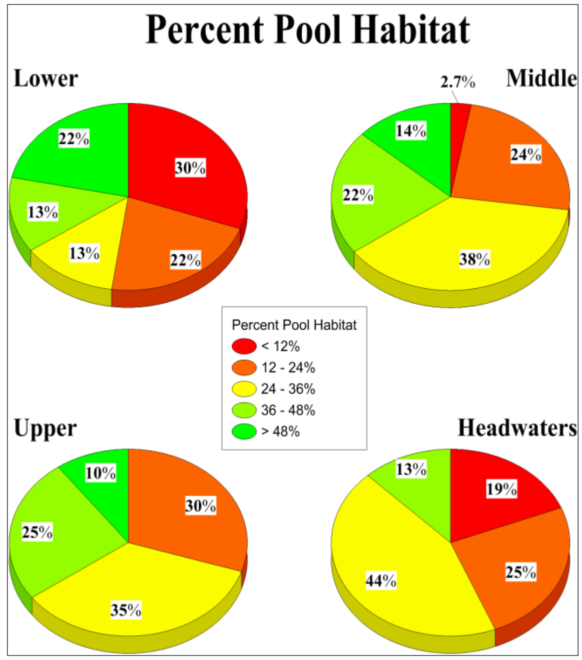

FIGURE 32 - REACH AVERAGED PERCENT POOL HABITAT

The Lower Bridge Creek HUC 6 had the highest distribution of both low pool density reaches and high density reaches; suggesting a large amount of diverse habitat. Overall the distribution of pool habitat was consistent throughout the four subwatersheds. The only areas that are relatively devoid of pool habitat are the lowest two miles above the mouth (RM0 - RM2) and the top three miles surveyed (RM20 - RM23). Distributions of the percent pool habitat is shown in plots (Figure 32 & Figure 33) and maps (Figure 34 & Figure 35).

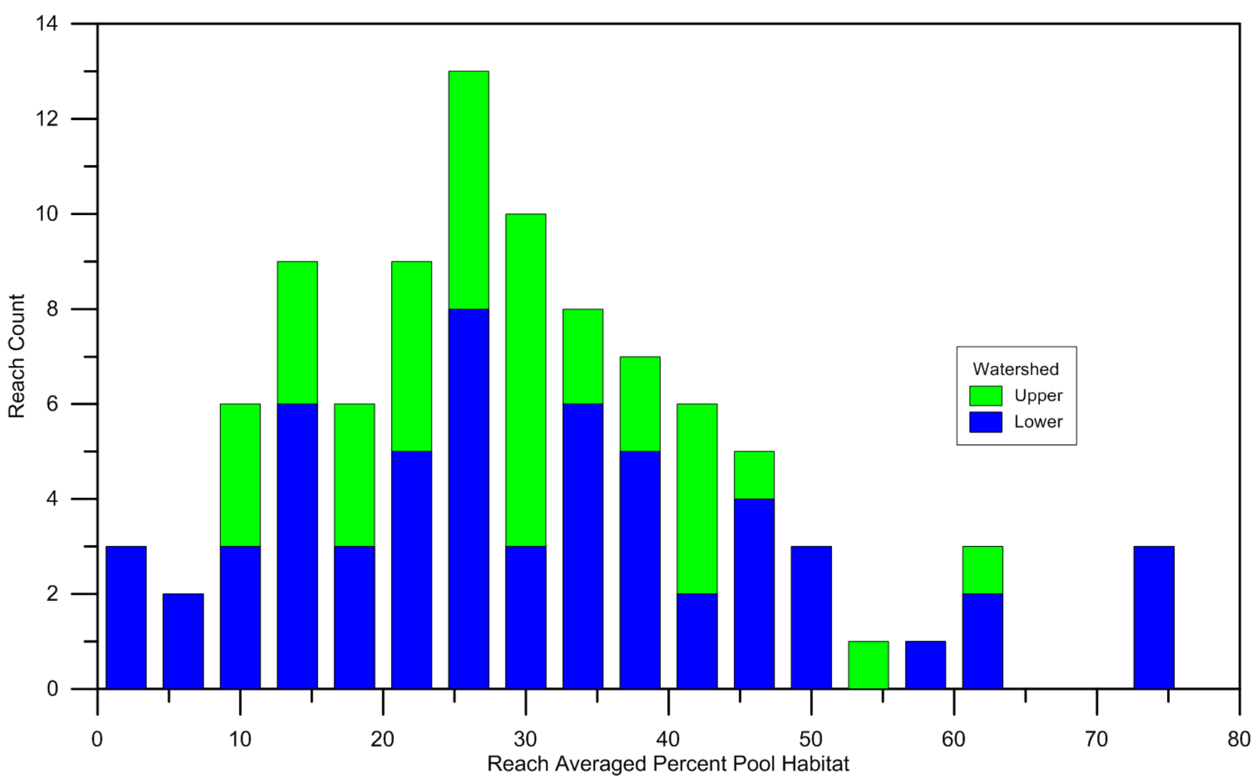

FIGURE 33 - PERCENT POOL HABIAT IN THE BRIDGE CREEK WATERSHED

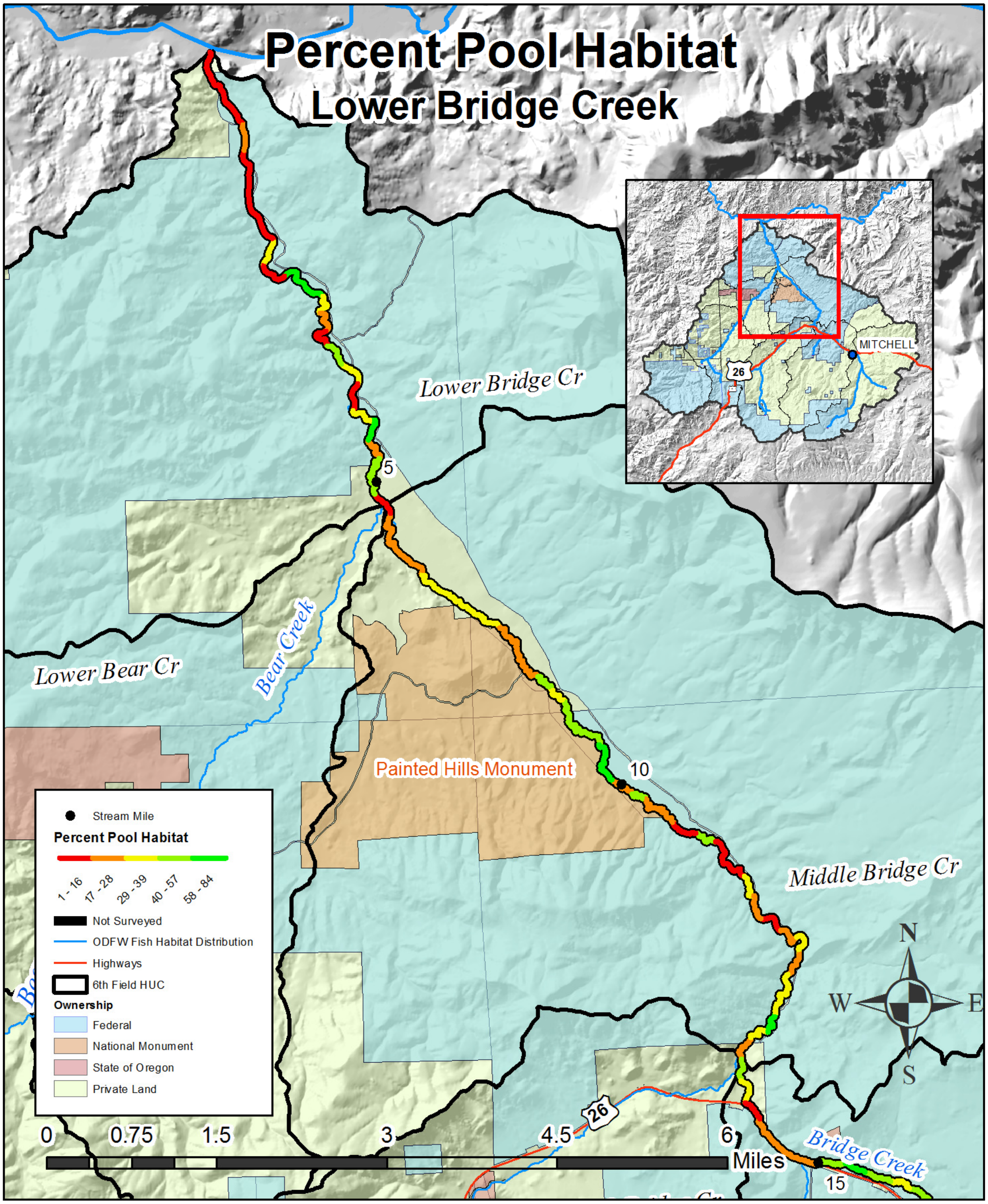

FIGURE 34 - PERCENT POOL HABITAT IN LOWER BRIDGE CREEK

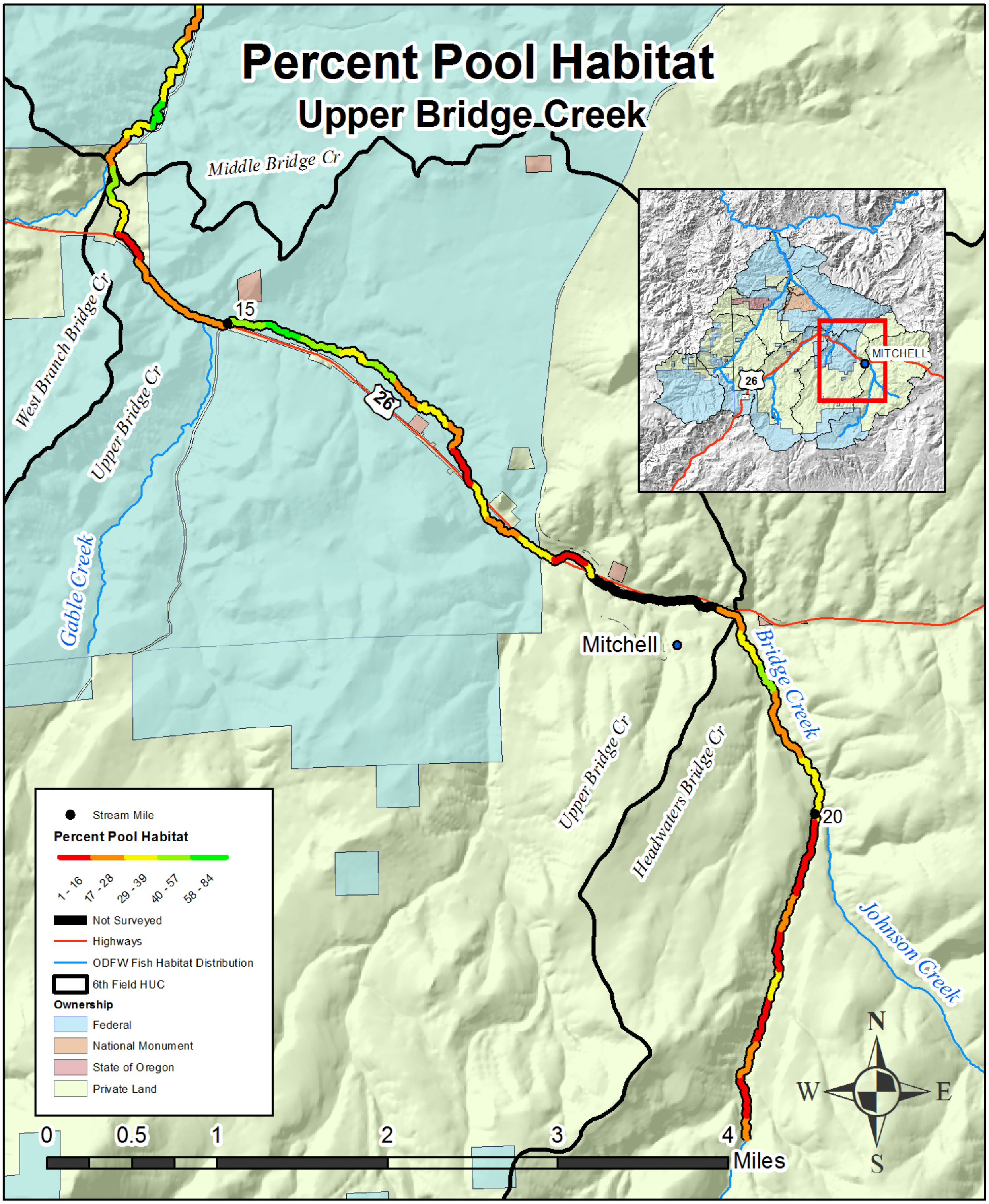

FIGURE 35 - PERCENT POOL HABITAT IN UPPER BRIDGE CREEK

POTENTIAL BARRIERS

During the survey 60 natural potential barriers and 47 artificial (or unnatural) potential barriers were identified along the surveyed length of Bridge Creek. Potential barriers were defined as a channel spanning vertical jump of 0.3 m or greater. The vast majority of the identified potential barriers were linked to beaver activity; both as naturally occurring beaver dams and artificially created structures installed as part of the Intensively Monitored Watershed (IMW) program. More information about the IMW program is available online through the NOAA website (http://www.nwfsc.noaa.gov/research/divisions/fe/wpg/beaver-assist-stld.cfm). All of the artificial barriers were located on public lands and due to the Wheeler SWCD's purview of focusing work on private lands and the intensive monitoring and analysis being done on the public lands portion, these potential barriers will not be analyzed as part of this assessment

All of the barriers on private lands were determined to be natural barriers during the assessment and are primarily linked to large woody debris jams. Although these jams have jumps associated with them, the chute and pool configuration that creates the jump is often not considered a barrier. The identified natural barriers which are not associated with large woody debris jams are linked to bedload material jams. Although they are natural in configuration and construction, they are in proximity to area of instream human influence. It is recommended that the identified sites be monitored to confirm fish passage is being achieved.

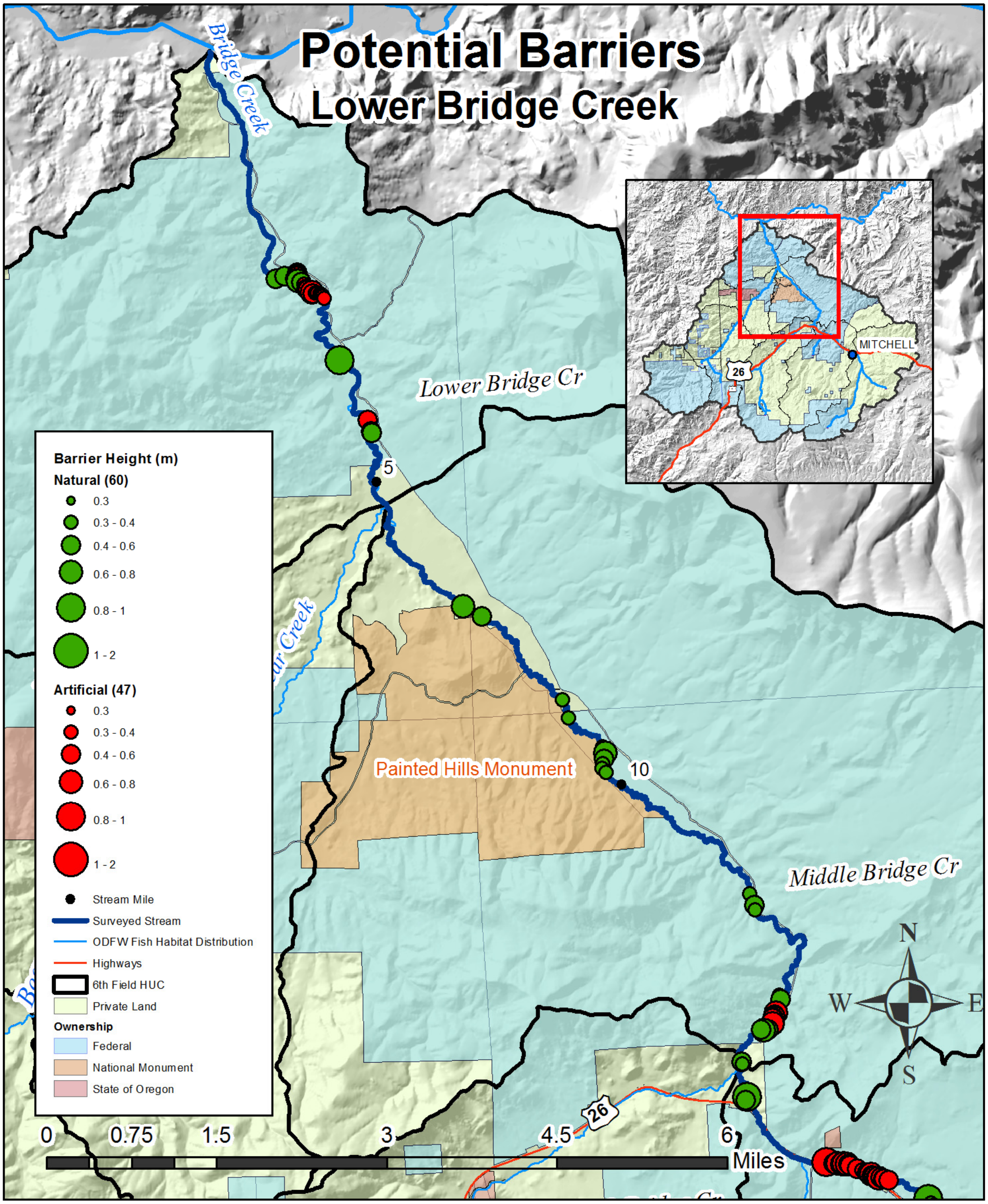

FIGURE 36 - NATURAL AND ARTIFICIAL BARRIERS IDENTIFIED IN LOWER BRIDGE CREEK

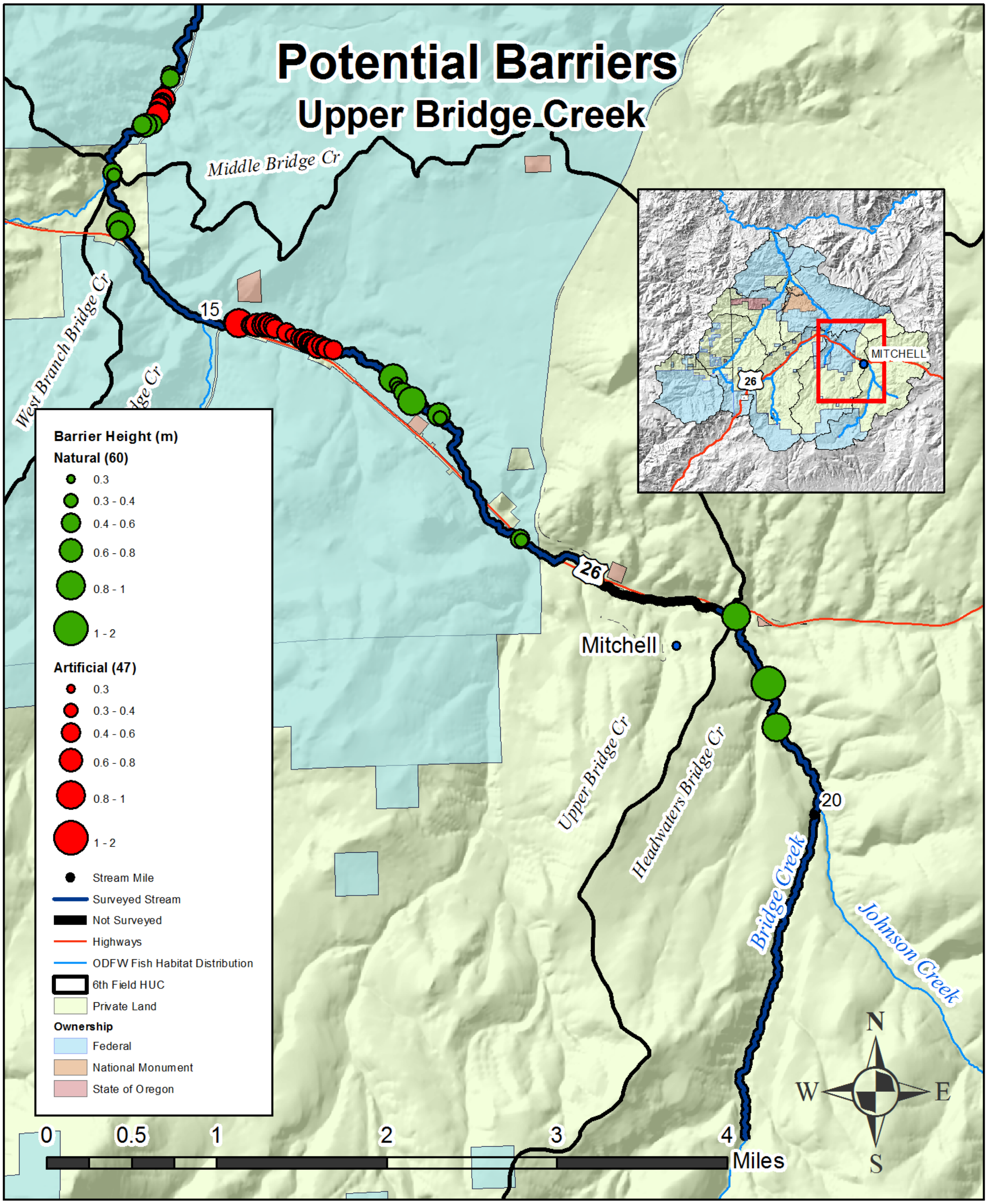

FIGURE 37 - NATURAL AND ARTIFICIAL BARRIERS IDENTIFIED IN UPPER BRIDGE CREEK

INTERDEPENDENCE OF MEASURED PARAMETERS

It was anticipated that several of the measured parameters would be interrelated; namely percent pool habitat vs. percent gravel substrate, and shade vs. active erosion. As expected, the percent gravel of the substrate was inversely proportional to the percent of pool habitat (Figure 38); the relationship is statistically significant but with an R^2 value of less than 0.2.

Reach averaged values of degrees of shade and percent active erosion were plotted against each other (Figure 39). Surprisingly, no significant relationship between shading and erosion was evident in the data.

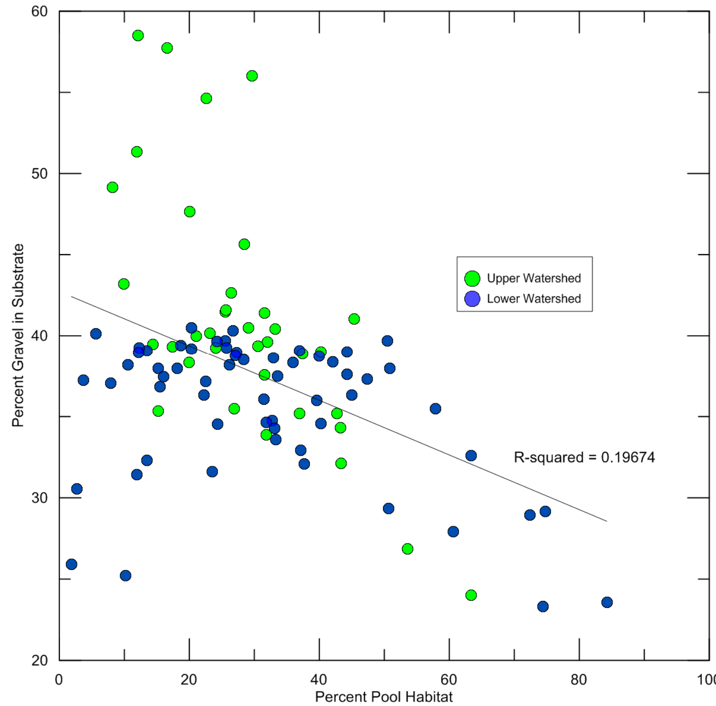

FIGURE 38 - RELATIONSHIP OF PERCENT POOL HABITAT AND PERCENT GRAVEL

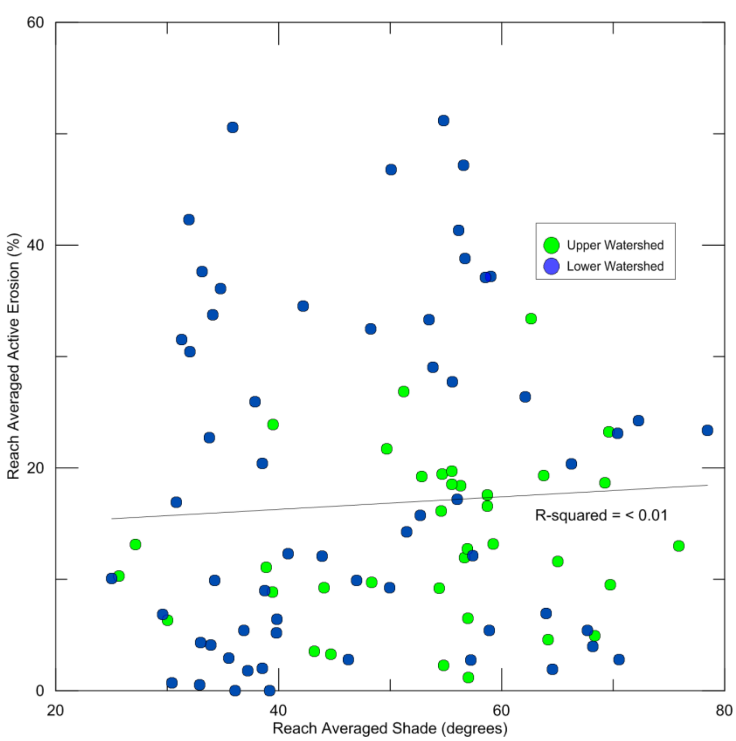

FIGURE 39 - RELATIONSHIP OF AVERAGE SHADE AND ACTIVE EROSION

WHEELER SWCD PAST PROJECTS

The Wheeler SWCD have been correcting in-stream and upland issues in the Bridge Creek watershed for over a decade. Most of the projects that have been completed were easily identified as areas that needed work. This report will hopefully serve as a guidemap to address the remaining issues within the watershed. Dozens of projects have been completed within the watershed by Wheeler SWCD. A map of the projects completed by Wheeler SWCD over the past 10 years is shown below in Figure 40. The projects depicted in the map are listed chronologically in Table 13.

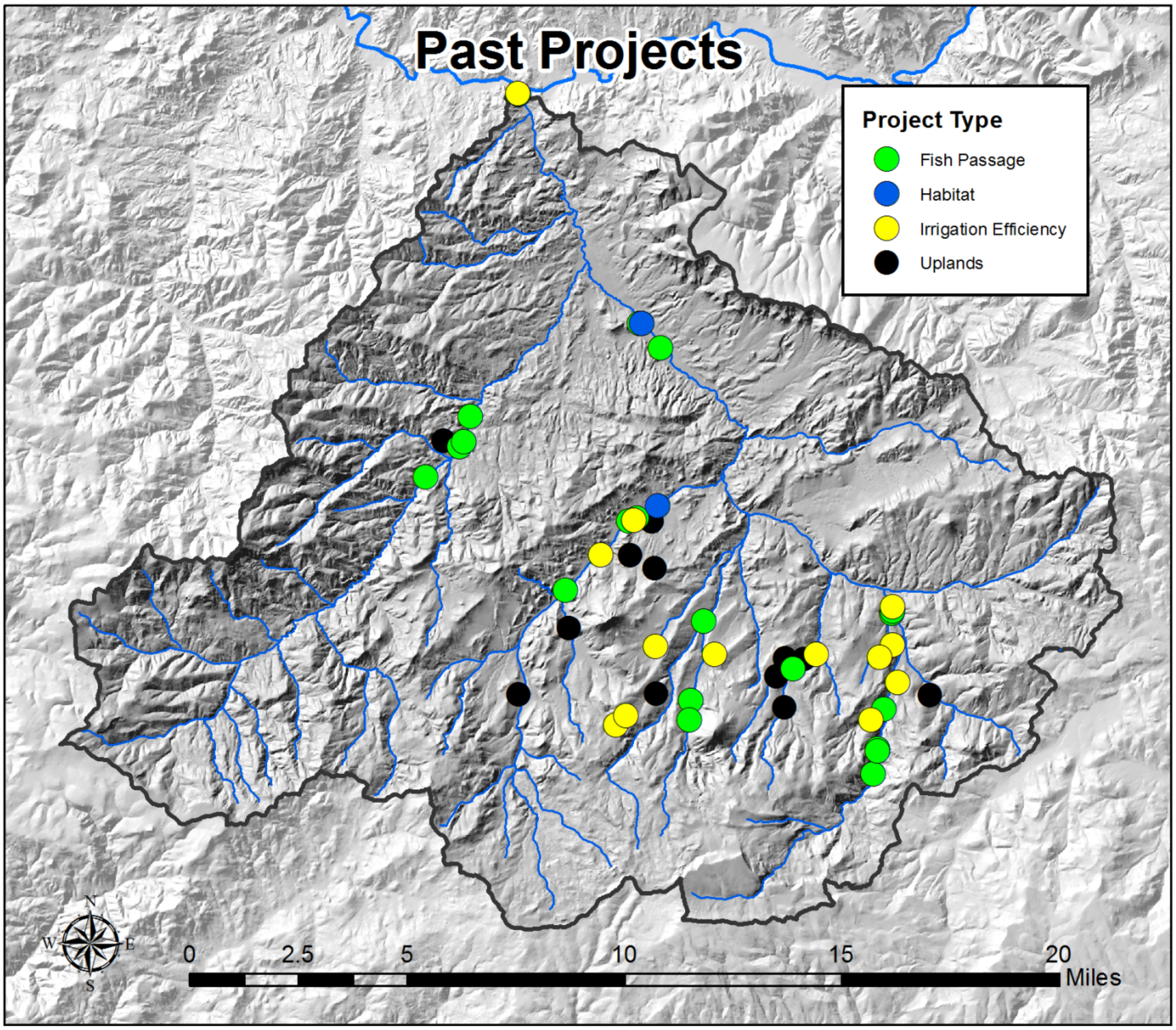

FIGURE 40 - PROJECTS COMPLETED BY WHEELER SWCD WITHIN THE PAST 10 YEARS

An assessment and action plan for the Headwaters of Bridge Creek subwatershed was produced by Wheeler SWCD in 2003. All of the projects identified in this document have been addressed by Wheeler SWCD. This document is provided in **Appendix I**.

TABLE 13 - COMPLETED WHEELER SWCD RESTORATION PROJECTS WITHIN THE BRIDGE CREEK WATERSHED

Date Completed	Project Name	Project Type
2002	Geer Old Cut Brush Management	Juniper Removal
2002	Frank's Place Field	Juniper Removal
2002	West Branch Juniper Control	Juniper Removal
2002	West Branch Watershed Improvement Project	Juniper Removal
2002	West Branch Creek Riparian Corridor Fencing Project	Riparian Habitat
2002	Bridge Creek Culvert Replacement Project	Fish Passage
2002	Five Minute Draw	Juniper Removal
2004	Gable Creek Ranch Riparian Improvements	Fish Passage/IE[1]
2004	Brooks-West Branch Bridge Creek Diversion Improvement	Fish Passage/IE
2005	Lillicrop Upland Stock Water	Upland Management
2005	Lost Coyote Upland Improvement	Juniper Removal
2006	Hashknife Bridge	Fish Passage
2006	Sweet Diversion Replacement	Fish Passage/IE
2006	Habecker-Wade Fish Passage and Irrigation	Fish Passage/IE
2006	Hashknife Irrigation	Fish Passage/IE
2007	Nelson Creek Uplands Management	Juniper Removal
2007	Nelson Creek Diversion Replacement	Fish Passage/IE
2007	Lower Bridge Creek Diversion Improvement	Fish Passage
2007	Bear Creek Diversion #1	Fish Passage
2007	Hashknife Pipeline #1	Irrigation Efficiency
2007	Hashknife Juniper Management	Juniper Removal
2008	Upper Bridge Creek Fish Passage/Irrigation Improvement	Fish Passage/IE
2008	Bear Creek Juniper Removal	Juniper Removal
2008	City of Mitchell Diversion Removal	Fish Passage
2009	Painted Hills Bridge	Fish Passage
2010	Woodward Phase #1 and #2	Irrigation Efficiency
2010	Castleberry Property Spring Development	Uplands Management
2010	Hashknife Diversion Pipeline #2	Irrigation Efficiency
2010	Upper Hashknife Fish Passage	Fish Passage/IE
2011	Thompson Creek Upland Improvement	Juniper Removal
2011	Gable Creek Irrigation Efficiency/Fish Passage	Fish Passage/IE
2011	Bear Creek Diversion #2 and #3	Fish Passage
2011	Gable Creek Culvert	Fish Passage
2012	Gable Creek Water Quality	Irrigation Efficiency
2012	Lower Bear Creek Crossing #1 and #2	Fish Passage
2013	Lower Bridge Creek Connectivity	Fish Passage/IE
2013	Bridge-Bear Phase #1 and #2	Riparian Habitat
2013	Woodward Phase #3	Irrigation Efficiency

1 IE = Irrigation Efficiency

FUTURE PROJECT RECOMMENDATIONS

Due to the Wheeler SWCD's purview of focusing work on private lands all future project recommendations are focused on private lands within the watershed. In addition to this, the IMW team is focused on all public lands within the watershed and as such is the principle entity determining future project recommendations in these areas.

PROTECTION

It is recommended that riparian protection programs be implemented wherever feasible within the watershed. Exclusion of the stream through such programs as the Conservation Reserve Enhancement Program (CREP) will greatly improve overall watershed health. Where exclusion is not a feasible option, fencing of the stream and incorporating prescribed grazing plans appropriate for riparian areas should be considered.

BARRIERS

No artificial barriers on private lands were found during the reach evaluation field work portion of this assessment. However; it is recommended that the natural barriers be monitored to ensure they provide passage. Other barriers are known to exist within the watershed outside of the evaluated areas. These barriers should continue to be addressed as the opportunity allows.

JUNIPER

The juniper prioritization can be found in Appendix D. The focus of future restoration work should be directed towards the level 1 and level 2 priority juniper area; thus providing the greatest watershed benefit. It is recommended that work be done first on the larger concentrations of level 2 juniper where they are in close proximity to the level 1 juniper so as to better realize a more immediate gain. Consideration should be given to proposed work in proximity to prioritized springs and in areas where additional practices such as range seeding, prescribed burns, and grazing management are being implemented. Funding sources and limitations should also be considered during project selection. It is recommended that the level 3 juniper should not be treated.

STREAM RESTORATION

The future project recommendations for stream restoration are based on the reach evaluation and as such only pertain to mainstem Bridge Creek on private lands. This should in no way be an indication that restoration opportunities do not exist on the other streams within the Bridge Creek Watershed. The restoration recommendations are broken up into the lower and upper sections of mainstem Bridge Creek as per the breakout analysis and mapping portion of the evaluation findings.

LOWER WATERSHED

In general, erosion is the primary limiting factor that stands out on the private lands in Lower Bridge Creek. There is limited large wood and boulders present, but since that is the case for the majority of the watershed it is difficult to ascertain if this is a limiting factor. One location does have several limiting factors in poor condition in respect to the rest of the lower watershed. These overlapping key physical indicators point to a much needed restoration project at the confluence of Bear and Bridge Creek. Figure 41 shows the physical indicators at and near the recommended project site. The area has a high level of active erosion throughout the reach and some areas with poor shading as compared to the rest of the watershed. There is also a very high unit length with poor pool density. This is an indicator that the stream type is likely an over elongated riffle or a glide. Field verification at the proposed project site showed a long riffle section through an area that appears to have been subjected to historic channel straightening. It was also noted that some of the shading was actually being created by the eroded vertical banks. It is recommended that a project be considered to correct these limiting factors. Much of Bridge Creek between RM 5 and RM 8 shows a high degree of shading; but in many areas this is due to a dense stand of invasive Russian olive trees. A project is currently underway by the Wheeler SWCD to eradicate this invasive species from the watershed.

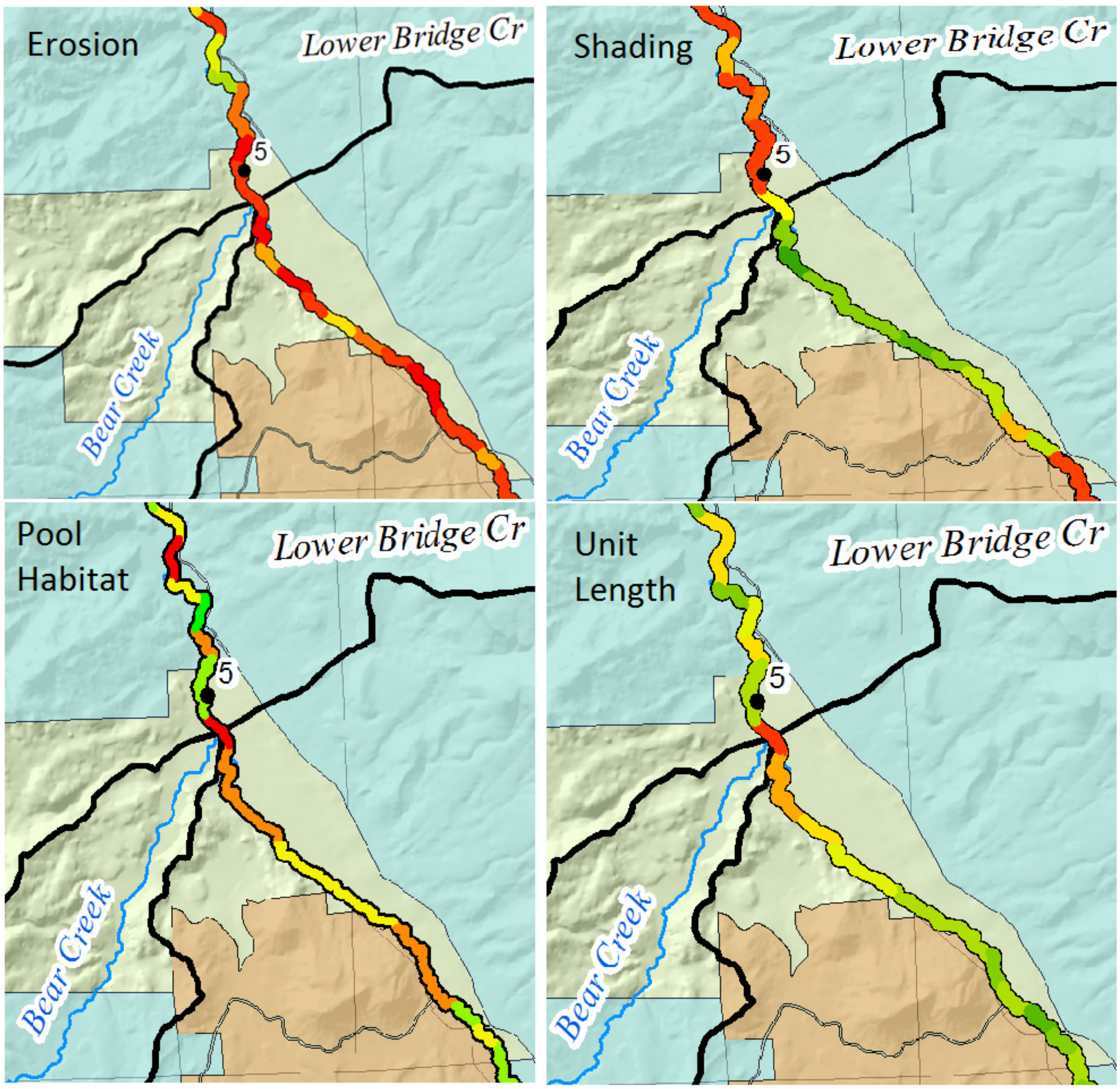

FIGURE 41 - STREAM CONDITIONS NEAR RM 5 IN THE LOWER PORTION OF BRIDGE CREEK

Upper Watershed

In general, pool habitat and erosion are the primary limiting factors that stand out on the private lands in the upper portions of Bridge Creek. Again, there is limited large wood and boulders present, but this seems to be a watershed wide problem not specific to any one reach. The upper reaches in the watershed are located within a forested area, so an elevated amount of large woody debris is expected. There are overlapping locations where the limiting factors of erosion, pool habitat, and until length are in poor condition and as such are an indicator that restoration work in these areas would be advisable.

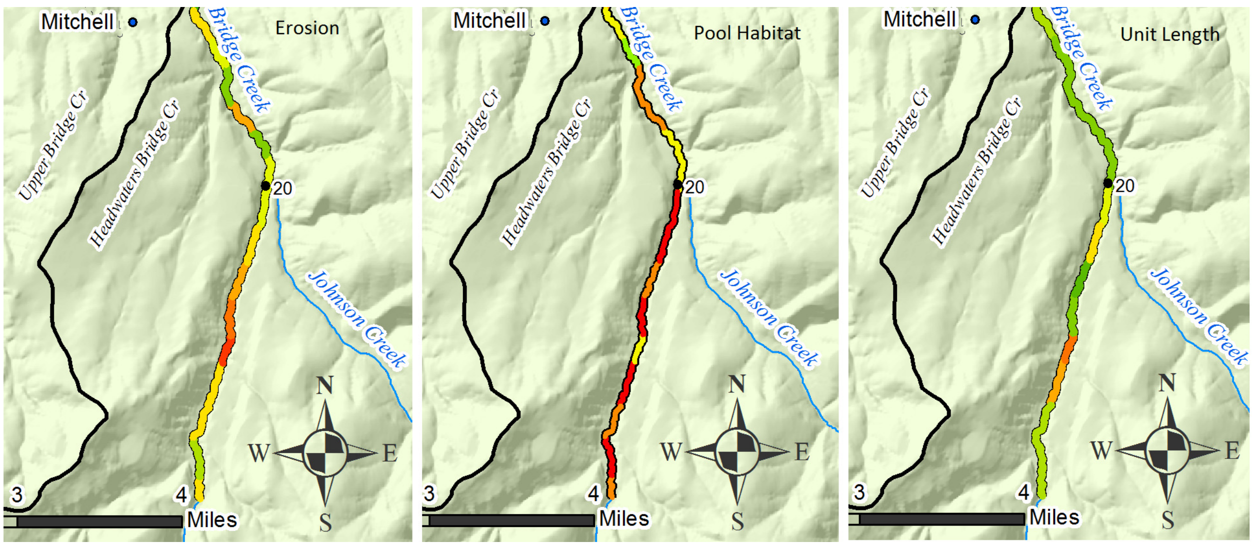

FIGURE 42 - STREAM CONDITIONS NEAR RM 20 IN THE UPPER PORTION OF BRIDGE CREEK

One site stands out, particularly in the unit length analysis (Figure 42). Field verification at the site showed remnants of a meandering historic channel, complete with vegetation. The current channel was straight with very embedded substrate. It was noted that the active channel had an over-steepened gradient as compared with the historic channel. It was also noted that while spawning size gravels were present in the dry historic meanders, the active channel was comprised of large cobbles. It is recommended that a project be considered to reactivate portions of the historic channel and thus address these limiting factors.

IMPROVEMENTS/FUTURE WORK

This reach evaluation represents a second effort at instituting a relatively new methodology designed to identify and prioritize problem stream reaches and projects which will most effectively utilize the available funding sources. The first application of this methodology was completed on Mountain Creek (a neighboring drainage within Wheeler County) in 2011. That assessment has served as a useful tool for identifying and prioritizing restoration efforts within the watershed.

When assembling this document, several items were identified that could have increased the usefulness of the survey data. Future surveys should include digital images of all identified barriers. A simple height metric is insufficient to make management decisions regarding the need to address a specific barrier. Notes on riparian species present and any invasive species would also be helpful.

The rating criteria for all parameters were defined by logical breaks associated with distribution throughout the watershed. Expert opinions will be needed in order to refine these criteria and establish acceptability thresholds. If possible, all pertinent habitat aspects could be consolidated into one or two metrics describing overall stream viability/health. The follow-up to the Mountain Creek Reach Evaluation is expected to be completed by 2015 and will incorporate this concept. Once these "viability thresholds" for the different limiting factors have been determined, a project atlas can be created to optimize the efficiency of restoration work. Just as importantly, this will also reduce restoration activities that have passed the diminishing rate of return threshold. Future restoration efforts in the Bridge Creek Watershed would benefit from the creation of such a project atlas.

This reach evaluation was restricted to the mainstem of Bridge Creek due to funding limitations. It is recommended that Bear Creek, Gable Creek, and West Branch Bridge Creek also be evaluated using this methodology as time and funding permits.

ACKNOWLEDGEMENTS

The authors would like to extend their gratitude to the Oregon Watershed Enhancement Board (OWEB) for providing funding for the survey, reach evaluation, and watershed assessment through grant #209-5047.

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