The Effectiveness of Idaho's Class I Stream Shade Rule:

Analysis of Before - After, Control - Impact Effective Shade Data

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Executive Summary

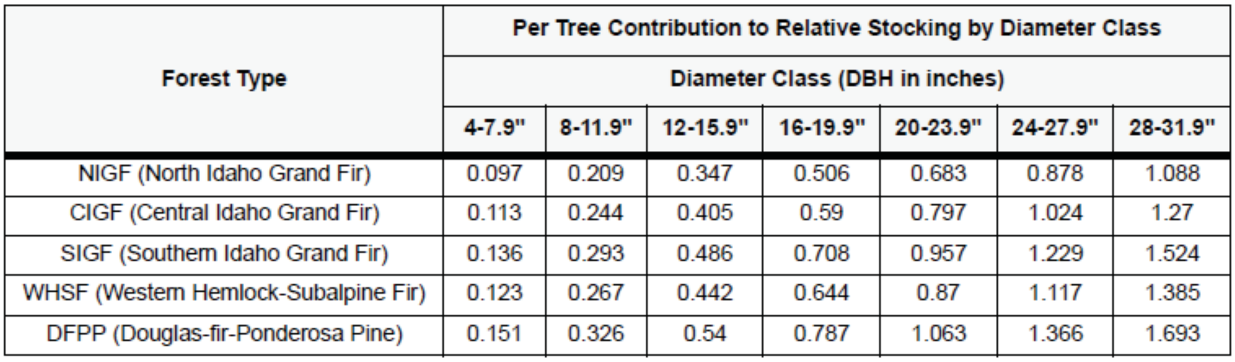
In 2012 the Idaho Forest Practices Advisory Committee (FPAC) proposed a new shade rule for Class I (fish-bearing) streams, based on relative stocking (RS) within Stream Protection Zones (SPZs). The new stream shade rule provides landowners with two options for harvesting timber adjacent to Class I streams, both of which are based upon stand RS for 5 defined forest types. The maximum allowable RS after timber harvest was designed to result in absolute effective shade reductions of no more than 10%. This study evaluated whether Idaho's new Shade Rule protects Class I effective stream shade under timber harvesting activities where the minimum amount of trees permitted by the Rule were retained in the riparian zone. A before-after, control-impact (BACI) study at the stream reach level was designed to sample reaches across the state of Idaho, weighted by the relative amount of timber harvest within different forest types and regions in the state. A total of 21 control and 44 treatment stream reaches were sampled for RS and effective stream shade before and after harvesting. The data were filtered to remove reaches that had been over- or under-harvested, resulting in a total of 33 pre- and post-harvest treatment reaches. Analysis of duplicate samples indicated that the precision of effective shade estimation for both field and image digitization duplicates were within 2%. Shade changes ranged from -22.8% to +12.9% across all treated sites, and from -10.2% to +6.3% across all control sites. Statistical analysis using a multi-level hierarchical linear mixed effects model indicated that estimated effective shade change was -2.7% on average between pre- and post-harvest conditions. When the 1.1% average increase in shade at the control sites are considered, the estimate of the change was -3.8% with 95% confidence bounds ranging from -4.7% to -2.9%, and a range from -23.9% to +11.8%. When the estimated values for effective shade changes are considered in the context of the field sampling and image digitization precision and potential bias, the results indicate that the average changes in estimated effective shade at sampled sites across the state under the new Rule are very likely within the target reduction level of <10%. Given all of these considerations, it is highly likely that the new Rule appears to be functioning as intended.

Background

Following the 2000 (Hoelscher et al. 2001) and 2004 (McIntyre et al. 2005, 2007) Idaho Department of Environmental Quality (DEQ)-led forest practices water quality audits, the DEQ recommended changing the Forest Practices Act streamside tree retention rule or "Shade Rule" standards. This rule governs how landowners are permitted to harvest timber in Stream Protection Zones (SPZs) adjacent to Class I streams. In Idaho, Class I streams are defined as either important for the spawning, rearing, or migration of fish (fish-bearing) or are used for domestic water supplies. The primary concern was the potential effect of timber harvest on effective shade which is defined as the amount of shortwave (0.28 – 3.5 µm) radiation at the stream surface relative to that at an unobstructed location. In 2009, a consultant was retained to model how much thinning could occur within SPZs to reduce effective stream shade by an absolute amount of no more than 10%. The shade simulations for the different thinning scenarios (Teply and McGreer, 2013; Teply et al., 2014) were based on vegetation height and density from the Forest Vegetation Simulator (FVS, Crookston and Dixon, 2005) combined with a simple Beer's Law based radiative transfer scheme (Chen et al., 1998) assuming a stream width of 10 feet, reach azimuth of 45/315°, and 2-sided harvest (Teply et al., 2014). Based on the shade modeling, in 2012 the Forest Practices Act Committee (FPAC) proposed a new shade rule based on relative stocking (RS) within SPZs. Following an extended period of public comment and several revisions, rule promulgation moved forward in 2013, was approved by the Idaho Legislature in 2014, and formally went into effect on July 1, 2014.

The new stream shade rule provides landowners two options for harvesting timber adjacent to Class I streams, both of which are based upon stand RS for 5 defined forest types (Table 1). RS is "a measure of site occupancy calculated as a ratio comparison of actual stand density to the biological maximum density for a given forest type" (IDAPA, 2014a). RS is a ratio of site occupancy expressed as a percentage of an estimated maximum for the most productive stands. The theoretical maximum stocking used as the denominator in the RS percentage calculation varies among each forest type. RS values are calculated based on stem diameter, which is tallied in 4" diameter classes (IDL, 2014a, 2014b). Individual stems within each diameter class represent a known contribution to total RS, depending on the physical area (length times width) of the streamside management zone. In other words, the calculation is "The extent to which trees utilize a plot of forestland (IDAPA, 2014a)."

Table 1. Relative Stocking Rates per Tree by Forest Type (IDAPA, 2014b)



Forest Type	Per Tree Contribution to Relative Stocking by Diameter Class						
	Diameter Class (DBH in inches)						
	4-7.9"	8-11.9"	12-15.9"	16-19.9"	20-23.9"	24-27.9"	28-31.9"
NIGF (North Idaho Grand Fir)	0.097	0.209	0.347	0.506	0.683	0.878	1.088
CIGF (Central Idaho Grand Fir)	0.113	0.244	0.405	0.59	0.797	1.024	1.27
SIGF (Southern Idaho Grand Fir)	0.136	0.293	0.486	0.708	0.957	1.229	1.524
WHSF (Western Hemlock-Subalpine Fir)	0.123	0.267	0.442	0.644	0.87	1.117	1.385
DFPP (Douglas-fir-Ponderosa Pine)	0.151	0.326	0.54	0.787	1.063	1.366	1.693

The Shade Rule 60/30 option allows harvests that leave a minimum of 60 percent RS within 25 feet of the Ordinary High Water Mark of Class I streams (inner zone) and 30 percent RS between 25 and 75 feet from the mark (outer zone). This option is illustrated in Figure 1 below.

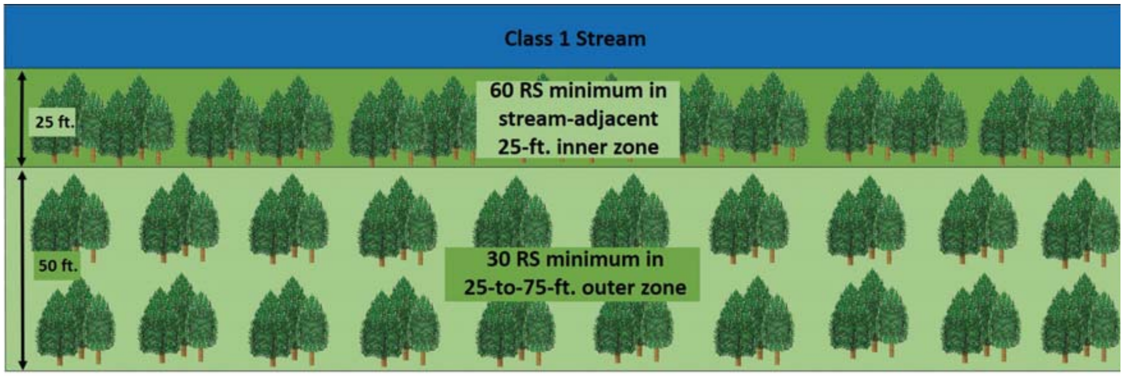


Figure 1. 60/30 Stream Shade Option 1 (IDL, 2014b)

The 60/10 option requires that a minimum RS of 60 percent is retained within 50 feet of the Ordinary High Water Mark (inner zone) after harvesting and minimum RS of 10 percent is retained in the 50 to 75 feet outer zone (IDL, 2014b). This option is illustrated in Figure 2 below.

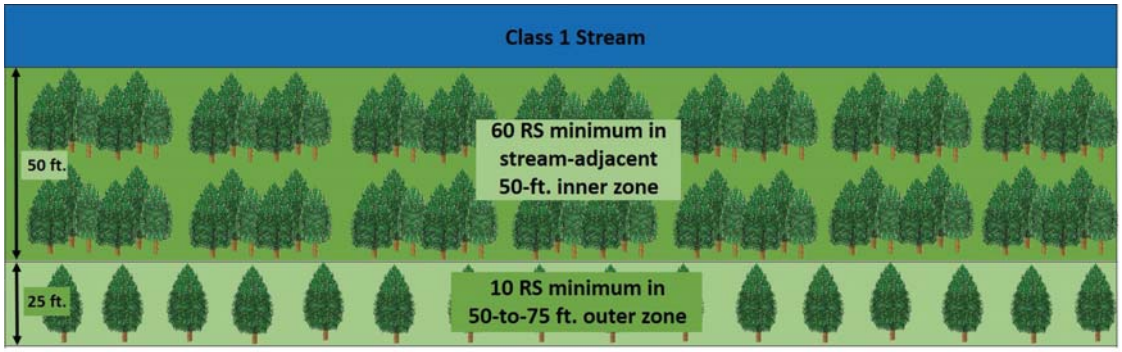


Figure 2. 60/10 Stream Shade Option 2 (IDL, 2014b)

In September 2014, DEQ in consultation with the Idaho Department of Lands (IDL) contracted the University of Idaho to develop a monitoring study to provide an assessment of the new rule. As part of the modeling study, Standard Operating Procedures (SOPs) were developed for the estimate of effective stream shade (Keefe et al., 2015d) and relative stocking (Keefe et al., 2015c). To further support the study, a Quality Assurance Project Plan (QAPP, Keefe et al., 2015b) and detailed description of the basis and approach to the study design were provided in an Experimental Design document (Keefe et al., 2015a). This report summarizes the key information in these documents to provide the reader with adequate background to interpret the results and conclusions of the study.

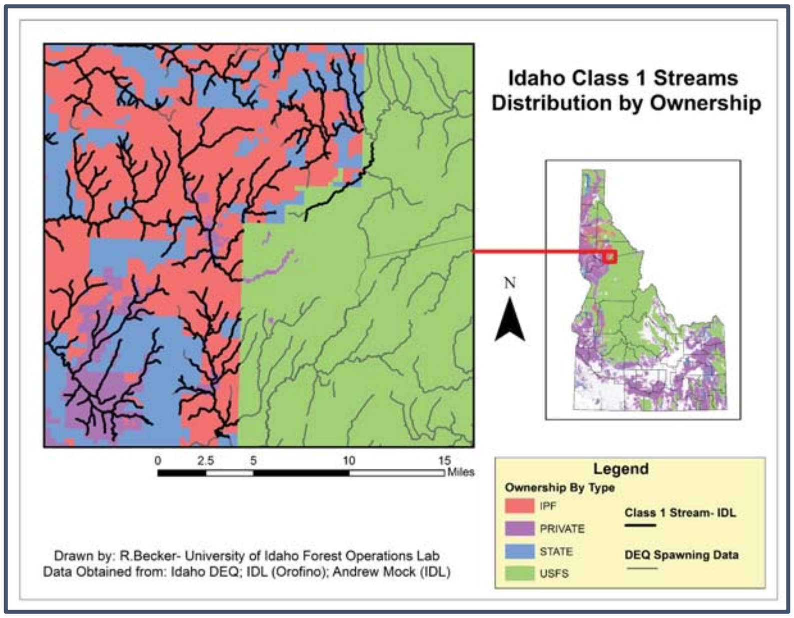
Objectives

The primary objective of this study is to evaluate whether Idaho's new Shade Rule protects Class I effective stream shade under timber harvesting activities where the approximate minimum amount of trees permitted by the Rule are retained in the riparian zone (i.e. the maximum allowed cut occurs). In this case, the rule will be deemed to be protective of shade levels if there is a statistically significant average effective shade change at the state level that does not exceed a value of 10%. A secondary objective of this study is to determine the specific characteristics of any sites that fail to meet the shade retention goal to provide insight into the conditions and processes that contribute to large shade losses or gains. This two-stage analysis approach was designed to facilitate science-based improvements to the Rule in the future if needed.

Methods

General Experimental Approach

A Before-After, Control-Impact (BACI) approach was used to identify changes in effective shade at the stream reach level within harvested units. Experimental designs employing a BACI approach are widely regarded as the most robust method to determine the effects of changes on environmental systems (Smith, 2002) and have been extensively used to determine the effects of timber harvest on stream and watershed variables (Loftis et al., 2001; Stednick, 1996). In this study, effective shade was measured in control reaches on two subsequent years and in test reaches before and after harvest. This experimental design enables the quantification and comparison of naturally occurring and harvest-related shade changes in the sample population of stream reaches. For example, natural variability that results in effective shade changes from year to year may be due to vegetation growth, tree mortality caused by insect damage or forest pathogens, age, windthrow, snow loading, wildland fire, or changes in understorey composition and density. Data from the control reaches can therefore be used to account for natural variations rather than assuming that effective shade is static between years.

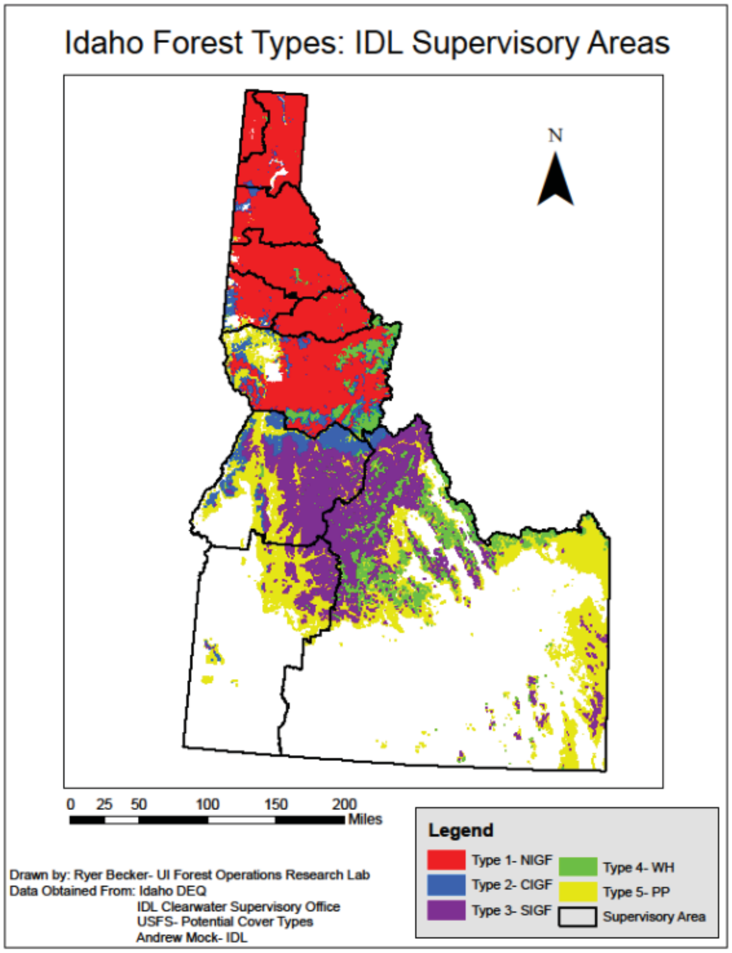


Drawn by: R.Becker- University of Idaho Forest Operations Lab
Data Obtained from: Idaho DEQ; IDL (Orofino); Andrew Mock (IDL)

Figure 3. Class I Streams Distribution by Ownership

Site Identification

For the purposes of this study, the population of interest was defined as the riparian stand area within 75 feet of all harvestable Class I streams on state and private lands in Idaho (Figure 3). On federal lands, the width of



Drawn by: Ryer Becker- UI Forest Operations Research Lab
Data Obtained From: Idaho DEQ
IDL Clearwater Supervisory Office
USFS- Potential Cover Types
Andrew Mock- IDL

Figure 4. General Forest Type Map Used to Develop Stratified Random Sample Sizes by Strata.

the no-harvest areas adjacent to Class I streams exceeds the applicable width of the Shade Rule. Therefore, federal ownership was excluded from the population of interest based on discussion and feedback from IDEQ and IDL during the study design phase. A stratified random sampling approach was used to identify potential study reaches across all state, private, and industrial private forest (IPF) ownerships, weighted by a combination of the relative annual harvest volume per IDL supervisory area and relative proportions of forest types statewide. As a result of this stratification, shade monitoring sites were primarily located in the northern portion of the state, within the North Idaho Grand Fir (NIGF) forest type with a smaller number in the central portion of the state within the Central Idaho Grand Fir (CIGF) forest type. Very few sites were located within the Southern Idaho Grand Fir (SIGF) and Western Hemlock Subalpine Fir (WH) forest types, and no sites were located within the Douglas Fir Ponderosa Pine (PP) forest type (Appendix A) due to the weighting by ownership, harvest volume, and forest type. The advantage of this approach is that the Shade Rule was evaluated where timber harvest is expected to have the greatest aggregate effect on riparian systems statewide. Sites were identified through communication with Idaho Dept. of Lands administrative personnel who identified candidate state and private timber sales from the pool of Forest Practices Act notification forms indicating planned harvesting of Class I streams during the prospective sampling period for pre-treatment measurements.

The ideal number of control and test sites to be sampled was determined based on the simulated use of a linear mixed effects model (Pinheiro et al. 2000) to test the interaction of time (before vs. after harvest) and harvest (control vs. impact) with a range of mean pre-treatment values, sample sizes, and level of effective shade or relative stocking removal. In each case, a one-sided multiple comparisons test was evaluated at the 90 percent confidence level using the multcomp package in R (Hothorn et al. 2008). Simulation results across a range of variability in post-harvest conditions consistently improved when approximately 50 treatment and 20 control reaches were included in the study design, therefore these were determined to be the optimal number of sites to accomplish the study objectives while simultaneously balancing operational logistics and cost. Details of the weighting procedure and statistical simulation to determine sample numbers are included in Keefe et al. (2015a). A number of sites were abandoned after pre-harvest sampling due to harvest delays related to market conditions, road failures, and steep or inaccessible SPZs. These cases resulted in 14 sampled pre-harvest reaches being abandoned, and as a result there were a total of 65 reaches sampled, consisting of 21 control and 44 harvested reaches.

It was not feasible to independently test the effects of the 60/30 (Option 1) and 60/10 (Option 2), stream orientation and width, harvest location, forest type, or the influence of different silvicultural systems outside the riparian area on effective stream shade due to the large number of sample reaches that would be required in a factorial study design. For this reason, a sampling strategy that covered as much variability as possible across all conditions represented in planned timber sales was needed. The rationale for this approach was to evaluate the effectiveness of the Rule overall and not specific combinations of factors separately. Rather, harvest options and site characteristics were cataloged at all sites to provide insight into the specific conditions that produced any observed large changes in effective shade.

Field Measurements and Data Processing

Relative Stocking

Relative stocking was estimated in identified stream reaches that were intended to have the maximum amount of forest harvest permitted under the new Shade Rule along Class I streams. Relative stocking within a 1-acre (approximately 600 ft x 75 ft) curvilinear plot (Figure 5) on one side of the stream was estimated before and after harvest using a Biltmore stick graduated in inches. Streams were included regardless of whether harvesting occurred on one or both sides of the stream. All live conifer and hardwood trees greater than 4 inches DBH were sampled before and after harvest. Stems were tallied in 4 inch Diameter at Breast Height (DBH) classes. Relative stocking is an estimated proportion of total site occupancy and is defined separately for each of five primary forest types in Idaho. After verifying which forest type is associated with the stream, RS values associated with individual stems in each DBH class were summed according to reference maximum stand density values

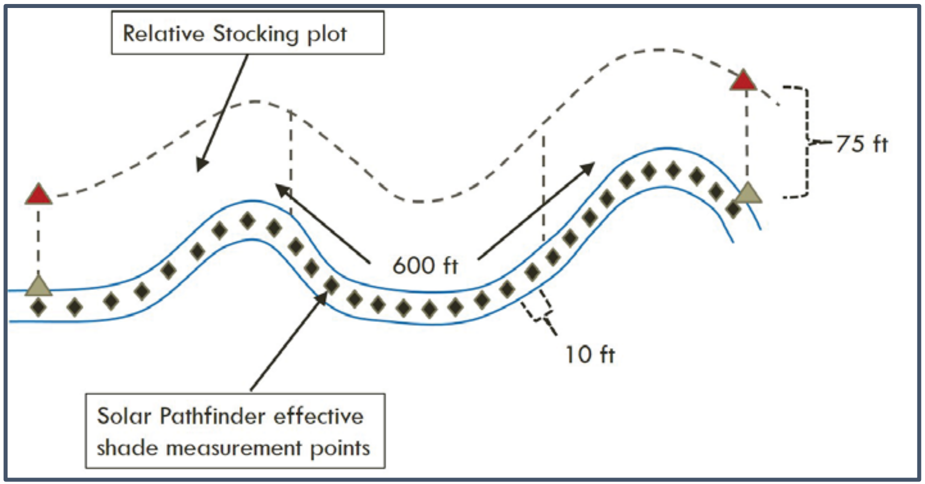


Figure 5. Relative Stocking and Shade Plot Design.

within the identified forest type. Total RS was summed within inner and outer zones corresponding to IDAPA Option 1 or Option 2 (IDAPA 030.07.e.ii), depending on which was being implemented.

RS plot lengths were targeted to be 600 feet as measured along the stream bank (Figure 5). The plot area thus varied with stream sinuosity. Inner and outer zone widths were 25 and 50 ft, or 50 and 25 ft, respectively, depending on whether the landowner associated with the harvest was implementing stream shade rule Option 1 or Option 2. In all cases, RS was sampled consistently in 3- 25 ft zones (inner, middle, outer) measured perpendicular to the mean stream course azimuth. The orientation azimuth and perpendicular angles were determined using GIS prior to visiting the site and recorded in field notes. The plot locations within the harvest units were identified at a random downstream starting point. Specific details of the relative stocking measurement procedure are further detailed in Keefe et al. (2015c).

Relative stocking data were compiled from field tally sheets to quantify the pre- and post-harvest relative stocking in both the 0 – 25 foot inner and 25 – 75 foot outer zones corresponding to the 60/30 Option, and 0 – 50 foot inner and 50 – 75 foot outer zones corresponding to the 60/10 Option.

The canopy conditions outside of the 75-foot buffer can also influence stream shade changes, and for this study the harvest prescriptions were complete clearcuts for all study sites. Minimal amounts of non-marketable overstory vegetation or isolated trees for wildlife use may have been retained in the harvested units but were assumed to have a negligible effect on stream shade, therefore no forest mensuration data were collected outside of the 75 foot SMZ. Other upslope stand conditions (e.g. on the opposite side of the harvested units) were not quantified for this study.

Shade Sampling

Effective shade was estimated in study stream reaches using a Solar Pathfinder which is a simple tool that is used to assess the percentage of solar radiation blocked by objects in a specific area throughout the course of a year (Figure 6). The Solar Pathfinder was used to estimate percent effective shade throughout the year based on a canopy image superimposed on local sun path diagrams (Amaranthus et al. 1989). The sun path diagram fits on a rotating base and tripod approximately 50 cm high with a polished plastic spherical dome mounted on top that reflects the overlying canopy. After the unit is oriented relative to cardinal directions, a digital image of the reflected canopy superimposed on the sun path diagram was recorded for analysis with the Solar Pathfinder Assistant 5.0 software package.

Figure 6. Example Solar Pathfinder Image Used to Estimate Effective Shade.

Pre-harvest shade sampling locations were marked with permanent monuments and labeled with flagging at the beginning and end of the study reach to ensure that post-harvest measurements were taken at the same locations. Flagging was also placed at midpoints no less than 100 feet apart to aid in the post-harvest sampling and to ensure that oblique images are collected at the same locations. Shade was imaged using the Solar Pathfinder every 10 feet along a 600 ft reach centered in the harvest unit for a total of 61 images (Figure 5). Two study reaches were sampled in duplicate for an estimate of field sampling precision to account for potential variations in the placement of the Solar Pathfinder relative to shade-producing materials.

Data were processed by cropping, calibrating, and correctly leveling and orienting the digital images of the Solar Pathfinder dome with the underlying sun path diagram in the Solar Pathfinder Assistant software. The Solar Pathfinder Assistant 5.0 software outputs the percent weighted unshaded portion of the image to account for higher solar radiation intensity at high sun angles, after shade producing features are manually traced within the program. The software corrects for magnetic declination to orient the photo to true north/south and overlays sun paths based on the specific latitude and longitude of the photo location. The weighted unshaded percentage outside of the traced shade producing features on the Solar Pathfinder image is calculated for each month of the year. Unshaded percentages from the months of April to September are converted to shaded percentage and then averaged to estimate the average effective shade at a site. This time period was used to represent the shade conditions and shortwave radiation levels that the stream would experience over the majority of the critical time period for aquatic life. Historically, temperature data have shown that criteria violations can occur during the late spring spawning period for salmonids (April through June), during the peak summer (July and August), and during early fall spawning (September). Stream temperatures are rarely a concern outside of this time period. Manual digitization is somewhat subjective, therefore a subset of 25 of the image sets for randomly selected study reaches were analyzed in duplicate by both the same and separate analysts to assess the digitization precision of the shade estimation method for quality assurance.

Additional data, including general stream orientation, bankfull width, stream channel gradients, side slope gradients, vegetation conditions, and upstream and downstream oblique digital images every 100 feet were also collected to help interpret pre- and post-harvest stream shade results.

Relative stocking and effective stream shade data were collected, processed, and compiled by the DEQ and provided to the University of Idaho in July 2019 for subsequent analysis.

Data Filtering

Specific sampling locations within the study reaches were omitted or filtered prior to analysis based on decisions made by DEQ specifying whether to keep or remove values due to a variety of issues with placing the Solar Pathfinder and/or obtaining an acceptable image. Specific observation points were primarily removed or omitted due to large amounts of downed wood in the channel or unspecified reasons for no images. Locations were less commonly omitted due to safety concerns related to stinging insect nests, dense vegetation in the channel, deep water, distorted, blurry, or excessive glare in the images, or other obstructions such as waterfalls, culverts, and bridges. A total of 343 discrete sampling locations out of a total of 10,309 potential points were removed, accounting for approximately 3.3% of the sampling sites. A negligible amount (13) of observations were also removed in instances where the image was not recorded at exactly the prescribed location, accounting for approximately 0.1% of the dataset.

Specific study reaches were also omitted from the dataset prior to analysis where relative stocking data indicated that sites were either over- or under-harvested relative to the study objective of harvesting the maximum amount of riparian timber permitted under the rule. If both zones were within ±10 RS of their harvest target, the site was deemed to be acceptable. For example, in the most extreme case (Bogus Bond) its final RS of 50/0 (60/10 option) or 59/20 (60/30 option) was within ±10 of the 60/10 harvest and therefore the site was deemed to be acceptable despite being overharvested. Also, if a tree is located exactly on the boundary between zones, the final RS can appear to be anomalous depending on whether it is considered to be in the inner or outer zone. For example, if a large tree is located on the inner/outer boundary edge, depending on which zone it is determined to be within, the final RS could either be 60/30 or 55/35. This depends on exactly where crews assign the high water mark, which may vary slightly between crews. When anomalous RS numbers occurred (like the 55/35 example) the data processor assessed the impact of moving trees between zones. If that led to a more reasonable final RS that fell within the ±10 criterion above, the site was deemed to be acceptable and was flagged as meeting the relative stocking target with edge effects (see Table 6, last column). This procedure was important to accomplish the objectives of the study, because if the RS values were used as measured, there would have only been 6 sites that would have qualified as being cut to the rule.

This filtering step was important to help ensure that changes in effective shade were not biased. In total, 9 pre- and post-harvest reaches were removed because they were specified as under-harvested, and 2 sets were removed because they were specified as over-harvested. This filtering reduced the available pre- and post-harvest reach datasets from 44 to 33 pairs, accounting for a 25% reduction in the available pre- and post-harvest data. None of the 21 unharvested control datasets were removed. Because the final dataset contained 21 and 33 control and harvested sites, respectively, which were less than the target amount of 20 and 50 control and harvested sites, respectively, the analysis was completed on both the filtered and unfiltered datasets to test the potential impacts of data filtering on the results of the analysis.

Data Analysis

Before-after, control-impact effective shade data were analyzed using a multi-level hierarchical linear mixed effects model. The model was specified for three levels of nested observational units: site (reach), position within site, and observation (i.e., pre- and post-harvest) within position within site. In this case random position-specific and site-specific effects were specified to capture variation between positions within sites and also between sites. The approach is specifically designed to test whether effective shade changed by more than 10% on average for all reaches sampled throughout the state. The analysis is therefore intended to test the mean response in effective shade % when harvesting to the minimum allowable Relative Stocking across reaches with different biophysical characteristics including stream orientations, forest types, soil productivity, and operational practices. The primary rationale for using mixed effects models in the analysis is to account for correlation that exists between multiple measurements that are similar to one another (non-independent). It accounts for the fact that two adjacent points of shade measurement along a particular stream are potentially more similar to one another than two points chosen at random along the stream.

Results

Quality Assurance Analysis

Differences in effective shade estimates based on 2 unique sets of Solar Pathfinder images for 2 stream reaches are shown in Figure 7. The median value of all digitized images is indicated by the hinge (vertical line), and the first and third quartiles (the 25th and 75th percentiles) by the lower and upper box bounds. The extent of the whiskers corresponds to 1.5 times the interquartile range (IQR), and the dots represent outliers. The absolute value of the mean difference between the two field duplicates ranged from 0.4% to 2.1% with an average difference of 1.3% (Table 2).

The absolute value of differences in effective shade estimates based on duplicate analyses of 25 sets of images were similarly less than 2% (Table 2). Differences for all sites are likewise depicted in Figure 8, which shows that there is generally a high degree of precision in the estimates of shade, with relatively small differences resulting from different digitizations of the Solar Pathfinder images. The two sites with the least precise shade estimates (Roosters Last Leg, pre-harvest and Fish Creek, post-harvest) were characterized by lots of small canopy gaps within the solar elevation-declination bands corresponding to the April to September time window. In contrast, sites with more precise estimates were generally characterized by larger more discrete canopy gaps within the April to September solar path band (e.g. Heywood Creek, post-harvest; First & Last, pre-harvest).

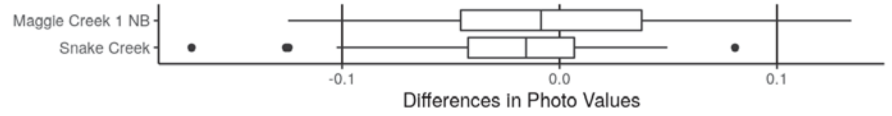


Figure 7. Results of Duplicate Field Shade Sample Analyses

Table 2. Summary of Duplicate Analyses

Type	Mean	StdDev
Field (n=2)	-1.3%	5.5%
Digitization (n=25)	1.9%	7.5%

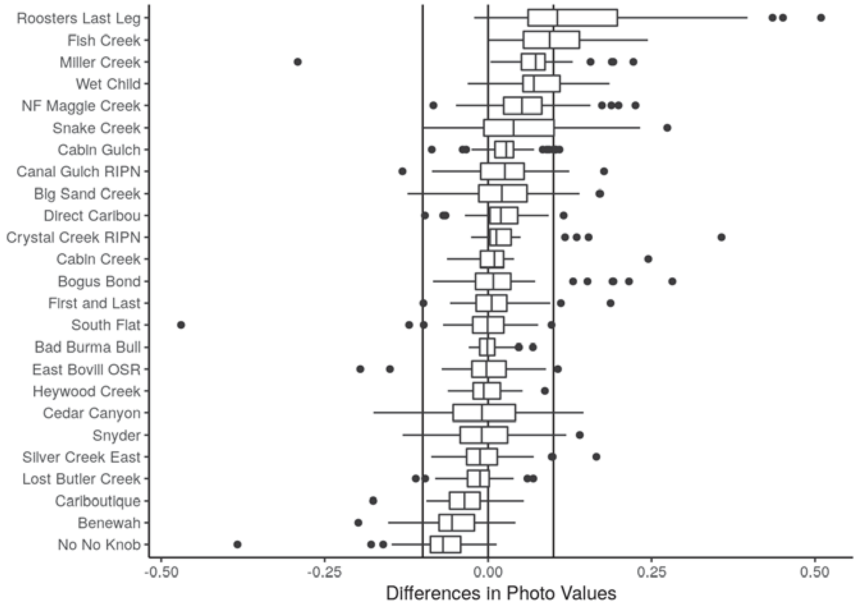


Figure 8. Results of Duplicate Solar Pathfinder Image Analysis

Before-After, Control-Impact (BACI) Effective Shade Analysis

The differences in effective shade for all sampled reaches are shown in Figure 9, ordered from the largest increase to the largest decrease. Stream shade and RS data are also presented

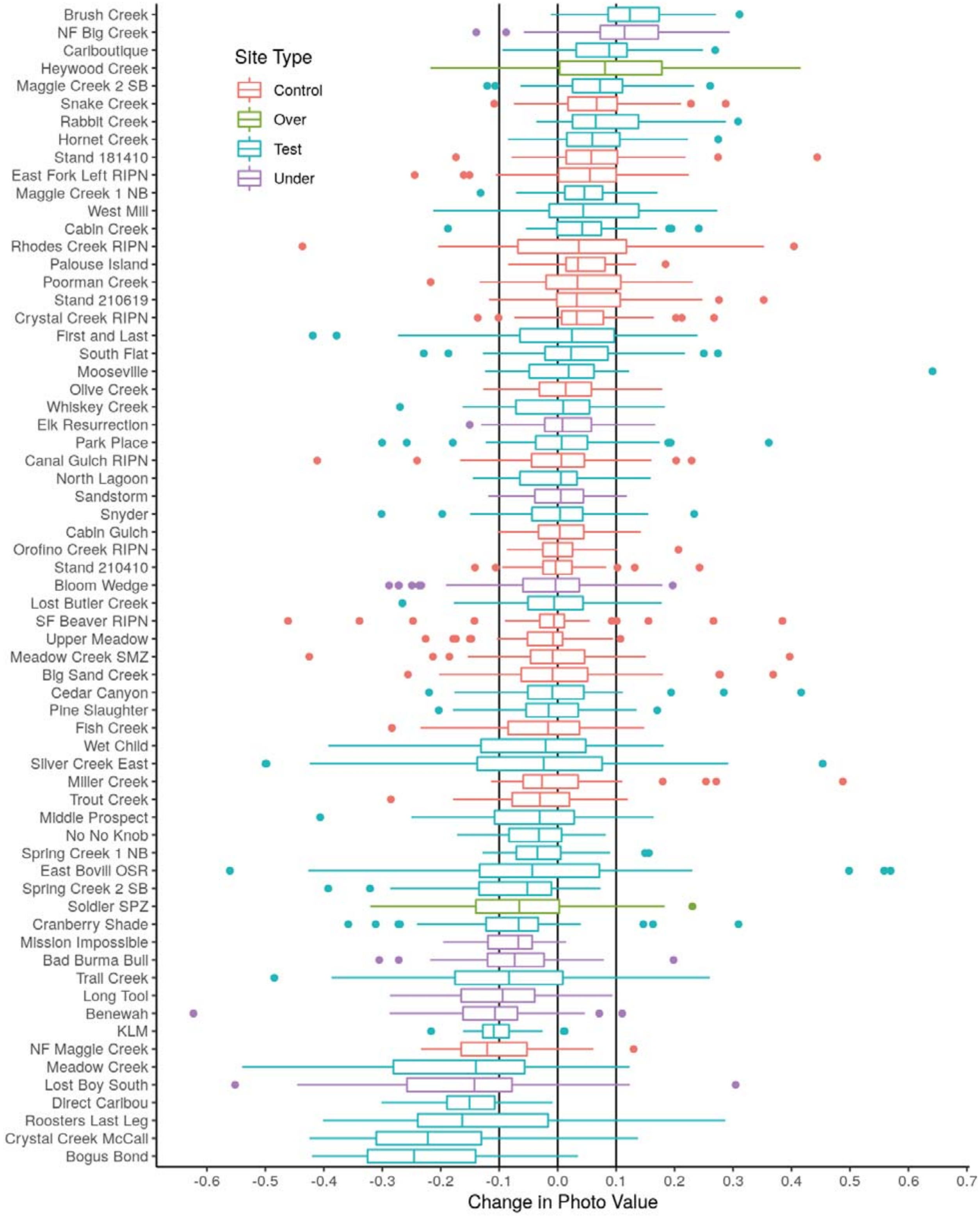


Figure 9. Post-Harvest Changes in Effective Shade Fraction (e.g. 0.1 is equivalent to 10%).

in tabular form in Appendix A and as maps in Appendix B. Positive values indicate an increase in estimated effective shade, whereas negative values indicate a decrease. As in Figure 7 and Figure 8, The median value of all digitized images for each study reach is indicated by the hinge (vertical line), and the first and third quartiles (the 25th and 75th percentiles) by the lower and upper box bounds. The extent of the whiskers corresponds to 1.5 times the interquartile range (IQR), and the dots represent outliers. Control sites are shown in red, whereas the treated test sites are shown in blue. The plot also includes sites that were identified as over-harvested (green) and under-harvested (purple), although these sites were excluded from the final analysis because they deviated from the objective of having the maximum allowable harvest permitted by the Rule without substantially exceeding this target.

The summary plot indicates that both increases and decreases in shade were observed in both control and treated reaches, although decreases appear to be associated more frequently with harvested reaches. Six treated sites exhibited a decrease in excess of 10% effective shade, with the maximum change of -22.8% (Bogus Bond). Conversely there was one treated site that exhibited an increase in shade exceeding 10% (Brush Creek, +12.9%) and one control site (NF Maggie Creek, -10.2%) that exceeded a 10% decline. Of the two sites that were identified as over-harvested, one exhibited an increase in shade whereas the other exhibited a decrease. Most of the under-harvested sites showed a decrease in shade, with 2 reaches exceeding 10% decreases, although one increased by more than 10%. Despite these outliers, the majority of reaches sampled exhibited effective shade changes within ±10%.

Results of the multi-level hierarchical linear mixed effects model are presented in Table 3. The model estimated that effective shade changed by +1.1%, from 76.8% to 77.9% in the control reaches, whereas a change of -2.7% in shade, from 80.3% to 77.5% was estimated for the treated test reaches across all sites. Both 95% confidence bounds are greater than -10%, so neither the control nor the test sites exhibited a decrease in effective shade that was significantly greater than 10%. Most importantly, the difference between the control and treatment reaches for the pre- and post-harvest period is -3.8% with 95% confidence intervals for the estimate of the difference ranging from -4.7% to -2.9%. Given concerns about the smaller number of treatment reaches than specified in the experiment plan, and potential

Table 3. Average Predicted Effective Stream Shade and Post-harvest Differences

Effective Shade

	Estimate	lower CI	upper CI
Control,Pre	76.8%	71.0%	82.6%
Control,Post	77.9%	72.1%	83.6%
Test,Pre	80.3%	75.7%	84.9%
Test,Post	77.5%	72.9%	82.1%

Effective Shade Differences
Pre- and Post-Harvest

	Estimate*	lower CI	upper CI
Control	1.1%	0.4%	1.7%
Test	-2.7%	-3.3%	-2.2%

Effective Shade Differences
Control vs. Treatment

	Estimate*	lower CI	upper CI
Difference	-3.8%	-4.7%	-2.9%

*All differences are significantly different than zero at p > 0.99. All confidence intervals are 95%.

to skew results by filtering several sites with relatively large shade decreases, the analysis was also completed with the inclusion of reaches that were identified as over- and under-harvested to reflect actual conditions across all study reaches. The estimate of the differences between the control and treatment reaches for the pre- and post-harvest period is -4.0% with 95% confidence intervals for the estimate of the difference ranging from -4.9% to -3.2%. The results were very similar to those obtained when omitting data from these reaches, and hence the resulting model was relatively insensitive to the data filtering.

Although the multi-level hierarchical linear mixed effects model is perhaps the most powerful and appropriate method to analyze this dataset, the robustness of the model was tested by also considering a two-level model for the difference in the shade estimates between the pre-treatment and post-treatment observation times. The estimates were comparable to those obtained from the multi-level model, with the expected decrease in effective shade and both confidence bounds less than 10%, although the standard errors were somewhat larger, as expected since aggregated data were being used. An even simpler comparison between the mean differences between pre- and post-harvest shade estimates between the control and test sites using a basic linear model was also completed as a further test of robustness. The decrease in the expected shade estimate based on this test was less than 10% and there was no statistically significant different between the control and test sites at the 95% confidence level.

Discussion

Accuracy and Precision

Accuracy is a measure of the agreement between a “true” or reference value and the associated measured value. The only way to assess the absolute accuracy of the effective shade estimates recorded with the Solar Pathfinder is to compare the results to measurements of shortwave radiation (0.28 – 3.5 μm) recorded with a high-quality pyranometer installed at the stream surface over at least a 24-hour clear sky period. An accuracy assessment using this method was beyond the scope of this investigation, however results of a preliminary study of stream radiation beneath a wide range of canopy structures indicates that on average, the Solar Pathfinder underestimates actual stream shade by 9% (Sydow et al., in prep.). The Solar Pathfinder method should provide a conservative estimate of stream shade for the purposes of this study, while balancing the acquisition of informative data with ease of use while maintaining consistency with other DEQ studies and protocols.

The primary purpose of this study was to assess changes in effective shade when harvesting to the minimum relative stocking allowable. Therefore, it is important to understand the degree of precision in the resulting data. Estimates of precision for the effective shade estimates at the reach scale indicate that differences were within 2% for duplicate field sampling, although this is based on a limited number (n=2) of field samples. The selection of specific locations for sampling within reaches is based on an objective protocol (Keefe et al., 2015d), therefore the limited number of duplicates is not particularly concerning, and the results suggest that the field methods are acceptable to accomplish the objectives of the study. Digitization of individual Solar Pathfinder images is more subjective, and results of the quality assurance analysis similarly indicated that the precision was within 2%, based on a much larger number (n=25) of sampled reaches. Given the large amount of spatial variability that can occur both within and between stream reaches and challenges with estimating the position of shade-producing canopy elements in the Solar Pathfinder images, the high degree of precision is probably a result of a combination of a large number of samples per reach, objective sampling protocol, and effective field personnel and analyst training. Estimated precision of both effective shade and Solar Pathfinder digitization are within recommended ranges for quality assurance and quality control.

Potential Bias

Based on limitations with available sites that had planned harvesting within the study period, it was not possible to equally balance site selection among the 2 Rule Options or reach orientations and directions to harvest units. Therefore, potential biases in the results is a possible concern due to the selection of biophysical conditions from among available operational activities. The largest potential bias concern is the azimuth from the selected reaches to the harvest units. For example, large effective shade losses might be expected to occur preferentially where south side harvests occur on east-west trending streams due to reductions in shade along the sun path where shortwave radiation is most intense, and hence the primary concern is that if the population of sites was biased away from southside harvests, the observed effective shade reductions could be biased low. The distribution of harvest directions (Figure 10) shows that the opposite was true: 55% percent of the sites sampled had harvests towards the south (S, SE, and SW), whereas only 27% percent had harvests toward the north (N, NE, and NW), and 18% were either towards the east or west. This suggests that the sample used in the study is likely to be relatively conservative if the majority of shade is generated by overstorey forest vegetation. Sampled sites are expected to be biased towards a greater potential for shade losses due to the larger percentage of south side harvest units in the sample population.

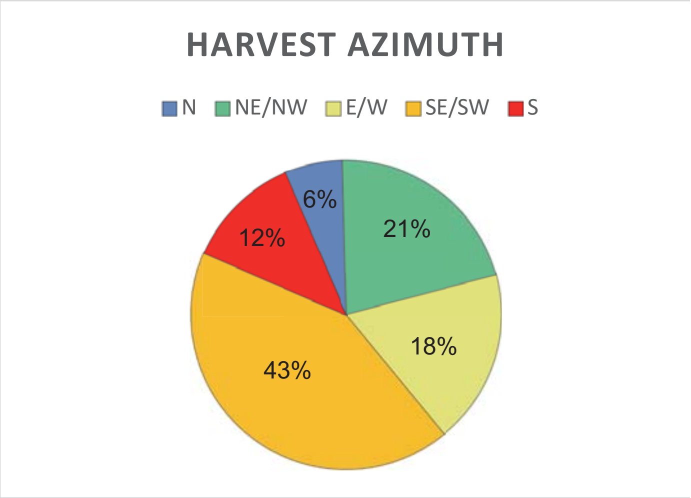


Figure 10. Distribution of Harvest Directions Relative to Study Reaches

An additional source of potential bias may be due to the widths of the sampled stream reaches relative to the entire population of streams across the state. This is because non-overstorey shade-generating elements such as understorey and low growing herbaceous vegetation, downed wood, and streambanks can provide a relatively large contribution to stream shade in very narrow streams (Klos and Link, 2018). A comparison of the approximate reach width distributions indicates that the control and treated study reaches were similar, with the vast majority of reaches less than 10 feet in width and with a minor amount ranging from approximately 10 to 30 feet in width (Figure 11). A greater proportion of the treated reaches were less than 5 feet in width, whereas the control reaches were comprised of a more equal split between the 0-5 foot and 5-10 foot width classes. The slightly lower amount of pre-

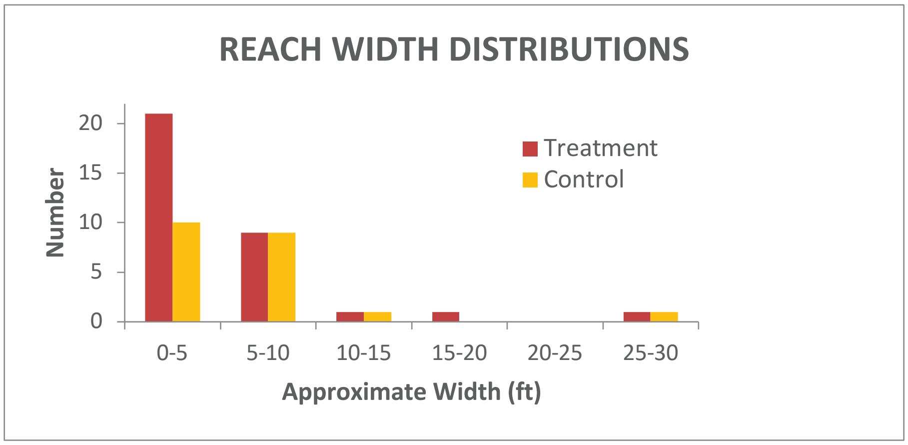


Figure 11. Distribution of Study Reach Approximate Widths

treatment effective shade (Table 3) in the control reaches is consistent with the larger width bias. The modeling exercise upon which the Rule was based used a stream width of 10 feet, whereas the majority of treated reaches were much narrower and hence effective shade changes may have been less sensitive to overstorey canopy removal due to the low shade considerations noted above. The observed reduction in shade that was well below 10% is consistent with the narrow width bias of the sampled reaches relative to the slightly wider simulated reaches that were used for the Rule development.

The sites surveyed were primarily one-sided harvests, with only 1 of the 33 sampled reaches, or ~3% listed as being harvested on both sides of the stream. Two-sided harvests have the potential to produce larger shade losses than were observed in this study, depending on a combination of stream orientation, width, and both over- and understorey vegetation characteristics in the path of the solar beam. Because Class I streams are often used as stand and harvest unit boundaries, one-sided harvesting of streams is the most common forest management scenario that occurs in the region. The exact of proportion of harvests that occur on one vs. both sides of streams in the state is not known. We assume that the true proportion of two-sided harvests occurring simultaneously is similar to that represented in the sample population, however the direction and approximate magnitude of this potential source of bias is unknown. If needed, analysis of statewide operational data may be used to quantify the proportion of harvests occurring within the 5 azimuth classes, range of stream widths, and the proportion of 1- and 2-sided harvests to further assess how representative the sample of sites used in this study is, relative to the statewide conditions. If the population of operational conditions are substantially different from the population of sites used in this study, this study could be expanded with a limited number of additional sites to more accurately represent statewide conditions.

Possible Limitations

The objective of this study was to estimate changes in effective shade at the statewide level which is why the locations of sampled reaches were weighted towards forest types (e.g. NIGF) and highly productive forested areas within the state that experience the greatest harvest levels. Although this was an effective approach to estimate large-scale differences across areas that are most strongly affected by timber harvest, there are a number of limitations regarding the scope of inference for comparing and contrasting among specific conditions that occur infrequently. Specifically, the vast majority of reaches were in the NIGF and CIGF forest types, with a minor amount in the SIGF and WHSF, and none in the DFPP forest types. Results of the study therefore should not be assumed to be representative of the minor forest types, although shade reductions in the minor forest types sampled (SIGF, WHSF) were all well within the -10% desired threshold. If effective shade changes in any of these forest types is specifically of concern, a complementary study to focus primarily on one or more of these forest types at the small proportion of sites where harvesting occurs is recommended.

It should also be noted that some sites were classified as different forest types between the 2 sampling campaigns, and there is the potential that sites may have been mis-classified during both RS samplings. The potential for mis-classified forest types does not directly affect the results of the shade change analyses, but may have an indirect effect since allowable residual riparian RS under the Rule varies by forest type, and hence may affect whether specific sites should or should not have been filtered from the dataset due to over- or under-harvesting. A practical solution for agencies involved in enforcing and monitoring the Shade Rule may be to simplify or clarify methods for identifying forest type.

The scope of inference is also limited in terms of assessing shade changes associated with other specific biophysical and operational conditions due to the sampling design and availability of sites. By design, the sampled population of reaches included variability among Rule Options (1 and 2), stream orientations and widths, locations of harvest units, and silvicultural systems to the extent these were available. The sample size could not feasibly be large enough to replicate all possible combinations of the many factors that could be of interest. Therefore, it is not possible to infer whether the new Rule works exactly as intended for all specific combinations of these factors. An expanded study is recommended if there is interest in assessing shade changes associated with specific practices (e.g. Options 1 and 2; 1 vs. 2-sided harvests) or biophysical conditions (e.g. stream widths; orientations). The results, however, indicate that the rule works effectively on average across conditions studied (mean change in effective shade percent less than 10% overall). The results also may be used to gain insight into the types of conditions where relatively large shade losses do or do not occur as detailed case studies based on the collected imagery, and through the summary Tables and Figures. The data summary maps (Appendix B) suggest that there is a not a preferential loss of shade for specific orientations, although the study design precludes a rigorous statistical analysis of higher order effects such as this.

Differences between the two Options were not assessed because in many cases the specific treatment Option was not specified in the dataset, the RS levels in the inner and outer zones exhibited a range of values, were dominated by RS levels that were not identical to either rule target until an allowance of ±10 RS and edge effects were considered (Figure 12). The post-harvest RS levels for 7% of reaches conformed only to the 60/10 Option whereas the post-harvest RS levels for only 2% conformed only to the 60/30 Option based on the ±10 RS threshold and adjusting for edge effects. The majority of sites (66%) could be considered as conforming to either Option. Approximately 25% of the treated reaches had post-harvest levels that did not conform to either Rule Option and are classified as ‘neither’ in Figure 12. In the vast majority of cases this was due to underharvesting, with a small minority due to overharvesting. In many cases these reaches flowed through fairly open meadows with relatively low amounts of overstorey vegetation in the inner zones. Despite these low RS values, the harvests did not violate the Shade Rule because there is no requirement to meet a minimum stocking level when pre-harvest stocking is less than the post-harvest targets for the two options under the Rule. If there is interest in quantifying the amounts of shade loss under the two different Options, it is recommended that the study be expanded to provide an adequate number of sampled reaches to determine the difference between pre- and post-harvest effective stream shade.

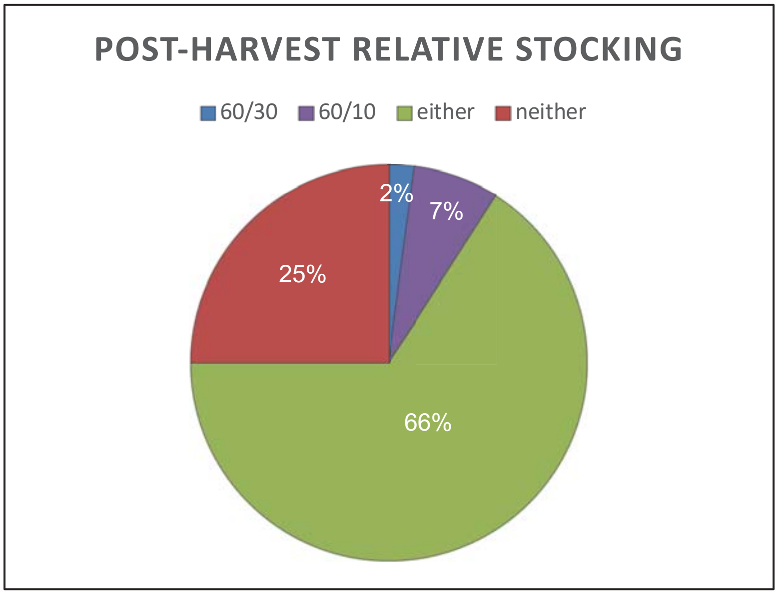


Figure 12. Post-Harvest Relative Stocking Classes for Treated Reaches. Sites were assigned 60/30 or 60/10 option classes if they were within ±10 RS accounting for edge effects. Sites were classified as either if they met RS levels for both Options based on the ±10 RS criteria with edge effects. Sites classified as neither met the Rule but typically had both pre- and post-harvest RS levels below the target stocking levels.

Additional insight can be gained where relatively large losses of shade greater than or equal to 15% were realized under the new rule by examining the field notes, Solar Pathfinder images, and oblique digital imagery collected by field crews. This high level of detail in measurements conducted for individual sites was a key part of the study design, providing availability of high-quality data for further scrutiny of individual sites. Discussion of four reaches where harvest resulted in effective shade losses equal to or exceeding 15% absolute effective shade is provided in the following section. Specific conditions producing absolute shade losses less than 15% were difficult to discern from Solar Pathfinder and oblique digital imagery and are not discussed in this report.

Specific Reach Conditions

Bogus Bond (-22.8%)

The largest loss of shade, from approximately 92% to 69% occurred at the Bogus Bond site in the NIGF forest type near Santa, ID (Figure 13). The stream is ~10 ft wide, and trends roughly north-south with a harvest unit on the eastern side. Post-harvest imagery reveals very little understorey or low branches that produce shade, hence most of the stream shade is generated by nearby branch-free tree

Figure 13. Bogus Bond Post-harvest Riparian Condition.

boles and canopy crowns. A notable post-harvest increase in sky area within the relatively open trunk space in the riparian zone is clearly evident within the Apr-Sep solar bands on the Solar Pathfinder images. Relative stocking data for Option B (60/10), show that harvesting changed the RS from 88/75 to 50/0 suggesting that both the inner and outer riparian zones were over-harvested. The stark absence of low-level shade-producing materials that contribute to the obstruction of shortwave radiation at lower solar elevation angles to the east, potentially combined with the relatively high harvest levels in the riparian zone are likely why this site experienced such a large decrease in effective shade.

Crystal Creek McCall (-22.1%)

Crystal Creek near Fernwood, ID exhibited the second largest observed loss of shade, from approximately 80% to 58%. This reach was in the NIGF forest type, was roughly 4 to 10 ft. wide, and trended roughly northeast-southwest with a single harvest unit on the southeastern side. Relative stocking data for Option B (60/10) show that harvesting changed the RS from 52/103 to 49/12 consistent with field notes and photos indicating that the reach flowed through a meadow with most of the timber located in the outer zones. Harvest effects are not particularly evident in the oblique digital images due to a large component of stream shade generated by proximal herbaceous and deciduous vegetation (Figure 14), although overstorey thinning is evident in the Solar Pathfinder images. Reductions in shade are clearly evident in the Solar Pathfinder images, primarily from reduced canopy density and increase in canopy gaps to the south. Low post-harvest shade values at this site appear to be due to relatively low RS in the inner zone coupled with losses due to harvest in distal zones, with pre- to post-harvest changes being driven almost exclusively by canopy reductions in the outer zone. Data from this site suggests that maintaining outer zone vegetation may be important to retain effective shade even in cases in where low-growing and herbaceous vegetation contributes to stream shade.

Figure 14. Crystal Creek McCall Unit Post-harvest Riparian Condition.

Meadow Creek (-16.8%)

Meadow Creek near Headquarters exhibited a change in effective shade from approximately 70% to 53%. This reach was in the NIGF forest type and is a very narrow (2-3 ft), deep, north-south trending channel through a meadow with a harvest unit on the eastern side. Both oblique and Solar Pathfinder images show a very large amount of shade from herbaceous and deciduous brushy vegetation near the stream channel (Figure 15) with distal forest vegetation in the pre-harvest imagery. Distinct effects of timber harvest are neither evident in the oblique nor the Solar Pathfinder imagery. Relative stocking data for

Figure 15. Meadow Creek Post-harvest Riparian Condition.

Option B (60/10) show that harvesting changed the RS from 24/56 to 27/27, indicating vegetation changes primarily in the outer zone. There appears to be less herbaceous and deciduous near stream shade in the post-harvest Solar Pathfinder imagery, but near stream vegetation in the oblique images appear to be very similar between the pre- and post-harvest conditions. Relatively large differences in shade can result from the location of Pathfinder placement when there are materials that obscure the solar disk very close to the Solar Pathfinder dome. Sampling for both phases occurred in early to mid-August but were completed by 2 different field crews therefore the estimated decreases may be due to small differences in where the Solar Pathfinder was placed relative to nearby low-growing, shade-producing vegetation in this system although the large number of sampling locations should reduce this potential source of variation. Data from this site also suggests that maintaining outer zone vegetation may be important to retain effective shade even in cases where low-growing and herbaceous vegetation contributes to stream shade.

Direct Caribou (-15.0%)

The Direct Caribou reach in the Priest Lake area exhibited a change in effective shade from approximately 81% to 66%. This reach was in a dense, mature, NIGF forest, and trended roughly northeast-southwest with a harvest unit on the southeastern side. The reach was one of the widest streams sampled, with a width of approximately 30 feet and a substrate consisting of large boulders (Figure 16). Relative stocking data for Option B (60/10) show that harvesting reduced the RS from 77/115 to 54/20. The oblique images indicate little evidence of harvest effects, likely due to the relatively small reductions in inner zone RS, and deep crowns along the banks of the relatively wide creek. Likewise, the Solar Pathfinder images suggest relatively subtle changes in the canopy conditions with some slight canopy density reductions in the southeastern quadrant of the sky. The field crews masked the solar disk at relatively high sun angles to minimize glare in many of the post-harvest images. It is unclear how the analysts who digitized the images estimated the canopy behind the masked areas

Figure 16. Direct Caribou Post-harvest Riparian Condition.

which in many cases covered a portion of the most important high solar angle portions of the sun path diagram when shortwave radiation intensity is highest. There is therefore potential for some post-harvest shade-producing vegetation to have been misclassified as open in the final analysis, potentially leading to larger estimates of shade reduction. Although some of the shade differences may be attributable to field and image processing methods, the data suggest that the relatively large reduction may be attributable to slight overharvesting in the inner zone combined with a lack of low shade producing materials in this particularly wide creek and hence resulting in greater sensitivity to overstorey removal.

In summary, for the reaches with the largest (≥15%) decreases in effective shade, there appears to be no consistent biophysical conditions that characterize these reaches, although none of these reaches experienced harvest on northern (NW, N, or NE) sides. The four reaches discussed above were all in the NIGF forest types, but were characterized by a range of stream widths and near-stream vegetation structures. The results of the detailed analysis of images suggests that the role of shade-producing materials very close to the water surface (e.g. low-growing herbaceous vegetation and suspended large wood) may play an important role in buffering the effect of overstorey reductions. For example, the Bogus Bond reach had minimal understorey vegetation and the Direct Caribou reach was very wide and hence largely unaffected by low-growing vegetation, therefore these sites may have been more sensitive to overstorey thinning in the riparian zone. The other sites with relatively large effective shade decreases (Crystal Creek McCall and Meadow Creek) were characterized by a relatively large amount of understorey shade both before and after harvest, but had relatively low relative stocking rates in the inner zones, and hence may have been less resilient to overstorey thinning in the outer zone.

Conclusions

The results of the multi-level hierarchical linear mixed effects model indicate that estimated effective shade changed by -2.7% on average between pre- and post-harvest conditions. When the increases in shade at the control sites are considered, the estimate of the change was -3.8% with 95% confidence bounds ranging from -4.7% to -2.9%. Estimates of effective shade loss provided by the study are robust even when less powerful statistical analyses were completed, and when sites that were identified as over- and under-harvested were included in the analysis. When these values are also considered in the context of the field sampling and image digitization precision which were both under 2%, the results indicate that the average changes in estimated effective shade under the new Rule are very likely within the target level of <10% on average at the statewide level. Collaboration between the Idaho Dept. of Environmental Quality, Idaho Dept. of Lands and University of Idaho to coordinate pre- and post-harvest measurement at 65 sites, as well as planning, marking and voluntary participation of state, private, and industrial landowners, foresters, and logging contractors in a designed experiment, was a substantial undertaking to coordinate over a 4 year period. Many of the landowners harvested ‘to the rule’, cutting the maximum allowable timber volume within the streamside protection zone in order to satisfy the research objectives. It is important to note that many may harvest less timber adjacent to the stream under normal forest management practices. Given all of these considerations, it is highly likely that the new Rule appears to be functioning as intended at the statewide level. However, an expanded study is recommended if the performance of the Rule for specific operational practices or biophysical conditions are deemed to be important for refinement of BMPs in the state of Idaho.

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Appendix A: Data Summary Tables

Table 4. Sampled Reaches and Estimated Effective Shade

					Effective Shade		
Site Number	**Site Name**	**Forest Type**[a]	**Prescription**[b]	**Azimuth**[c]	**Pre-Harvest**	**Post-Harvest**	**Difference**
1	Bad Burma Bull	CIGF	Under	SW	87.7%	80.4%	-7.2%
2	Benewah	NIGF	Under	NE	89.2%	77.8%	-11.4%
3	Big Sand Creek	CIGF	Control	NW	86.9%	86.7%	-0.2%
4	Bloom Wedge	NIGF	Under	NW	86.9%	84.2%	-2.8%
5	Bogus Bond	NIGF	Test	E	92.2%	69.4%	-22.8%
6	Brush Creek	NIGF	Test	NE	71.0%	83.9%	12.9%
7	Cabin Creek	CIGF	Test	NW	84.7%	89.4%	4.7%
8	Cabin Gulch	NIGF	Control	SE	89.4%	89.9%	0.5%
9	Canal Gulch RIPN	NIGF	Control	W	52.3%	52.3%	0.0%
10	Cariboutique	NIGF	Test	S	75.1%	82.9%	7.8%
11	Cedar Canyon	CIGF	Test	SE	82.1%	81.9%	-0.2%
12	Cranberry Shade	NIGF,CIGF	Test	E	57.9%	50.0%	-8.0%
13	Crystal Creek McCall	NIGF	Test	SE	80.5%	58.4%	-22.1%
14	Crystal Creek RIPN	NIGF	Control	NE	80.4%	84.9%	4.5%
15	Direct Caribou	NIGF	Test	SE	81.2%	66.3%	-15.0%
16	East Bovill OSR	CIGF	Test	N	57.6%	55.8%	-1.8%
17	East Fork Left RIPN	CIGF,NIGF	Control	N	85.0%	88.7%	3.7%
18	Elk Resurrection	NIGF	Under	SE	87.3%	88.3%	1.0%
19	First and Last	NIGF	Test	SE	56.1%	56.9%	0.9%
20	Fish Creek	NIGF	Control	S	86.4%	83.4%	-3.0%
21	Heywood Creek	CIGF	Over	E	73.1%	81.5%	8.4%
22	Hornet Creek	SIGF	Test	W	69.4%	75.1%	5.7%
23	KLM	CIGF	Test	SE	95.1%	84.8%	-10.3%
24	Long Tool	NIGF	Under	SW	89.7%	80.0%	-9.7%
25	Lost Boy South	NIGF	Under	SW	75.6%	59.3%	-16.3%
26	Lost Butler Creek	NIGF	Test	NW	87.5%	86.2%	-1.4%
27	Maggie Creek 1 NB	NIGF,CIGF	Test	N	86.6%	90.7%	4.1%
28	Maggie Creek 2 SB	NIGF	Test	S	80.5%	87.4%	7.0%
29	Meadow Creek	NIGF	Test	E	69.6%	52.8%	-16.8%
30	Meadow Creek SMZ	NIGF	Control	SE	79.1%	78.6%	-0.5%
31	Middle Prospect	NIGF	Test	SE	85.4%	80.9%	-4.6%
32	Miller Creek	NIGF	Control	SW	86.7%	87.0%	0.3%
33	Mission Impossible	NIGF	Under	E	89.1%	81.3%	-7.8%
34	Mooseville	NIGF	Test	SE	82.1%	83.9%	1.8%

35	NF Big Creek	CIGF	Under	W	79.8%	91.6%	11.8%
36	NF Maggie Creek	CIGF	Control	N	89.0%	78.9%	-10.2%
37	No No Knob	NIGF	Test	E	92.2%	88.4%	-3.8%
38	North Lagoon	NIGF	Test	SW	88.8%	88.3%	-0.5%
39	Olive Creek	SIGF	Control	W	82.4%	83.6%	1.2%
40	Orofino Creek RIPN	NIGF	Control	NE	32.1%	32.4%	0.3%
41	Palouse Island	NIGF	Control	S	84.8%	89.5%	4.8%
42	Park Place	NIGF	Test	NW	86.7%	87.8%	1.1%
43	Pine Slaughter	CIGF,SIGF	Test	NE	86.7%	85.3%	-1.3%
44	Poorman Creek	NIGF	Control	NE	86.9%	90.7%	3.7%
45	Rabbit Creek	NIGF	Test	NE	82.6%	90.9%	8.3%
46	Rhodes Creek RIPN	NIGF	Control	NW	75.6%	79.1%	3.4%
47	Roosters Last Leg	NIGF	Test	SW	76.3%	64.8%	-11.5%
48	Sandstorm	NIGF	Under	NE	92.5%	93.1%	0.5%
49	SF Beaver RIPN	NIGF,CIGF	Control	W	31.6%	30.5%	-1.1%
50	Silver Creek East	CIGF,NIGF	Test	E	65.7%	61.2%	-4.5%
51	Snake Creek	CIGF,NIGF	Control	E	80.9%	87.1%	6.3%
52	Snyder	NIGF	Test	SW	82.8%	82.6%	-0.2%
53	Soldier SPZ	NIGF	Over	SE	77.1%	70.3%	-6.8%
54	South Flat	NIGF,CIGF	Test	SE	82.3%	84.7%	2.4%
55	Spring Creek 1 NB	NIGF	Test	NE	87.1%	84.0%	-3.1%
56	Spring Creek 2 SB	NIGF	Test	S	90.0%	82.4%	-7.6%
57	Stand 181410	NIGF	Control	N	58.0%	64.0%	6.0%
58	Stand 210410	NIGF	Control	SW	89.2%	89.1%	-0.1%
59	Stand 210619	NIGF,CIGF	Control	NW	83.5%	89.6%	6.2%
60	Trail Creek	NIGF	Test	SW	82.0%	73.9%	-8.1%
61	Trout Creek	NIGF	Control	NE	78.0%	74.8%	-3.2%
62	Upper Meadow	NIGF	Control	S	94.9%	92.6%	-2.3%
63	West Mill	SIGF	Test	S/N[d]	81.8%	85.7%	3.9%
64	Wet Child	WHSF	Test	SE	81.5%	76.0%	-5.5%
65	Whiskey Creek	CIGF	Test	SW	86.8%	87.0%	0.2%

[a] Forest Types: NIGF – North Idaho Grand Fir; CIGF – Central Idaho Grand Fir; SIGF – Southern Idaho Grand Fir; WHSF – Western Hemlock-Subalpine Fir. Where 2 forest types are listed, the types correspond with those determined by field crews during each sampling event.

[b] Prescription Codes: Control – control reach sampled twice with no harvest; Test – reach sampled before and after harvest; Over – reach estimated to have been over-harvested; Under – reach estimated to have been under-harvested. Data from both over- and under-harvested reaches were excluded from the statistical analysis.

[c] Azimuth indicates the direction from the sampled reach to the harvested unit.

[d] Reach was harvested on both sides of the study stream. All other reaches were only harvested on one side.

Table 5. Sampled Reaches and Estimated Effective Shade Sorted by Treatment

					Effective Shade		
Site Number	**Site Name**	**Forest Type[a]**	**Prescription[b]**	**Azimuth[c]**	**Pre-Harvest**	**Post-Harvest**	**Difference**
3	Big Sand Creek	CIGF	Control	NW	86.9%	86.7%	-0.2%
8	Cabin Gulch	NIGF	Control	SE	89.4%	89.9%	0.5%
9	Canal Gulch RIPN	NIGF	Control	W	52.3%	52.3%	0.0%
14	Crystal Creek RIPN	NIGF	Control	NE	80.4%	84.9%	4.5%
17	East Fork Left RIPN	CIGF,NIGF	Control	N	85.0%	88.7%	3.7%
20	Fish Creek	NIGF	Control	S	86.4%	83.4%	-3.0%
30	Meadow Creek SMZ	NIGF	Control	SE	79.1%	78.6%	-0.5%
32	Miller Creek	NIGF	Control	SW	86.7%	87.0%	0.3%
36	NF Maggie Creek	CIGF	Control	N	89.0%	78.9%	-10.2%
39	Olive Creek	SIGF	Control	W	82.4%	83.6%	1.2%
40	Orofino Creek RIPN	NIGF	Control	NE	32.1%	32.4%	0.3%
41	Palouse Island	NIGF	Control	S	84.8%	89.5%	4.8%
44	Poorman Creek	NIGF	Control	NE	86.9%	90.7%	3.7%
46	Rhodes Creek RIPN	NIGF	Control	NW	75.6%	79.1%	3.4%
49	SF Beaver RIPN	NIGF,CIGF	Control	W	31.6%	30.5%	-1.1%
51	Snake Creek	CIGF,NIGF	Control	E	80.9%	87.1%	6.3%
57	Stand 181410	NIGF	Control	N	58.0%	64.0%	6.0%
58	Stand 210410	NIGF	Control	SW	89.2%	89.1%	-0.1%
59	Stand 210619	NIGF,CIGF	Control	NW	83.5%	89.6%	6.2%
61	Trout Creek	NIGF	Control	NE	78.0%	74.8%	-3.2%
62	Upper Meadow	NIGF	Control	S	94.9%	92.6%	-2.3%
21	Heywood Creek	CIGF	Over	E	73.1%	81.5%	8.4%
53	Soldier SPZ	NIGF	Over	SE	77.1%	70.3%	-6.8%
5	Bogus Bond	NIGF	Test	E	92.2%	69.4%	-22.8%
6	Brush Creek	NIGF	Test	NE	71.0%	83.9%	12.9%
7	Cabin Creek	CIGF	Test	NW	84.7%	89.4%	4.7%
10	Cariboutique	NIGF	Test	S	75.1%	82.9%	7.8%
11	Cedar Canyon	CIGF	Test	SE	82.1%	81.9%	-0.2%
12	Cranberry Shade	NIGF,CIGF	Test	E	57.9%	50.0%	-8.0%
13	Crystal Creek McCall	NIGF	Test	SE	80.5%	58.4%	-22.1%
15	Direct Caribou	NIGF	Test	SE	81.2%	66.3%	-15.0%
16	East Bovill OSR	CIGF	Test	N	57.6%	55.8%	-1.8%
19	First and Last	NIGF	Test	SE	56.1%	56.9%	0.9%
22	Hornet Creek	SIGF	Test	W	69.4%	75.1%	5.7%

23	KLM	CIGF	Test	SE	95.1%	84.8%	-10.3%
26	Lost Butler Creek	NIGF	Test	NW	87.5%	86.2%	-1.4%
27	Maggie Creek 1 NB	NIGF,CIGF	Test	N	86.6%	90.7%	4.1%
28	Maggie Creek 2 SB	NIGF	Test	S	80.5%	87.4%	7.0%
29	Meadow Creek	NIGF	Test	E	69.6%	52.8%	-16.8%
31	Middle Prospect	NIGF	Test	SE	85.4%	80.9%	-4.6%
34	Mooseville	NIGF	Test	SE	82.1%	83.9%	1.8%
37	No No Knob	NIGF	Test	E	92.2%	88.4%	-3.8%
38	North Lagoon	NIGF	Test	SW	88.8%	88.3%	-0.5%
42	Park Place	NIGF	Test	NW	86.7%	87.8%	1.1%
43	Pine Slaughter	CIGF,SIGF	Test	NE	86.7%	85.3%	-1.3%
45	Rabbit Creek	NIGF	Test	NE	82.6%	90.9%	8.3%
47	Roosters Last Leg	NIGF	Test	SW	76.3%	64.8%	-11.5%
50	Silver Creek East	CIGF,NIGF	Test	E	65.7%	61.2%	-4.5%
52	Snyder	NIGF	Test	SW	82.8%	82.6%	-0.2%
54	South Flat	NIGF,CIGF	Test	SE	82.3%	84.7%	2.4%
55	Spring Creek 1 NB	NIGF	Test	NE	87.1%	84.0%	-3.1%
56	Spring Creek 2 SB	NIGF	Test	S	90.0%	82.4%	-7.6%
60	Trail Creek	NIGF	Test	SW	82.0%	73.9%	-8.1%
63	West Mill	SIGF	Test	S/N[d]	81.8%	85.7%	3.9%
64	Wet Child	WHSF	Test	SE	81.5%	76.0%	-5.5%
65	Whiskey Creek	CIGF	Test	SW	86.8%	87.0%	0.2%
1	Bad Burma Bull	CIGF	Under	SW	87.7%	80.4%	-7.2%
2	Benewah	NIGF	Under	NE	89.2%	77.8%	-11.4%
4	Bloom Wedge	NIGF	Under	NW	86.9%	84.2%	-2.8%
18	Elk Resurrection	NIGF	Under	SE	87.3%	88.3%	1.0%
24	Long Tool	NIGF	Under	SW	89.7%	80.0%	-9.7%
25	Lost Boy South	NIGF	Under	SW	75.6%	59.3%	-16.3%
33	Mission Impossible	NIGF	Under	E	89.1%	81.3%	-7.8%
35	NF Big Creek	CIGF	Under	W	79.8%	91.6%	11.8%
48	Sandstorm	NIGF	Under	NE	92.5%	93.1%	0.5%

[a]Forest Types: NIGF – North Idaho Grand Fir; CIGF – Central Idaho Grand Fir; SIGF – Southern Idaho Grand Fir; WHSF – Western Hemlock-Subalpine Fir. Where 2 forest types are listed, the types correspond with those determined by field crews during each sampling event.

[b]Prescription Codes: Control – control reach sampled twice with no harvest; Test – reach sampled before and after harvest; Over – reach estimated to have been over-harvested; Under – reach estimated to have been under-harvested. Data from both over- and under-harvested reaches were excluded from the statistical analysis.

[c]Azimuth indicates the direction from the sampled reach to the harvested unit.

[d]Reach was harvested on both sides of the study stream. All other reaches were only harvested on one side.

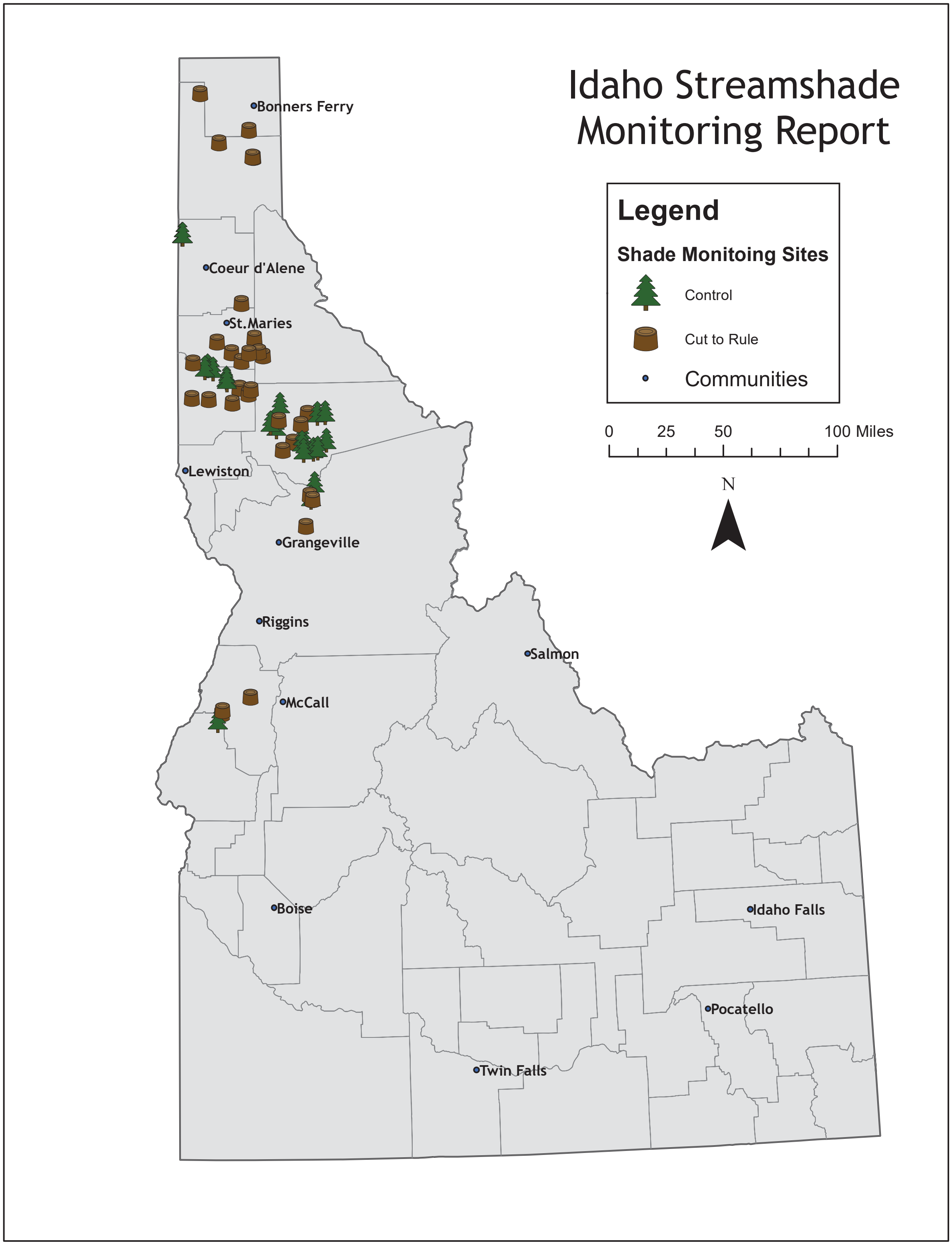
Table 6. Relative Stocking Data

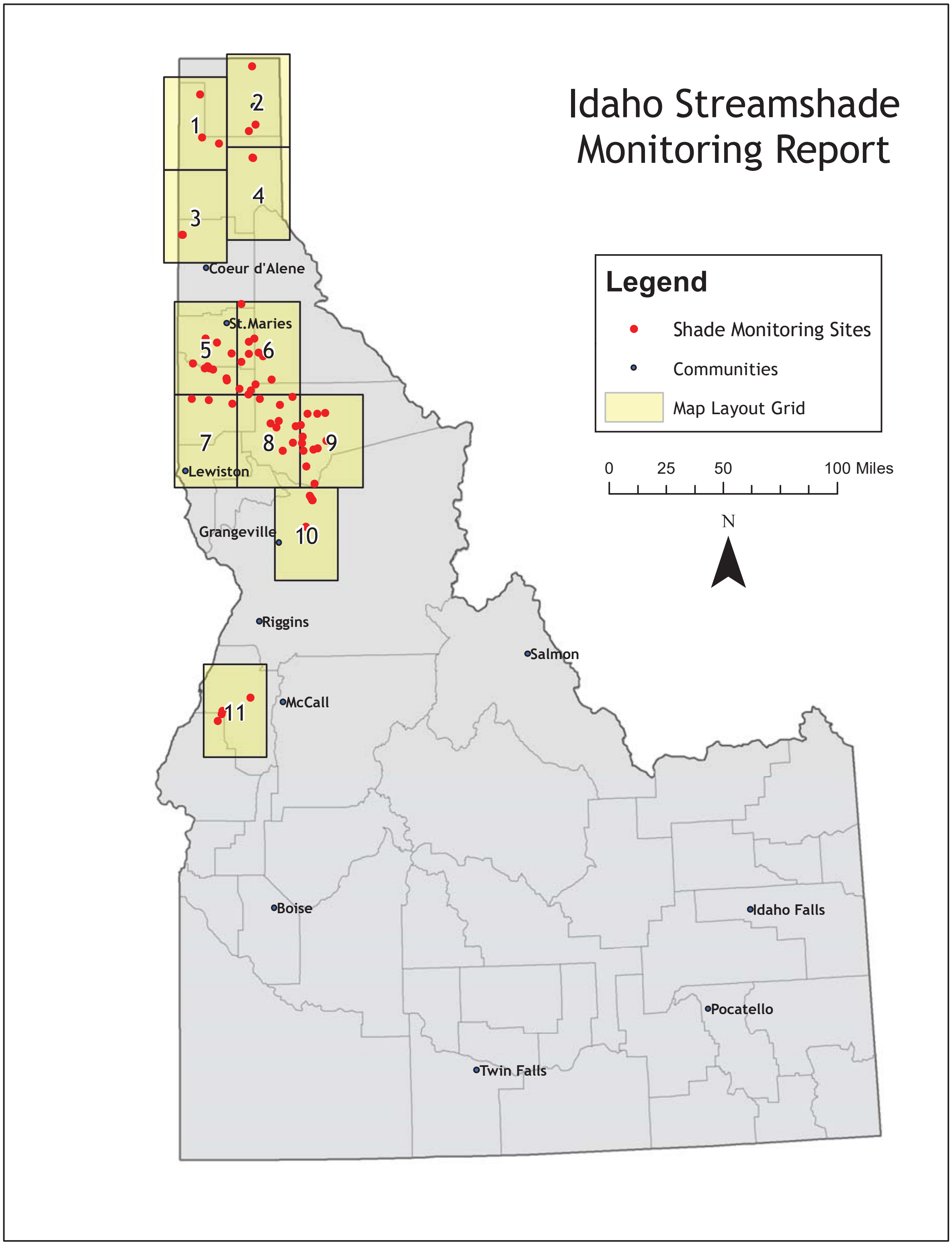
Site Number	Site Name	Pre-harvest RS (60/30)	Pre-harvest RS (60/10)	Post-harvest RS (60/30)	Post-harvest RS (60/10)	Cut to Rule ±10?	Cut to Rule ±10 with edge effects?[a]
1	Bad Burma Bull	37/88	69/74	53/69	71/47	n	n
2	Benewah	51/86	45/104	51/59	60/49	n	n
3	Big Sand Creek	112/75	94/74	108/66	84/71	control	
4	Bloom Wedge	31/72	47/76	36/52	52/36	n	n
5	Bogus Bond	102/76	88/75	78/11	50/0	y	
6	Brush Creek	118/21	79/2	75/18	55/1	y	
7	Cabin Creek	58/77	61/80	66/34	61/13	y	
8	Cabin Gulch	70/62	63/66	64/59	57/67	control	
9	Canal Gulch RIPN	12/34	20/40	12/47	28/51	control	
10	Cariboutique	50/21	47/48	66/32	54/20	y	
11	Cedar Canyon	49/75	59/70	48/41	51/28	n	y, equiv to 60/12
12	Cranberry Shade	74/56	68/50	71/40	64/23	n	y, equiv to 66/19
13	Crystal Creek McCall	24/97	52/103	24/43	49/12	y	y
14	Crystal Creek RIPN	44/20	36/14	60/34	51/26	control	control
15	Direct Caribou	97/86	77/115	84/22	54/20	y	y
16	East Bovill OSR	2/37	10/56	1/18	9/19	y	y
17	East Fork Left RIPN	46/25	31/34	45/22	31/26	control	control
18	Elk Resurrection	72/71	74/58	85/47	70/39	n	n
19	First and Last	31/32	31/31	35/16	32/4	y	y
20	Fish Creek	82/97	89/83	79/97	91/91	control	control
21	Heywood Creek	61/92	78/89	39/22	35/12	n	n
22	Hornet	88/58	62/47	75/31	62/13	y	y
23	KLM	82/93	89/89	51/30	45/21	y	y
24	Long Tool	116/91	104/82	119/81	114/53	n	n
25	Lost Boy South	17/45	21/66	18/48	26/61	n	n
26	Lost Butler Creek	131/65	102/54	102/13	61/5	y	y
27	Maggie Creek 1 NB	55/67	66/58	51/44	62/15	y	y
28	Maggie Creek 2 SB	71/67	76/54	74/30	57/20	y	y
29	Meadow Creek	15/45	24/56	17/32	27/27	y	y
30	Meadow Creek SMZ	32/65	68/26	28/57	58/26	control	control
31	Middle Prospect	53/32	30/45	30/23	25/18	y	y
32	Miller Creek	116/116	115/118	112/98	105/99	control	control
33	Mission Impossible	110/92	95/89	110/46	88/28	n	n
34	Mooseville	88/61	76/58	46/29	44/15	n	y, equiv to 50/4

35	NF Big Creek	137/106	92/117	112/30	77/17	n	n
36	NF Maggie Creek	38/42	24/35	46/27	35/30	control	control
37	No No Knob	81/84	42/87	86/19	60/4	y	y
38	North Lagoon	63/50	60/43	65/33	55/22	y	y
39	Olive Creek	188/88	135/94	170/79	124/79	control	control
40	Orofino Creek RIPN	0/16	6/20	0/23	9/29	control	control
41	Palouse Island	71/62	70/55	73/67	70/66	control	control
42	Park Place	95/39	60/54	78/25	56/17	y	y
43	Pine Slaughter	65/49	65/50	60/39	54/30	y	y
44	Poorman Creek	44/44	46/41	51/48	53/42	control	control
45	Rabbit Creek	79/69	74/70	76/49	69/37	y	y
46	Rhodes Creek RIPN	52/69	67/58	42/63	58/54	control	control
47	Roosters Last Leg	97/100	99/101	99/24	70/9	y	y
48	Sandstorm	136/74	94/96	116/32	79/22	n	n
49	SF Beaver RIPN	0/20	04/32	0/26	5/42	control	control
50	Silver Creek East	26/45	28/61	16/44	25/55	n	y, equiv. to 25/40
51	Snake Creek	83/56	69/57	88/58	73/57	control	control
52	Snyder	47/52	39/60	56/40	53/30	y	y
53	Soldier SPZ	66/88	63/83	18/40	27/43	n	n
54	South Flat	43/83	61/73	48/46	66/8	y	y
55	Spring Creek 1 NB	89/99	96/94	70/32	54/27	y	y
56	Spring Creek 2 SB	51/59	59/51	38/43	45/35	n	y, equiv. to 53/20
57	Stand 181410	22/14	24/02	2/23	13/22	control	control
58	Stand 210410	44/65	55/64	51/66	59/65	control	control
59	Stand 210619	61/88	85/67	72/104	94/91	control	control
60	Trail Creek	83/86	83/90	75/24	49/23	n	y, equiv. to 65/29
61	Trout Creek	40/41	17/39	37/53	47/48	control	control
62	Upper Meadow	52/46	46/52	46/53	47/58	control	control
63	West Mill	34/36	36/34	33/20	35/4	y	y
64	Wet Child	127/104	118/98	107/10	63/2	y	y
65	Whiskey Creek	73/79	56/86	48/44	58/20	y	y

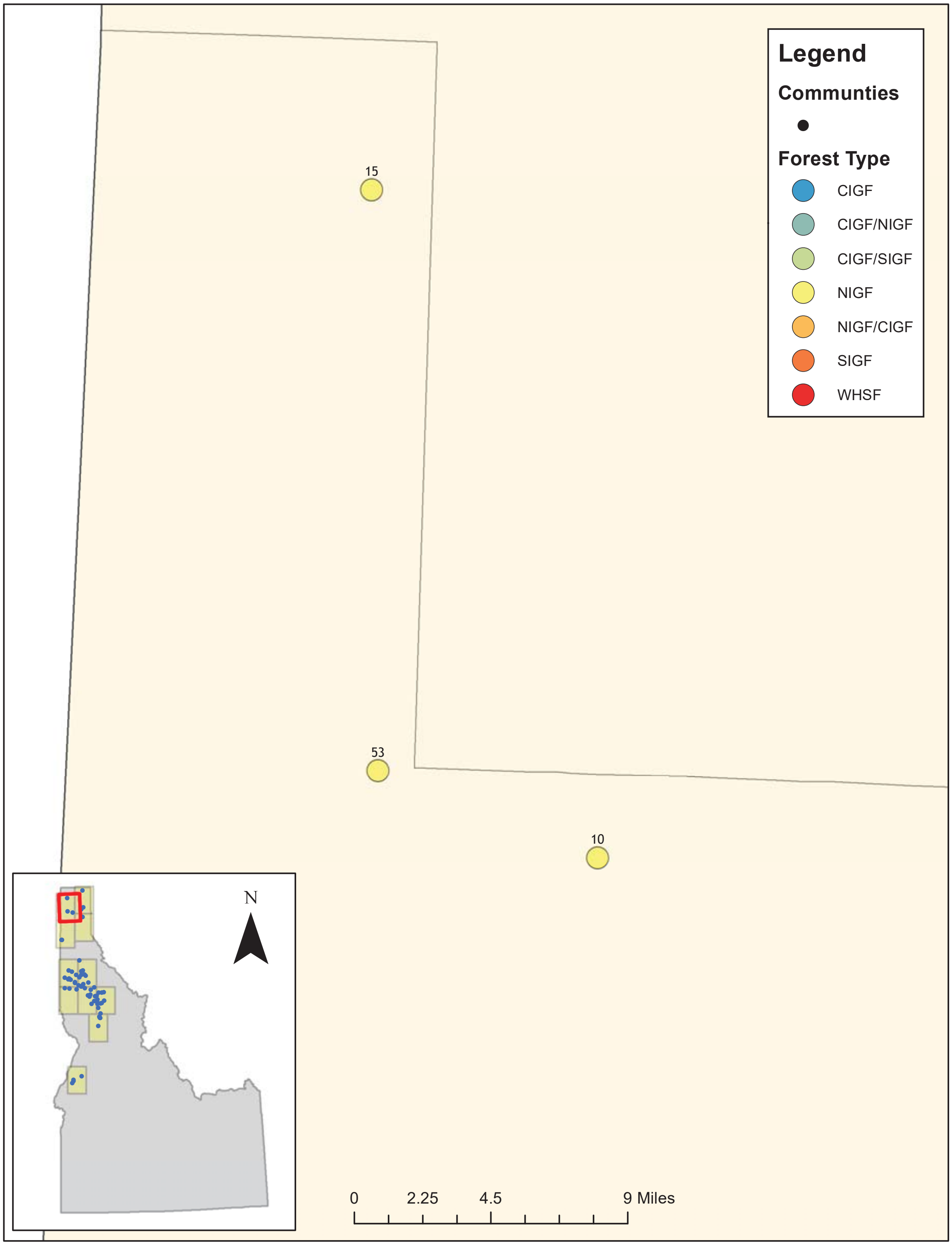
[a] Some sites may not be cut to the rule for a specific Option, but when edge effects between the inner and outer zones specified under the different options are accounted for, a site may qualify as being cut to the rule under the alternative Option.

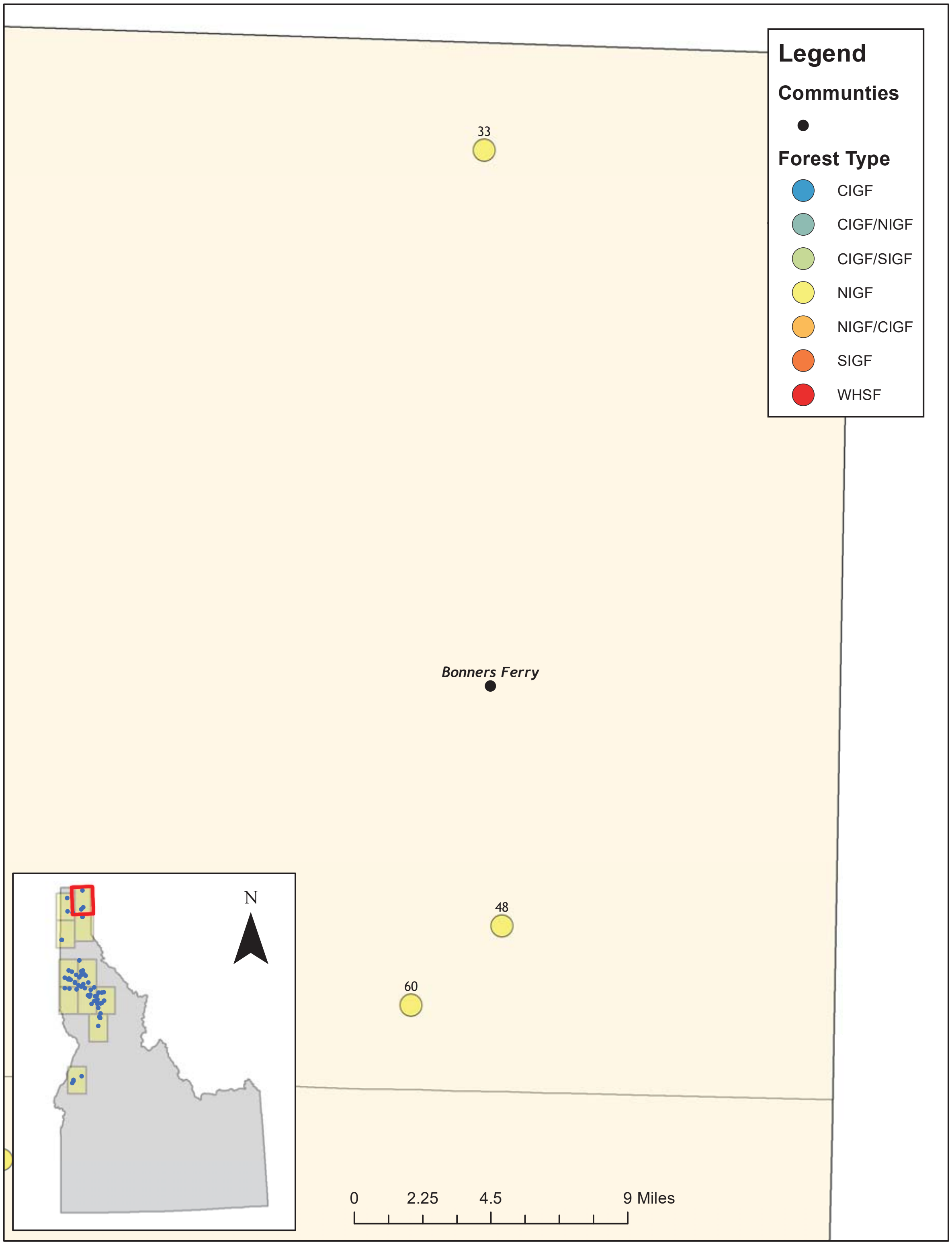
Appendix B: Maps of Sampled Stream Reaches

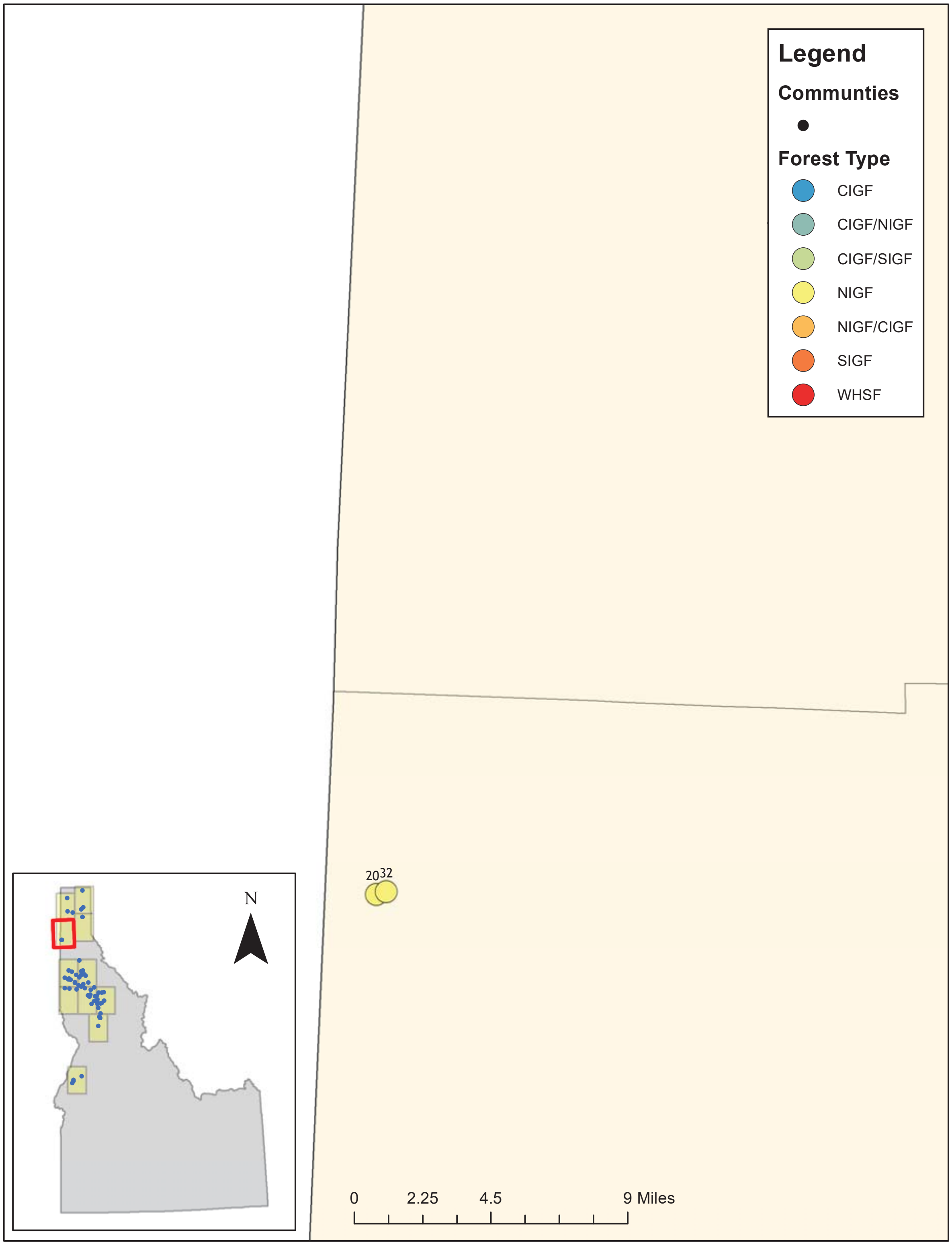


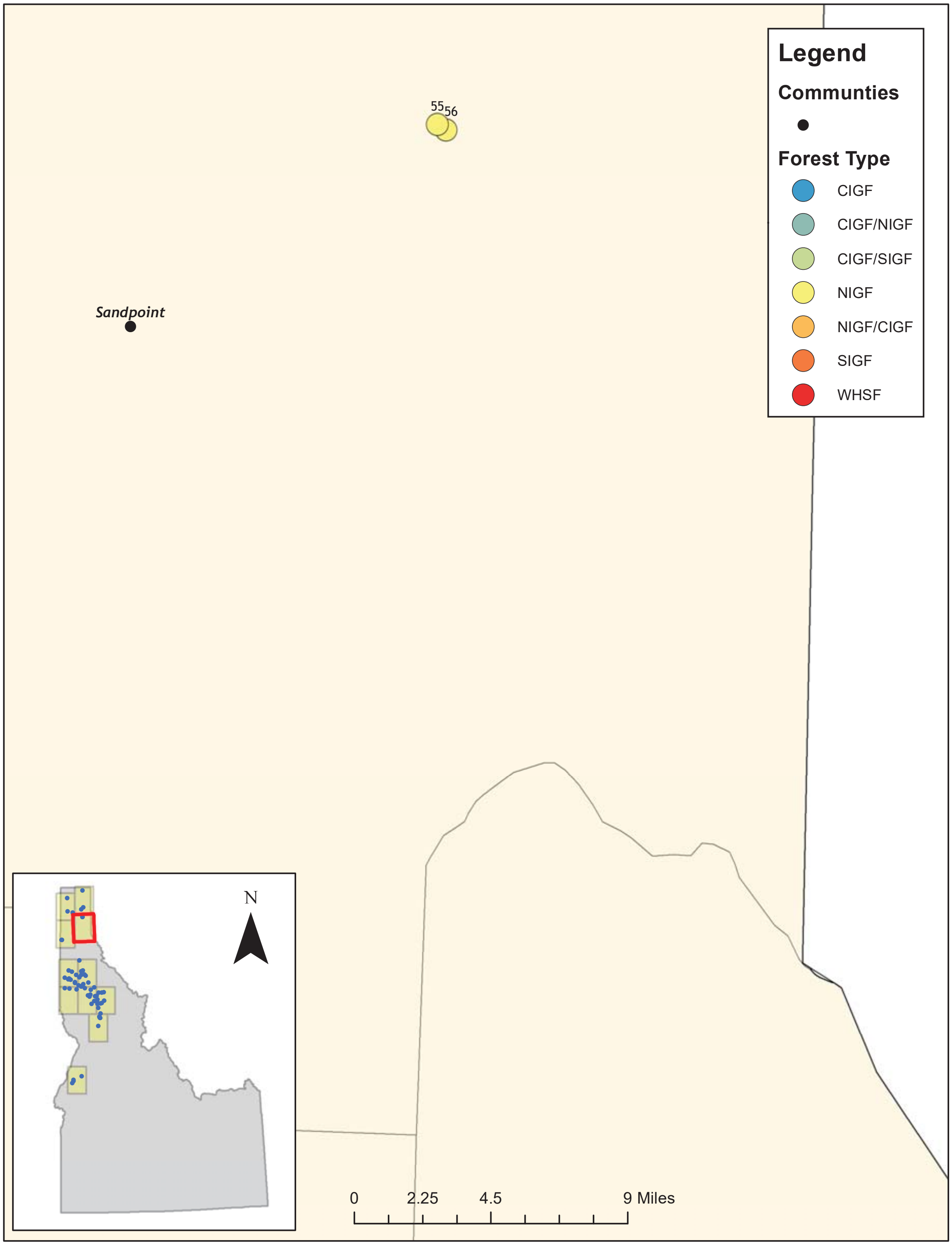

Idaho Streamshade
Monitoring Report
Legend
● Shade Monitoring Sites
● Communities
▨ Map Layout Grid
0
25
50
100 Miles
N
1
2
3
4
5
6
7
8
9
10
11
Coeur d'Alene
St.Maries
Lewiston
Grangeville
Riggins
McCall
Salmon
Boise
Idaho Falls
Pocatello
Twin Falls

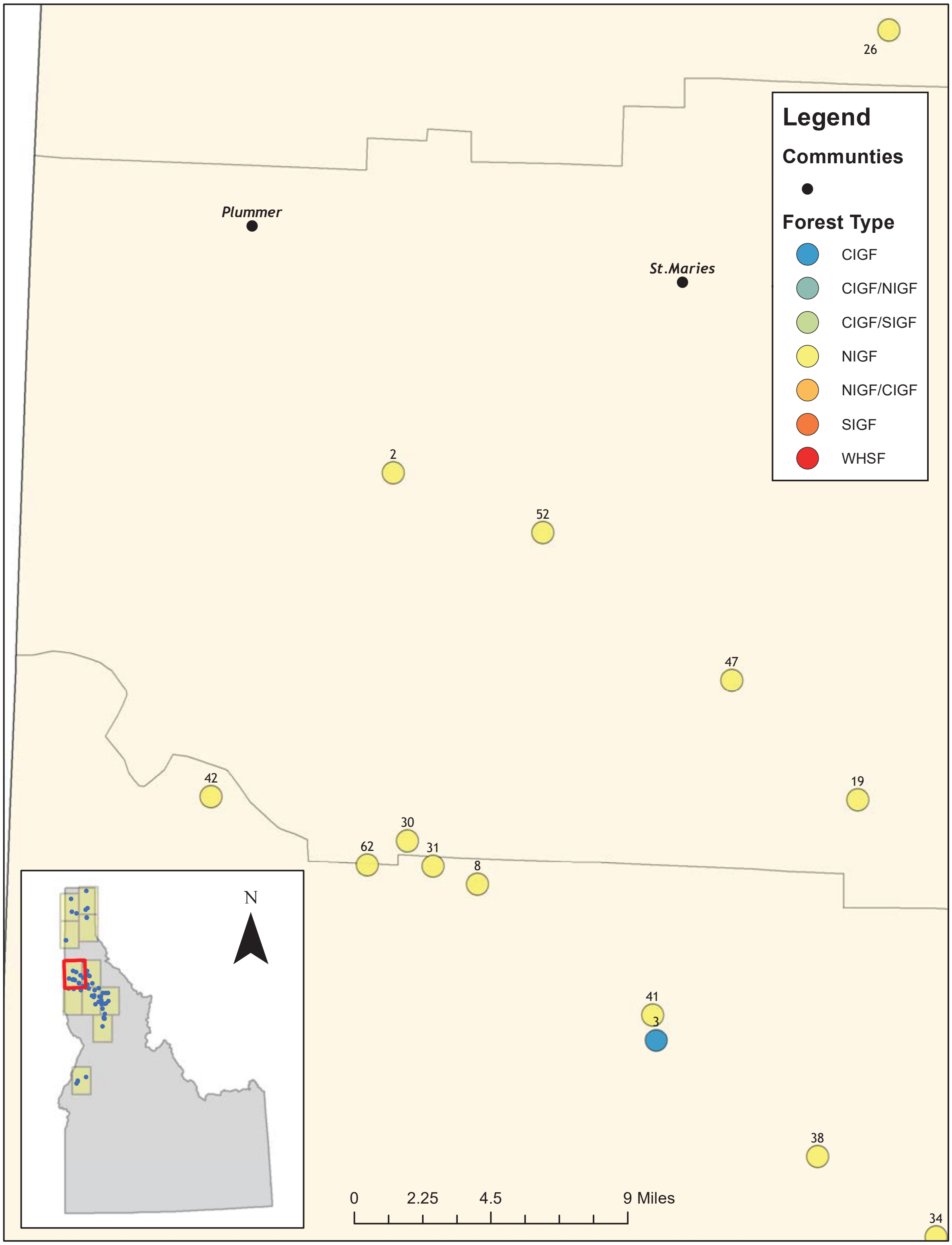
Appendix B1: Forest Type Maps

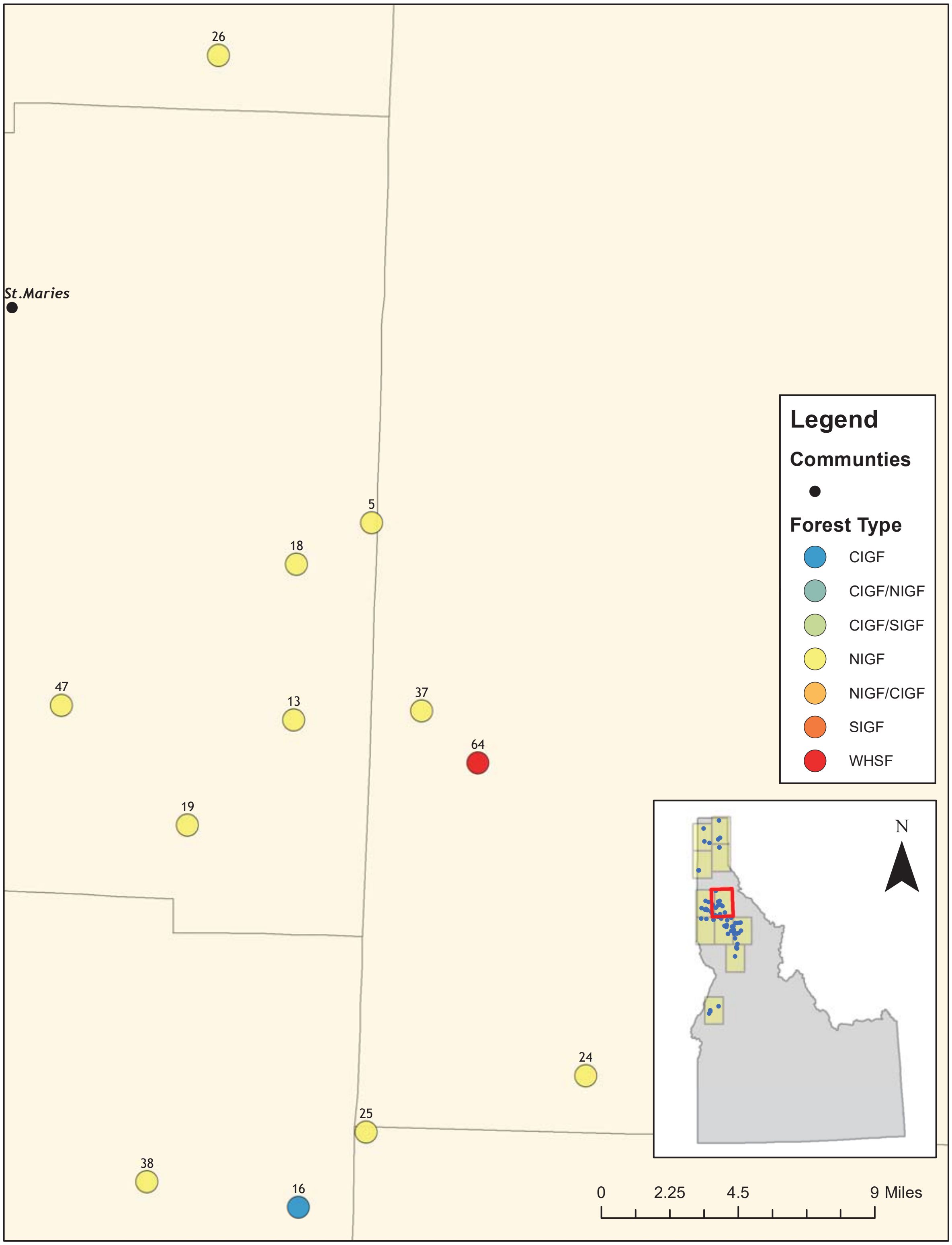

Legend
Communties
●
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
15
53
10
N
0
2.25
4.5
9 Miles


Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
33
Bonners Ferry
48
60
N
0
2.25
4.5
9 Miles


Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
20
32
N
0
2.25
4.5
9 Miles


Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
55
56
Sandpoint
N
0
2.25
4.5
9 Miles


Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
Plummer
St.Maries
26
2
52
47
42
19
30
62
31
8
41
3
38
34
N
0
2.25
4.5
9 Miles


26
St.Maries
5
18
47
13
37
64
19
24
25
38
16
Legend
Communties
Forest Type
CIGF
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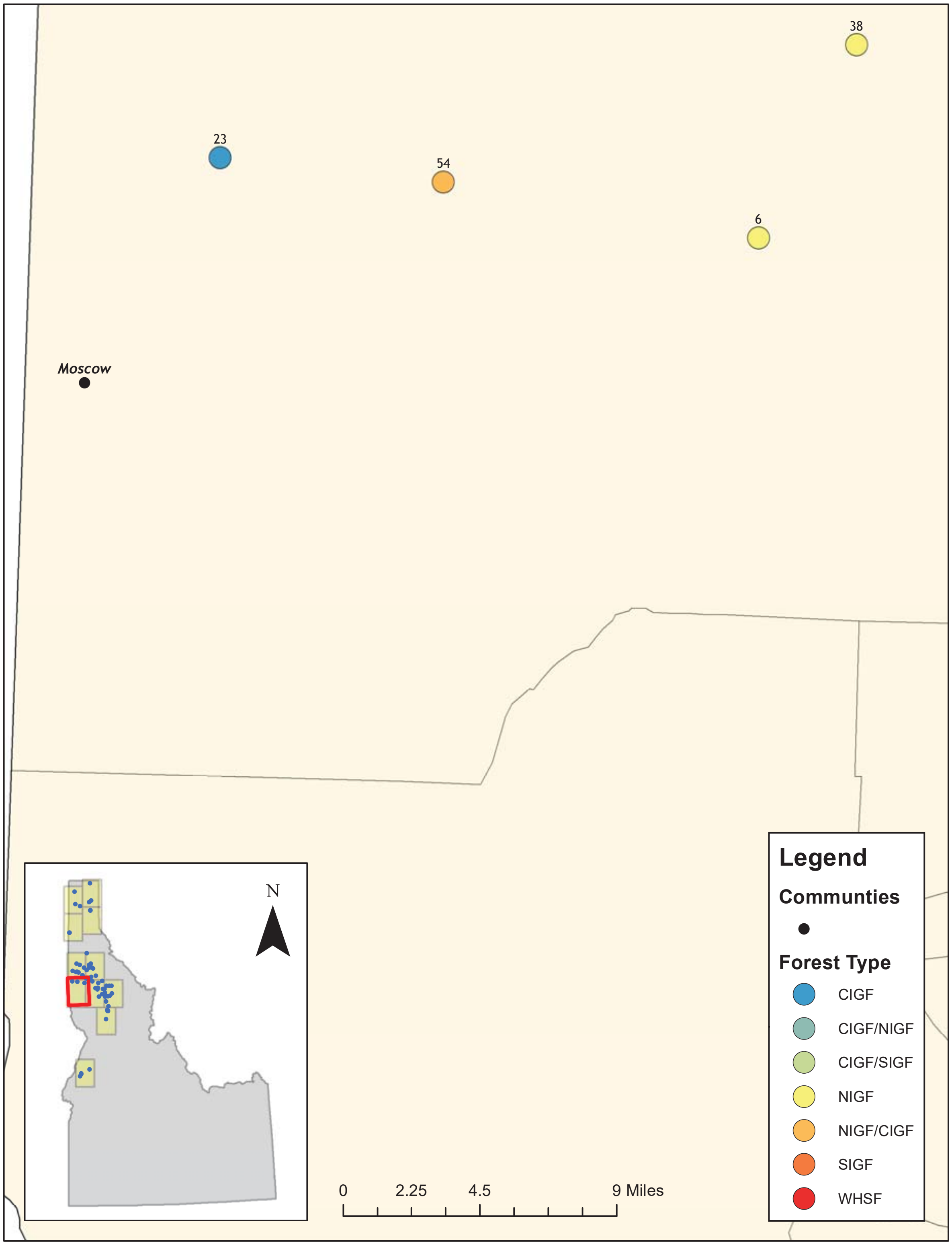
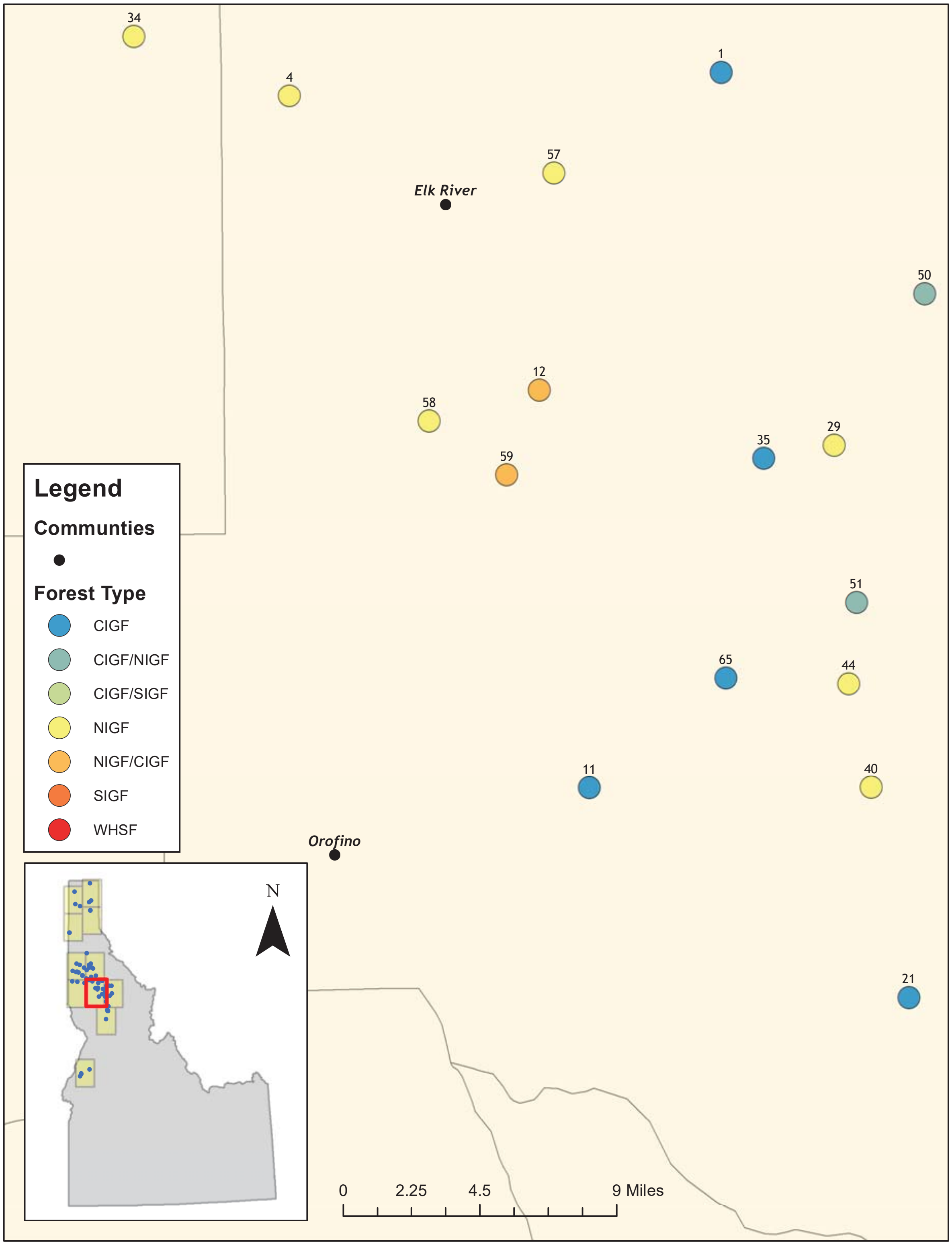
N
0
2.25
4.5
9 Miles


38
23
54
6
Moscow
N
0
2.25
4.5
9 Miles
Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF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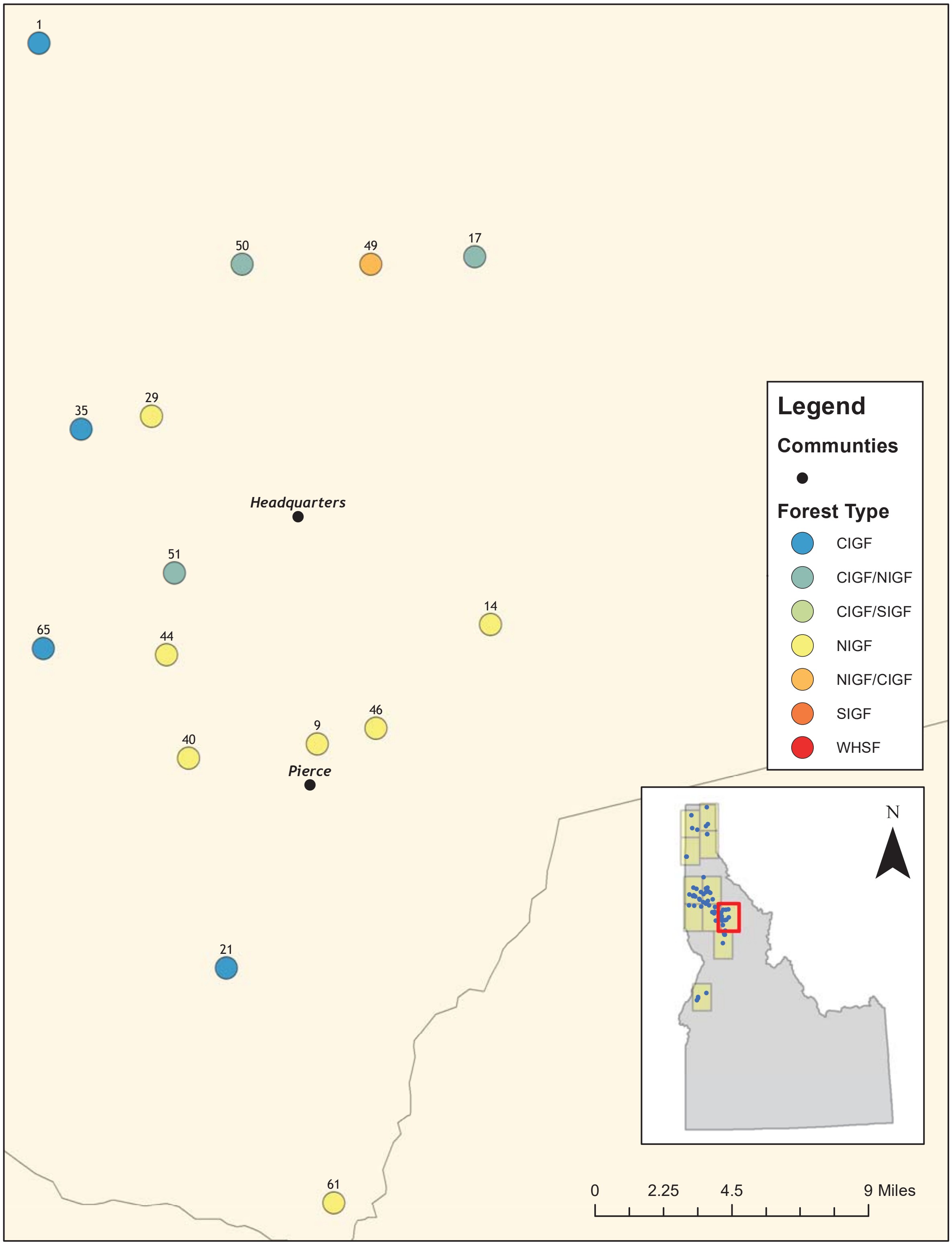
4
1
57
Elk River
50
12
58
29
35
59
51
65
44
11
40
Orofino
21
Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
N
0
2.25
4.5
9 Miles


1
50
49
17
35
29
Headquarters
51
65
44
14
40
9
46
Pierce
21
61
Legend
Communties
Forest Type
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SIGF
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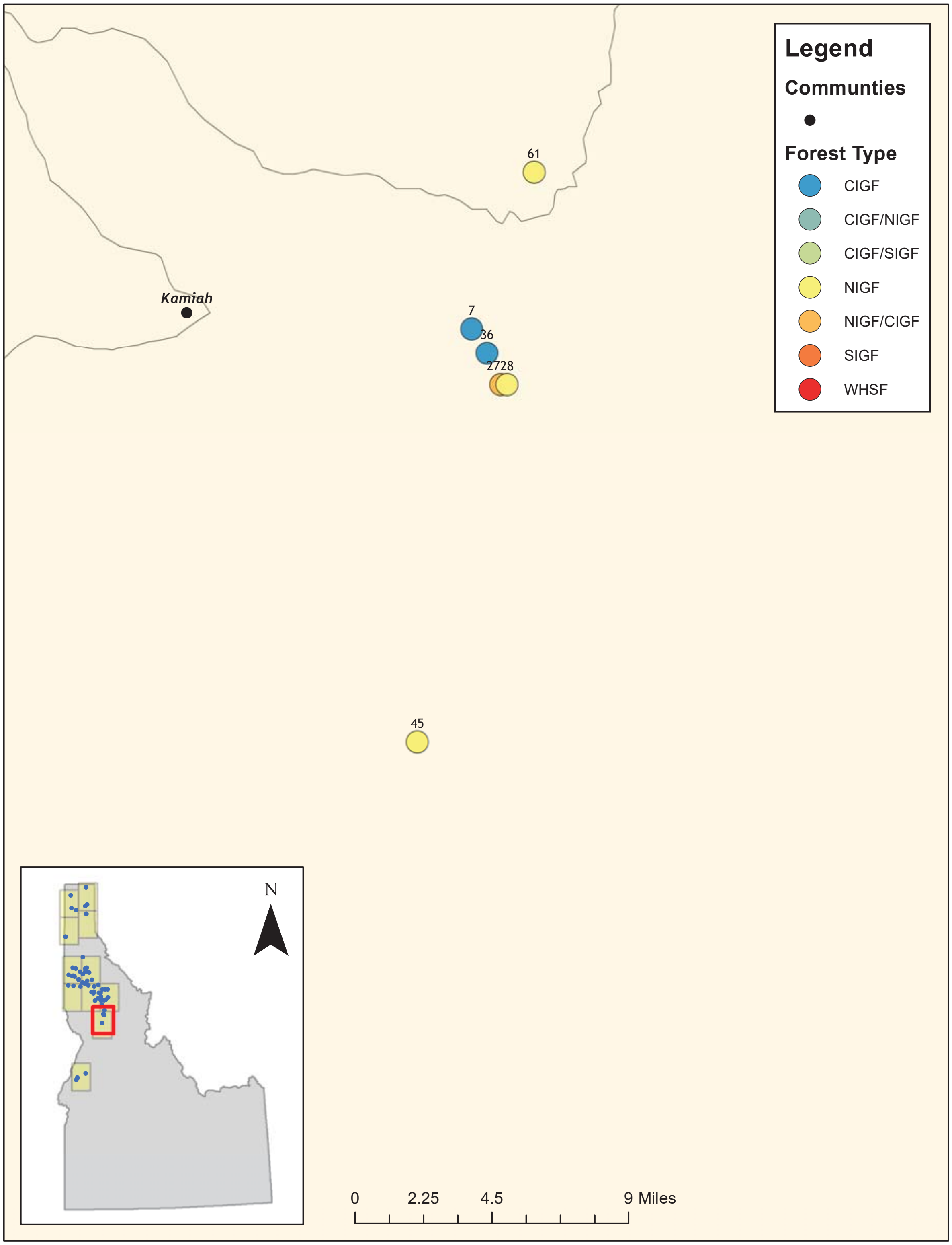
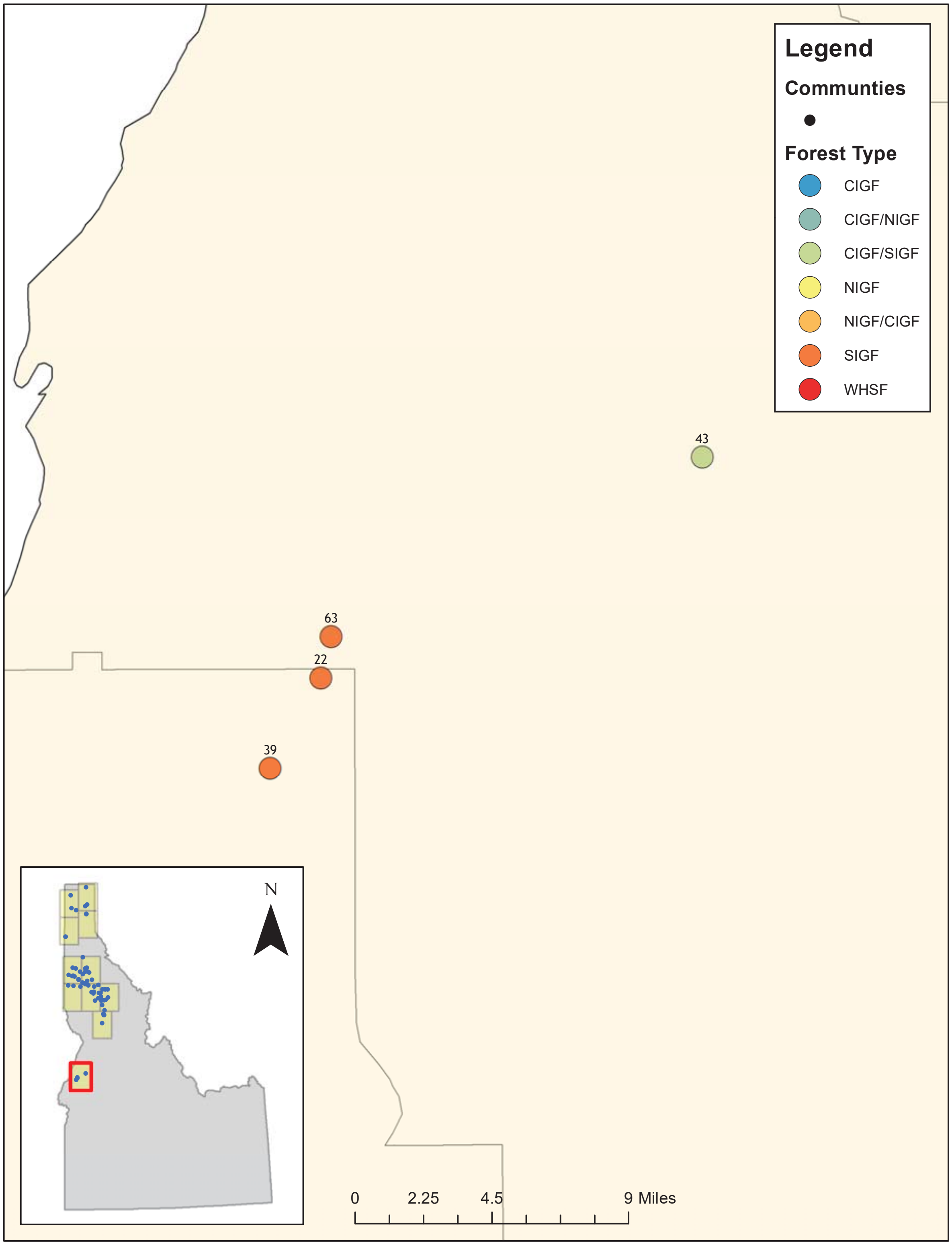
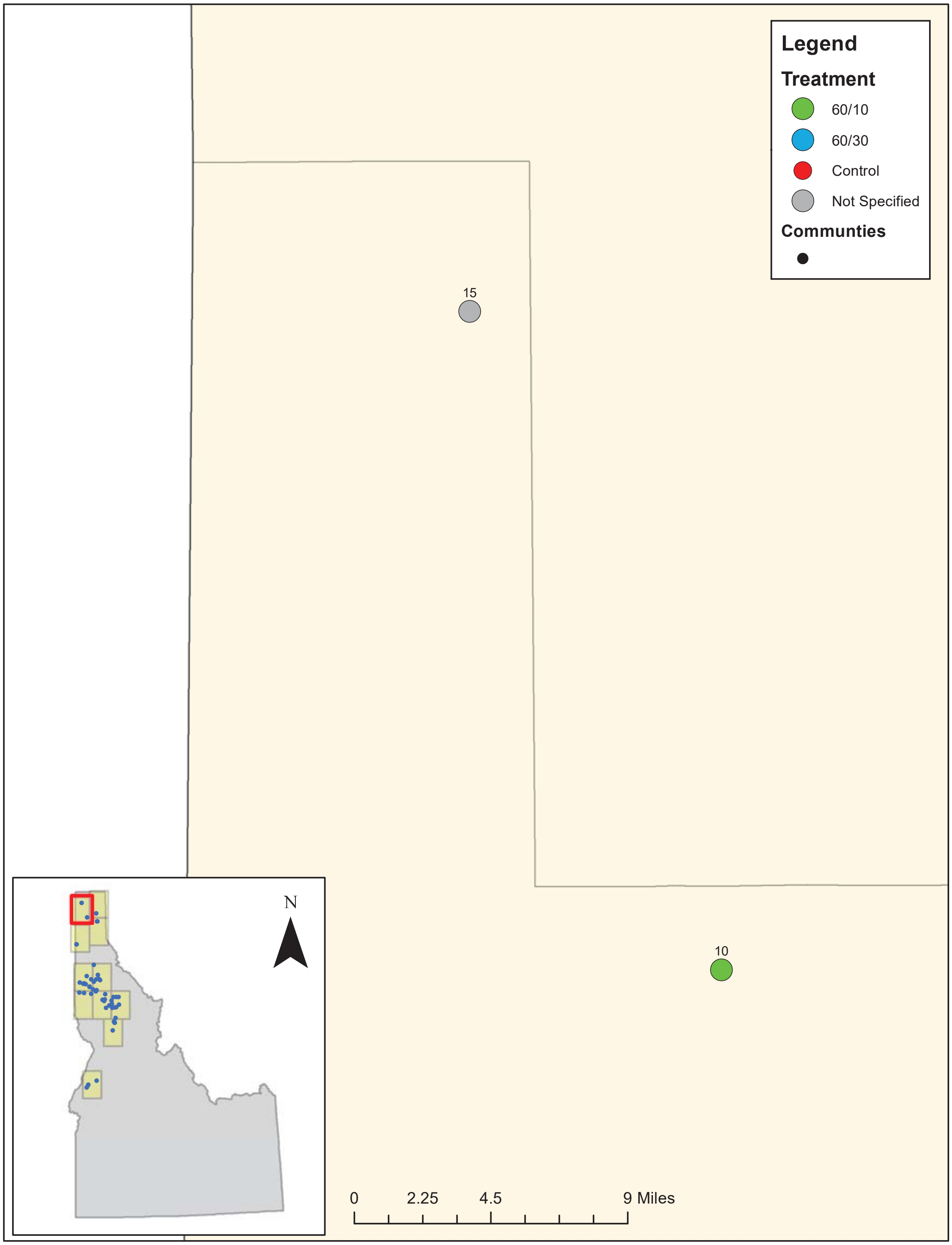
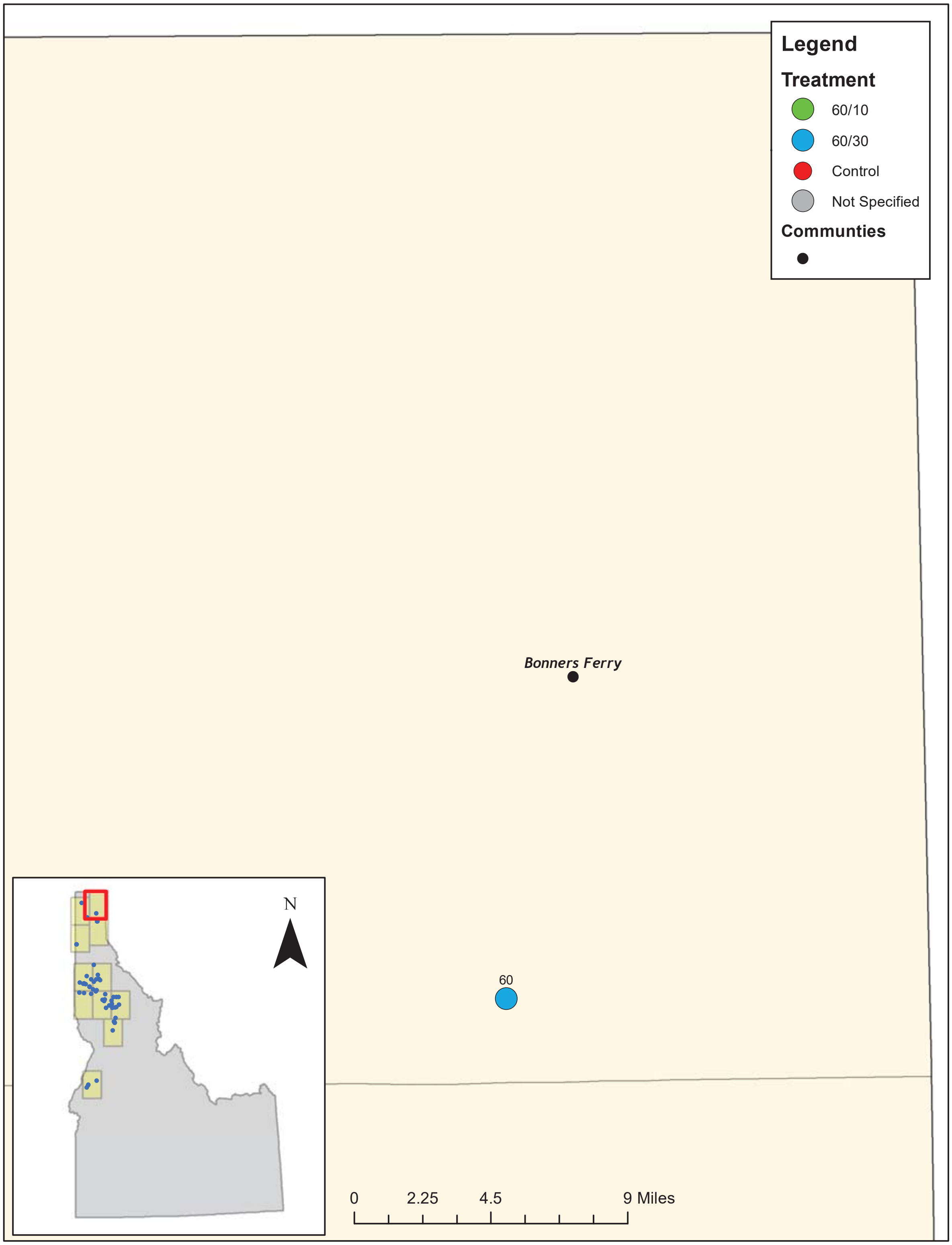
N
0
2.25
4.5
9 Miles

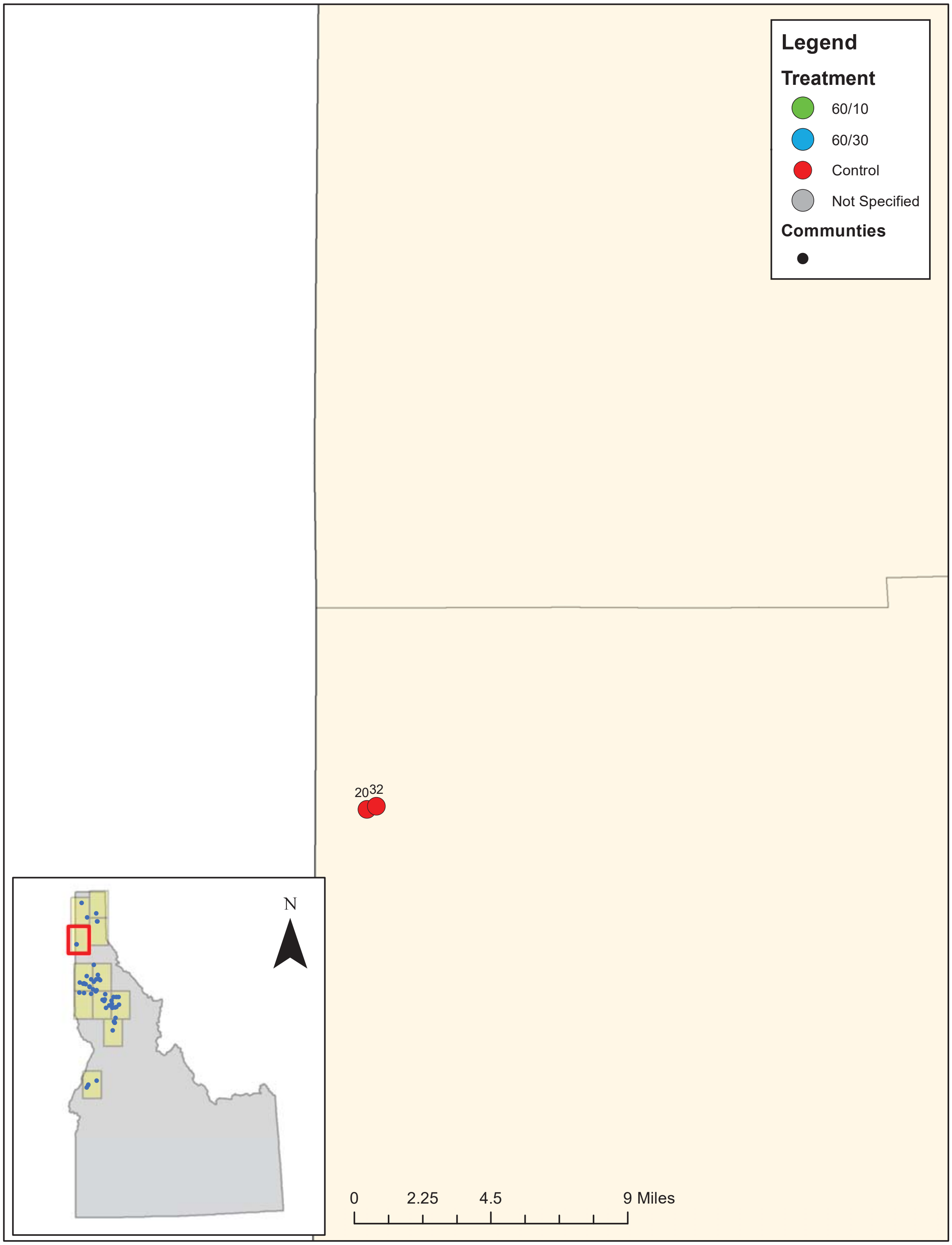

Legend
Communties
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
Kamiah
61
7
36
2728
45
N
0
2.25
4.5
9 Miles

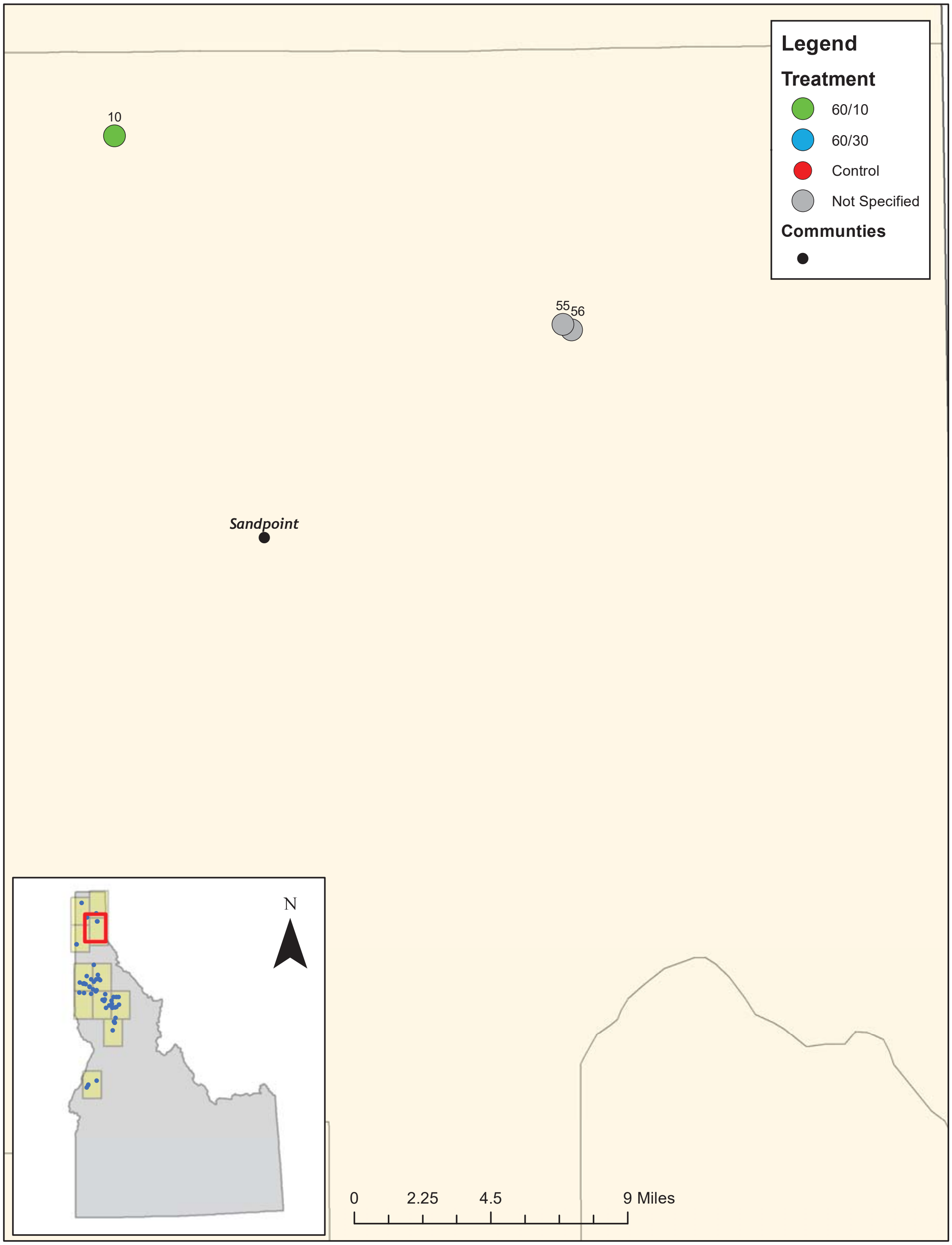

Legend
Communties
●
Forest Type
CIGF
CIGF/NIGF
CIGF/SIGF
NIGF
NIGF/CIGF
SIGF
WHSF
43
63
22
39
N
0
2.25
4.5
9 Miles

Appendix B2: Harvest Option Maps


Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
15
10
N
0
2.25
4.5
9 Miles


Legend
Treatment
🟢 60/10
🔵 60/30
🔴 Control
⚪ Not Specified
Communties
●
Bonners Ferry
60
N
0
2.25
4.5
9 Miles


Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
20
32
N
0
2.25
4.5
9 Miles


Legend
Treatment
60/10
60/30
Control
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Communties
10
55
56
Sandpoint
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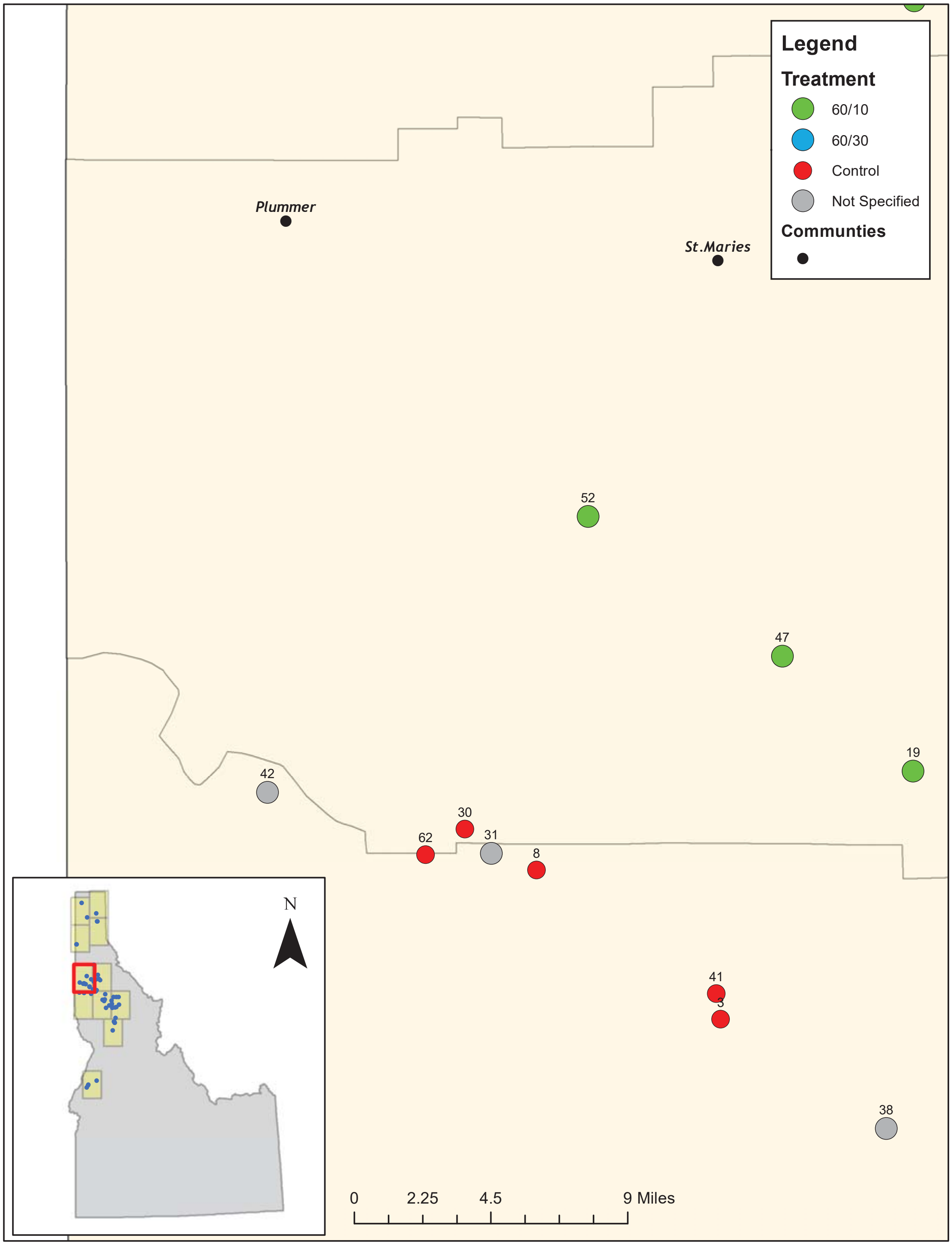
0
2.25
4.5
9 Miles


Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
Plummer
St.Maries
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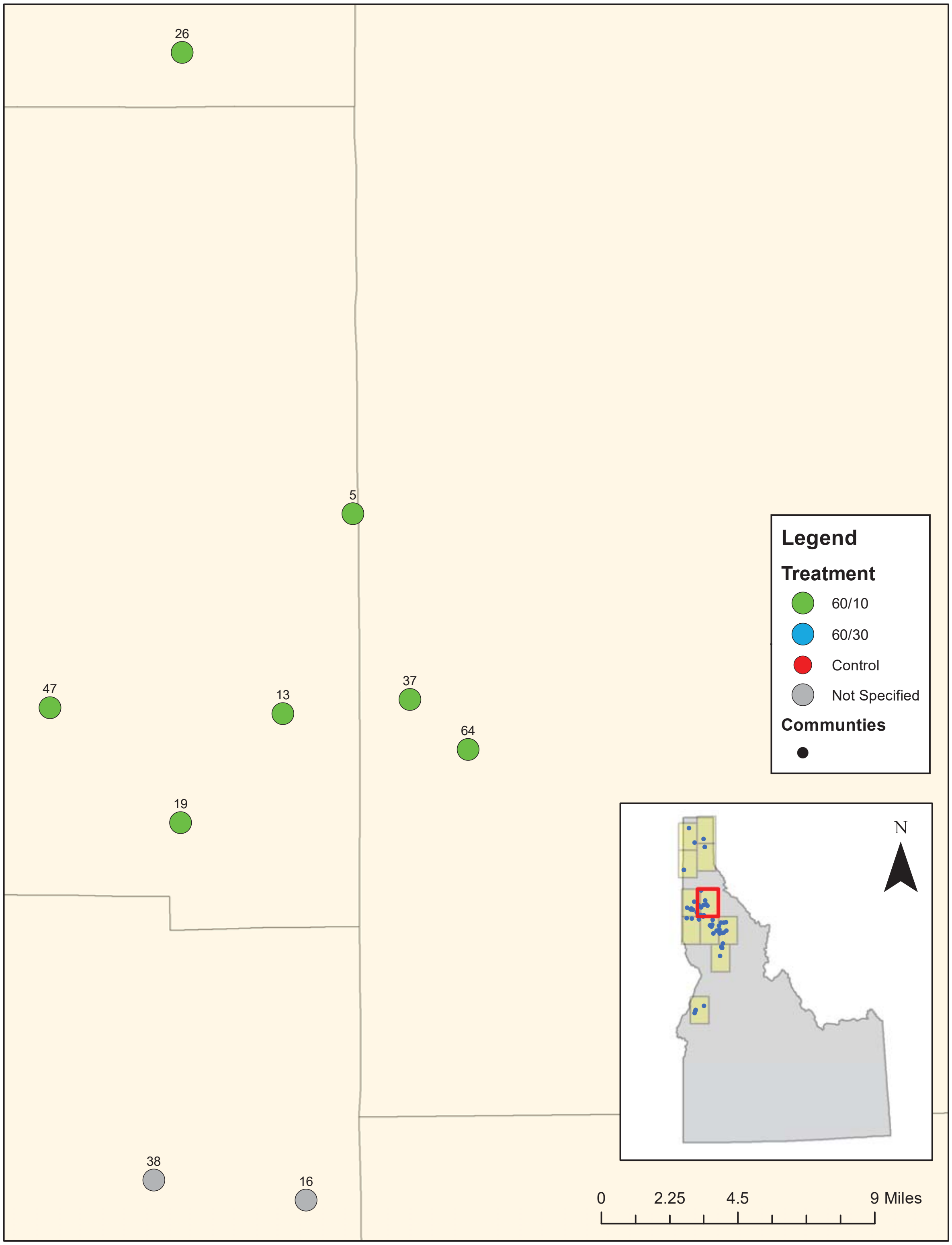
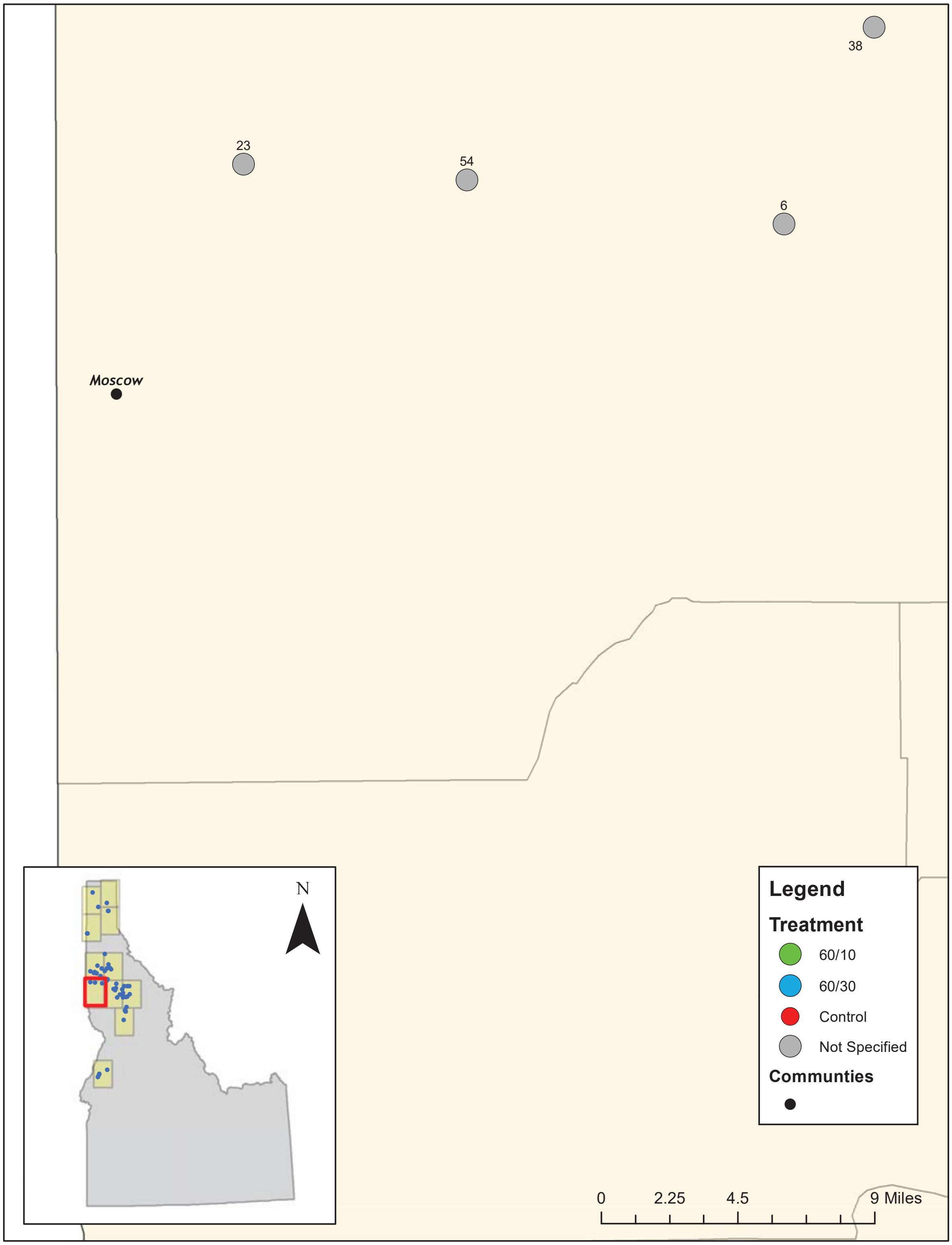
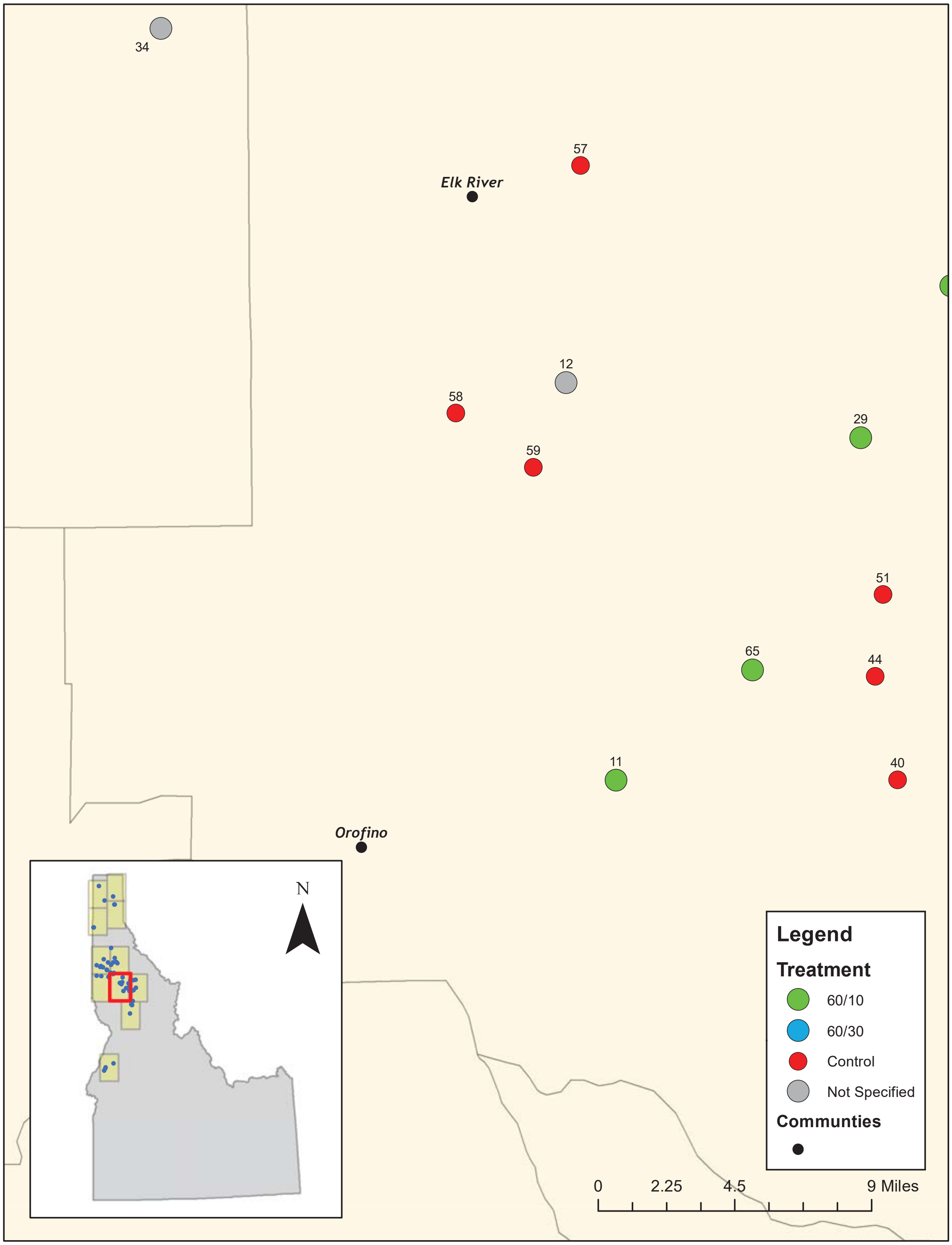
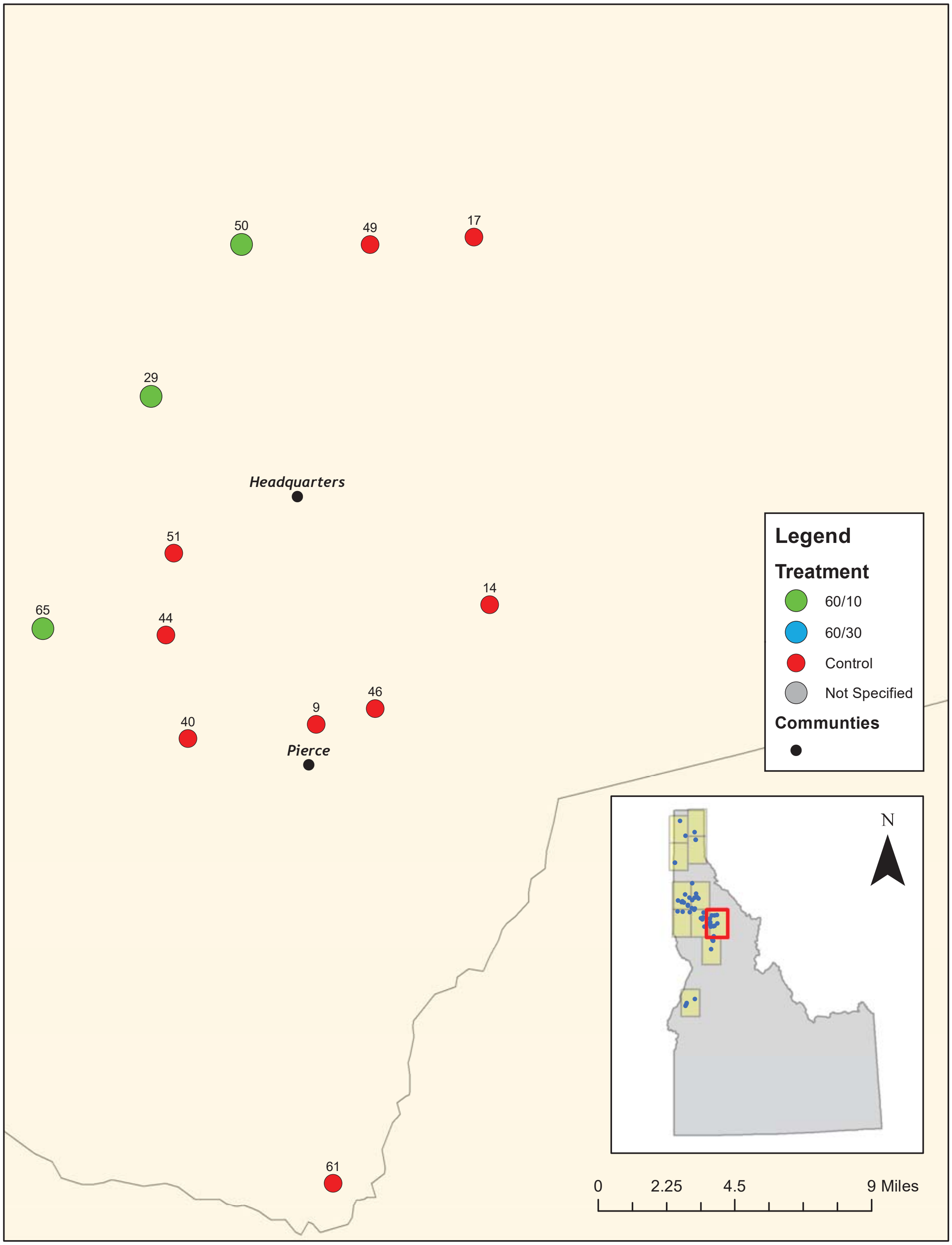
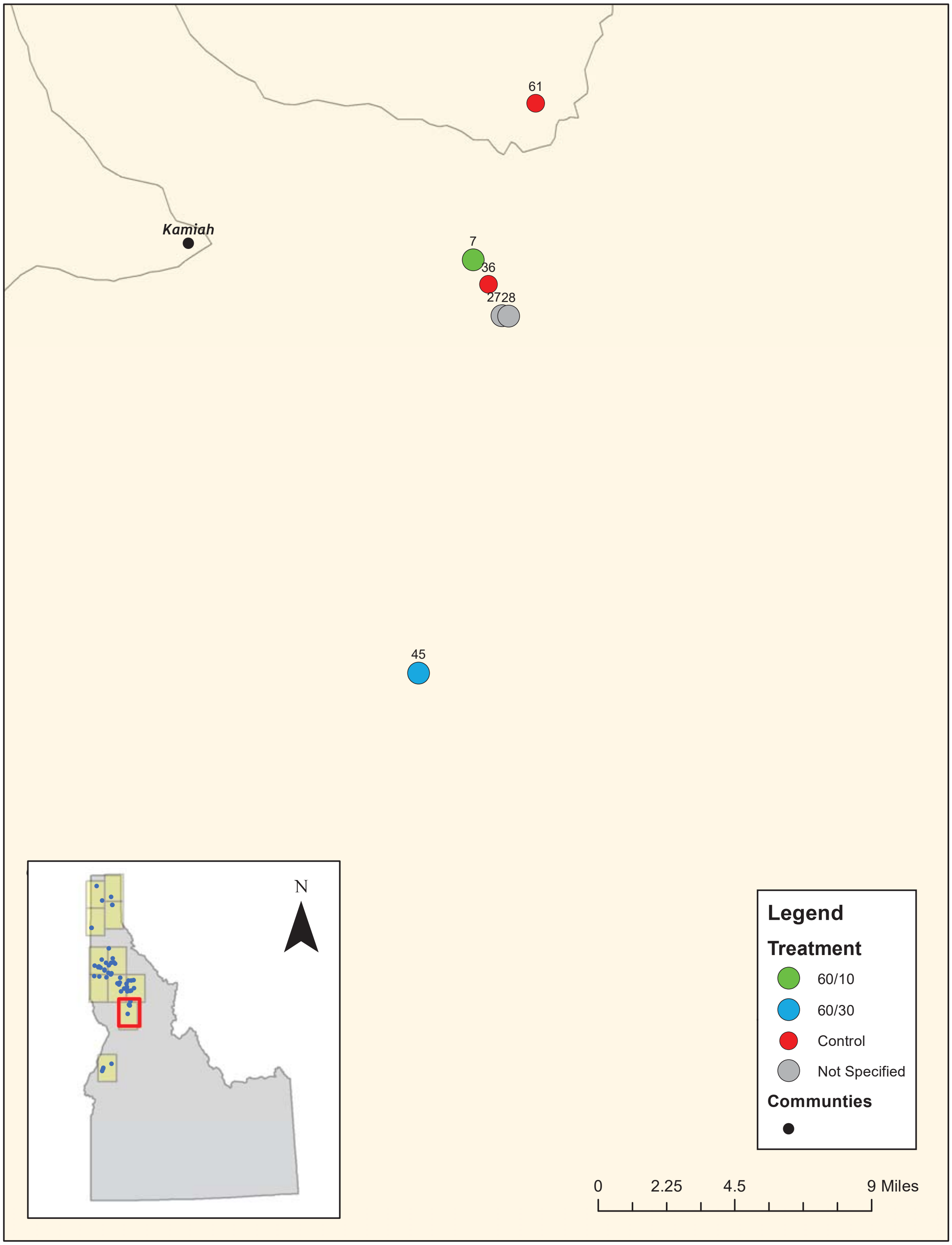
47
19
42
30
31
62
8
41
3
38
N
0
2.25
4.5
9 Miles

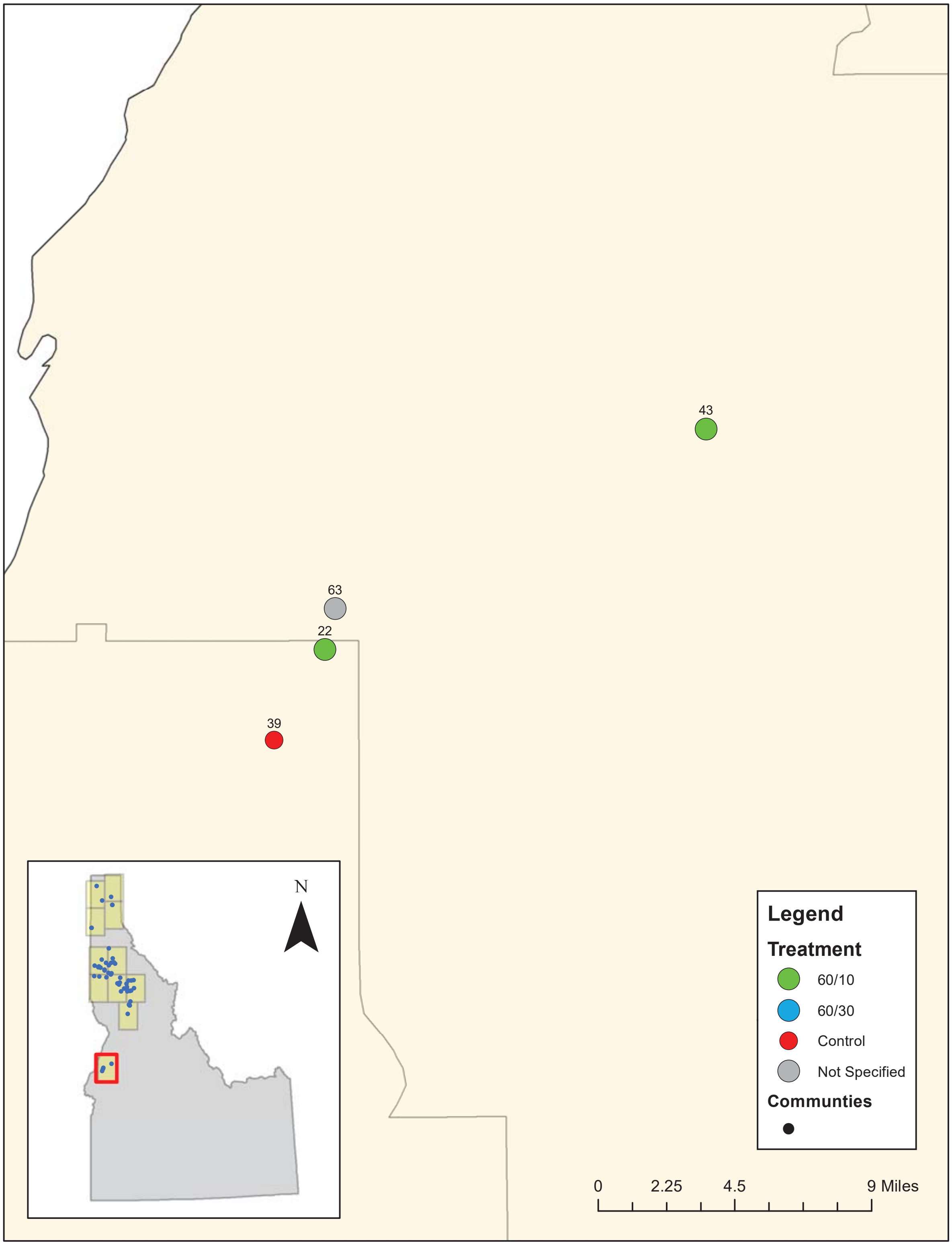

26
5
47
13
37
64
19
38
16
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
N
0
2.25
4.5
9 Miles


38
23
54
6
Moscow
N
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
0
2.25
4.5
9 Miles

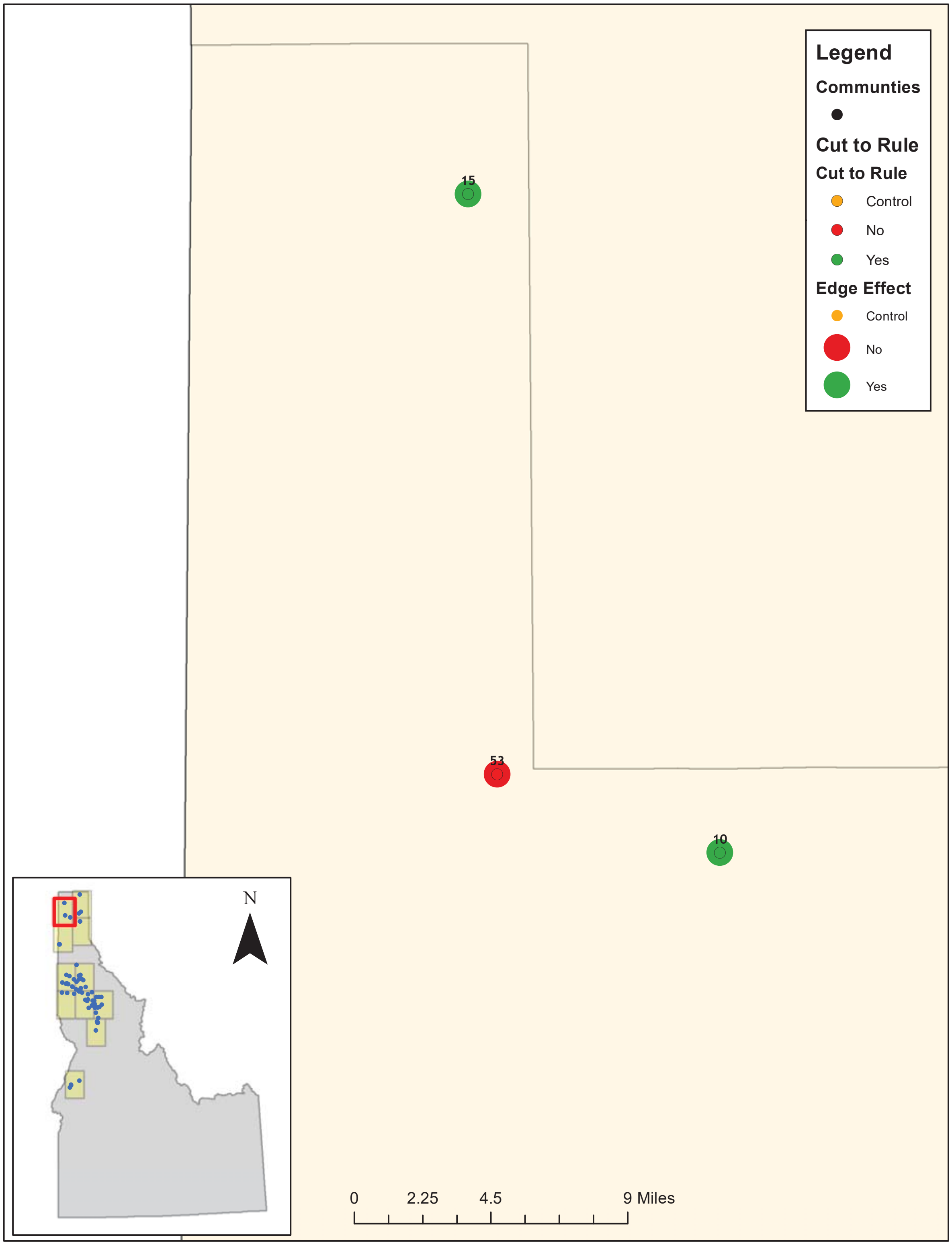

34
57
Elk River
12
58
59
29
51
65
44
11
40
Orofino
N
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
0
2.25
4.5
9 Miles

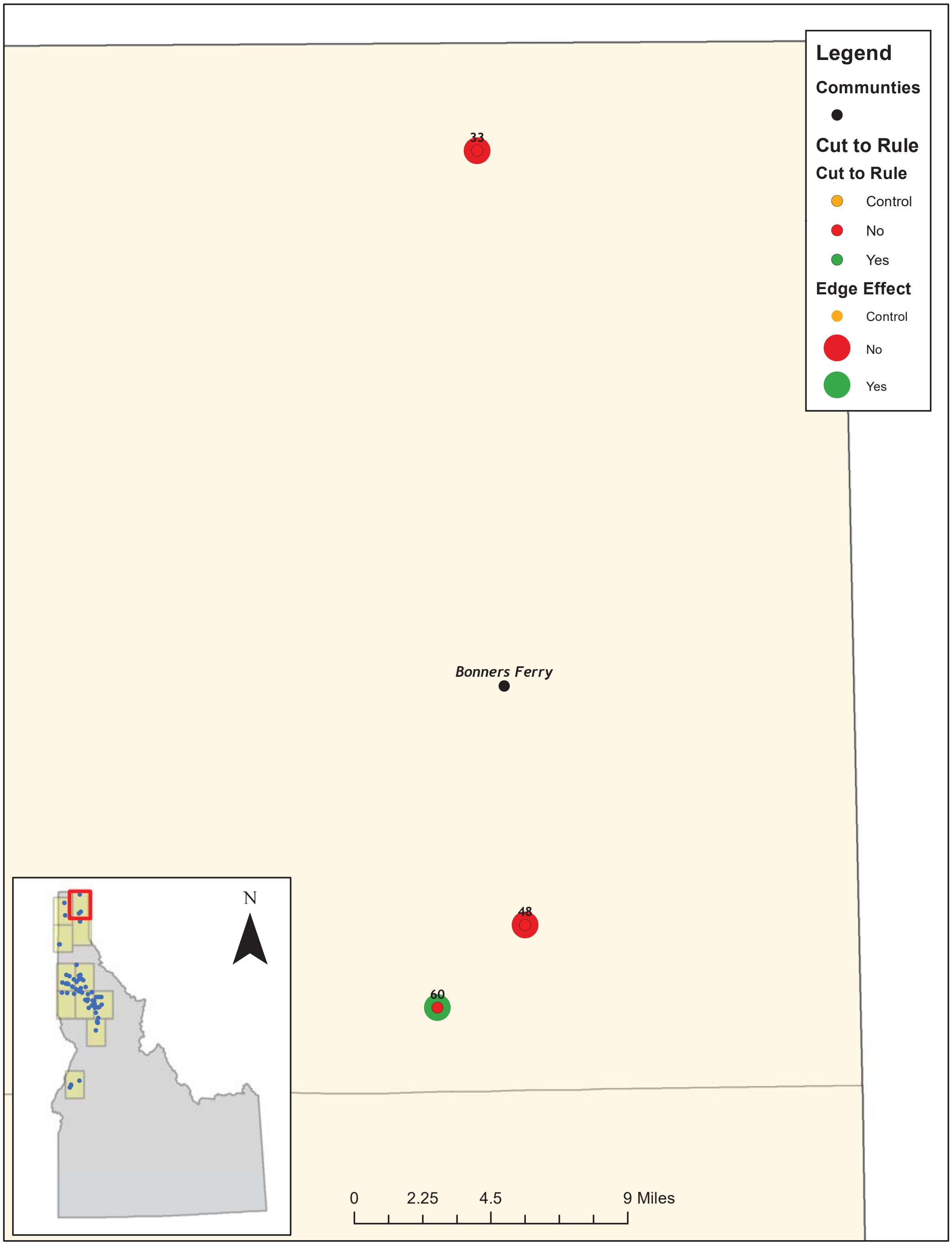

50
49
17
29
Headquarters
51
14
65
44
46
9
40
Pierce
61
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
N
0
2.25
4.5
9 Miles

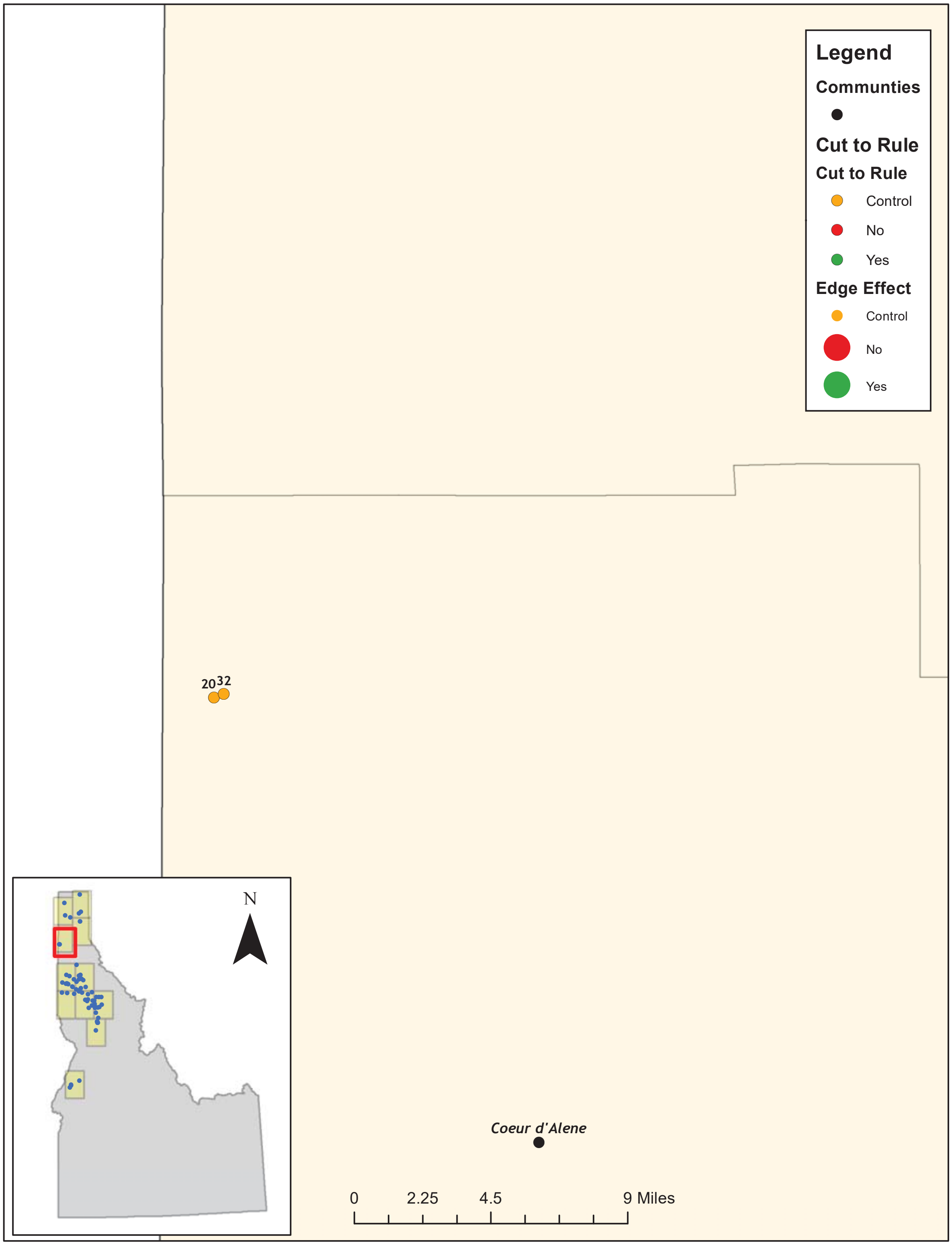

61
Kamiah
7
36
27
28
45
N
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
0
2.25
4.5
9 Miles

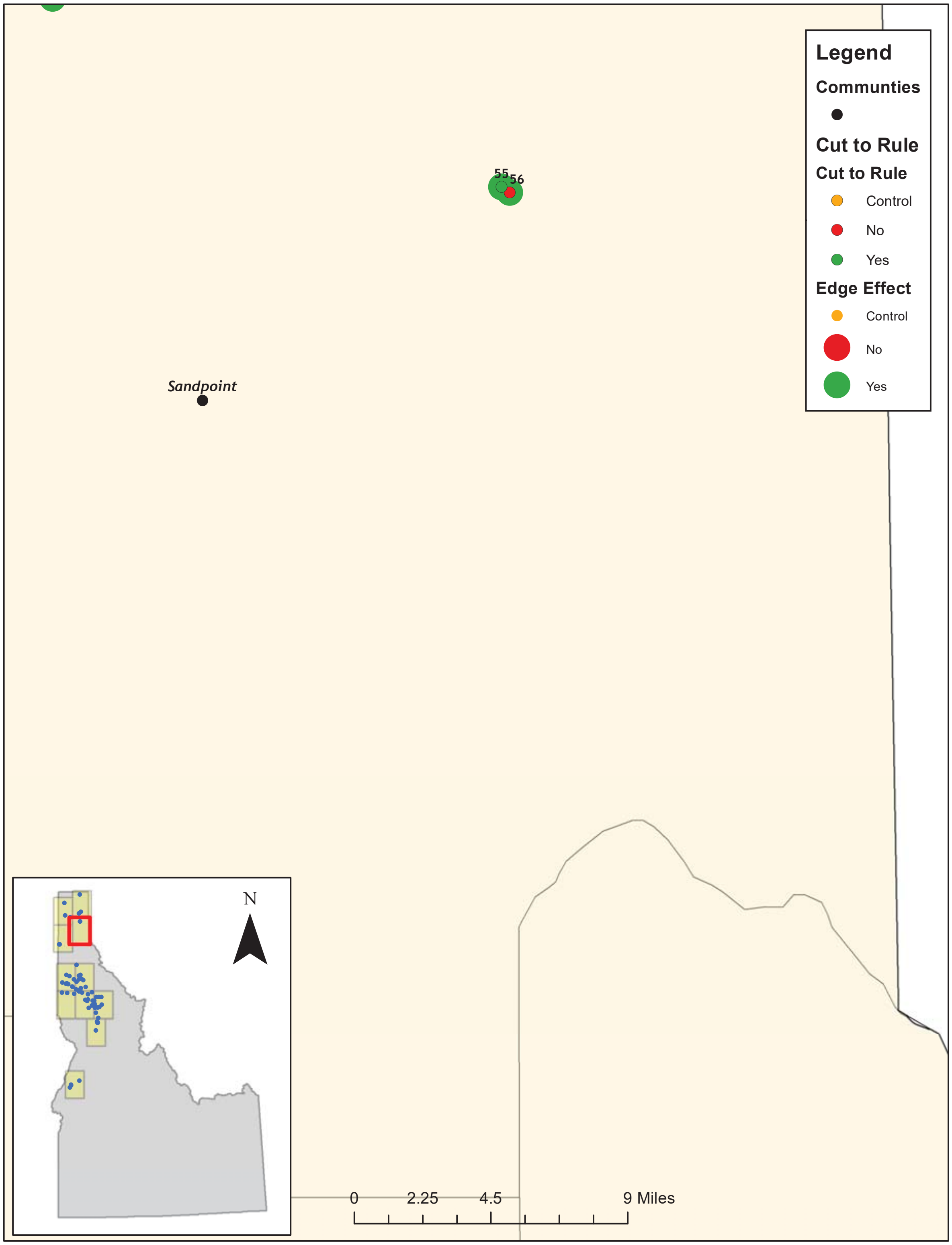

43
63
22
39
N
Legend
Treatment
60/10
60/30
Control
Not Specified
Communties
0
2.25
4.5
9 Miles

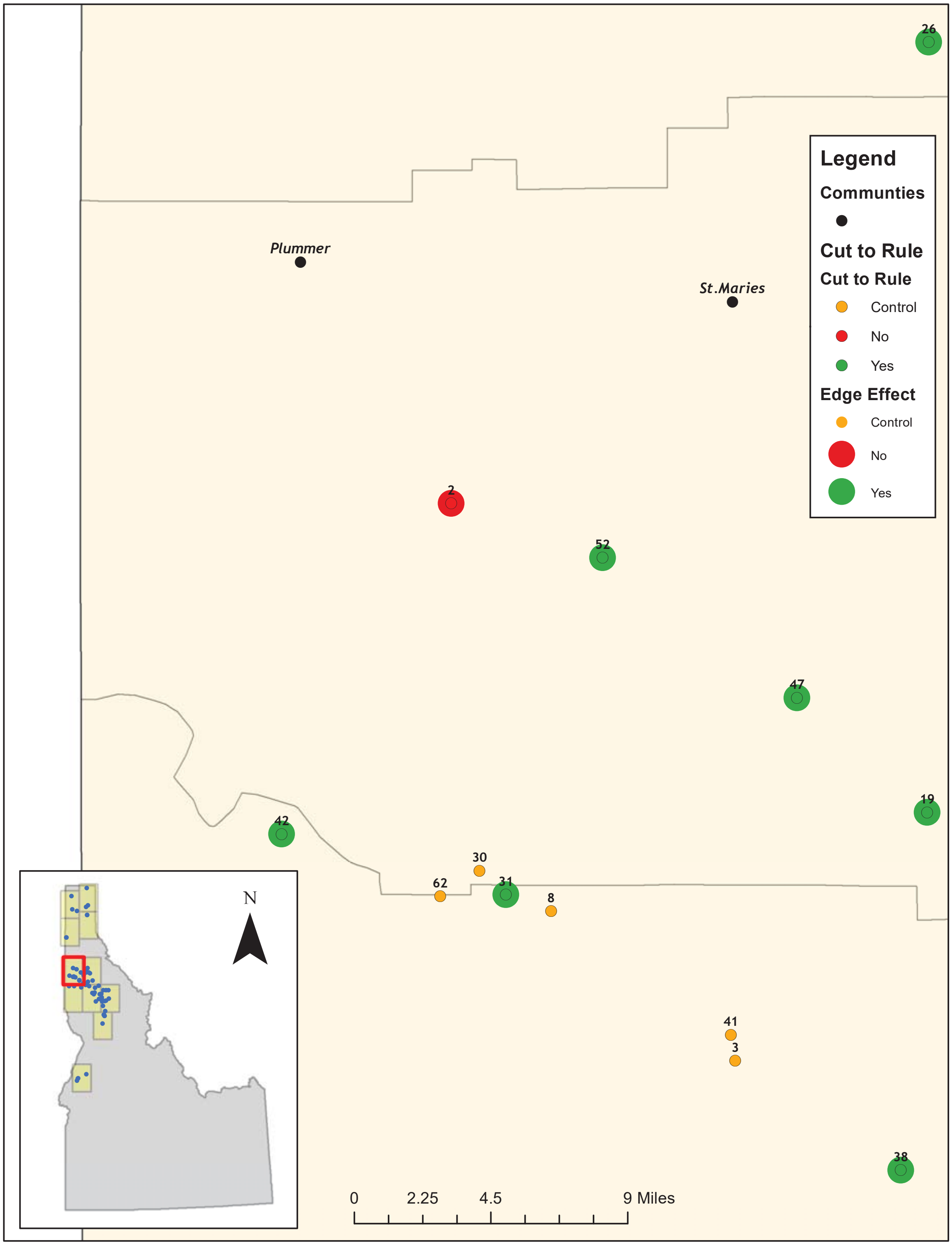
Appendix B3: Cut to Rule Maps

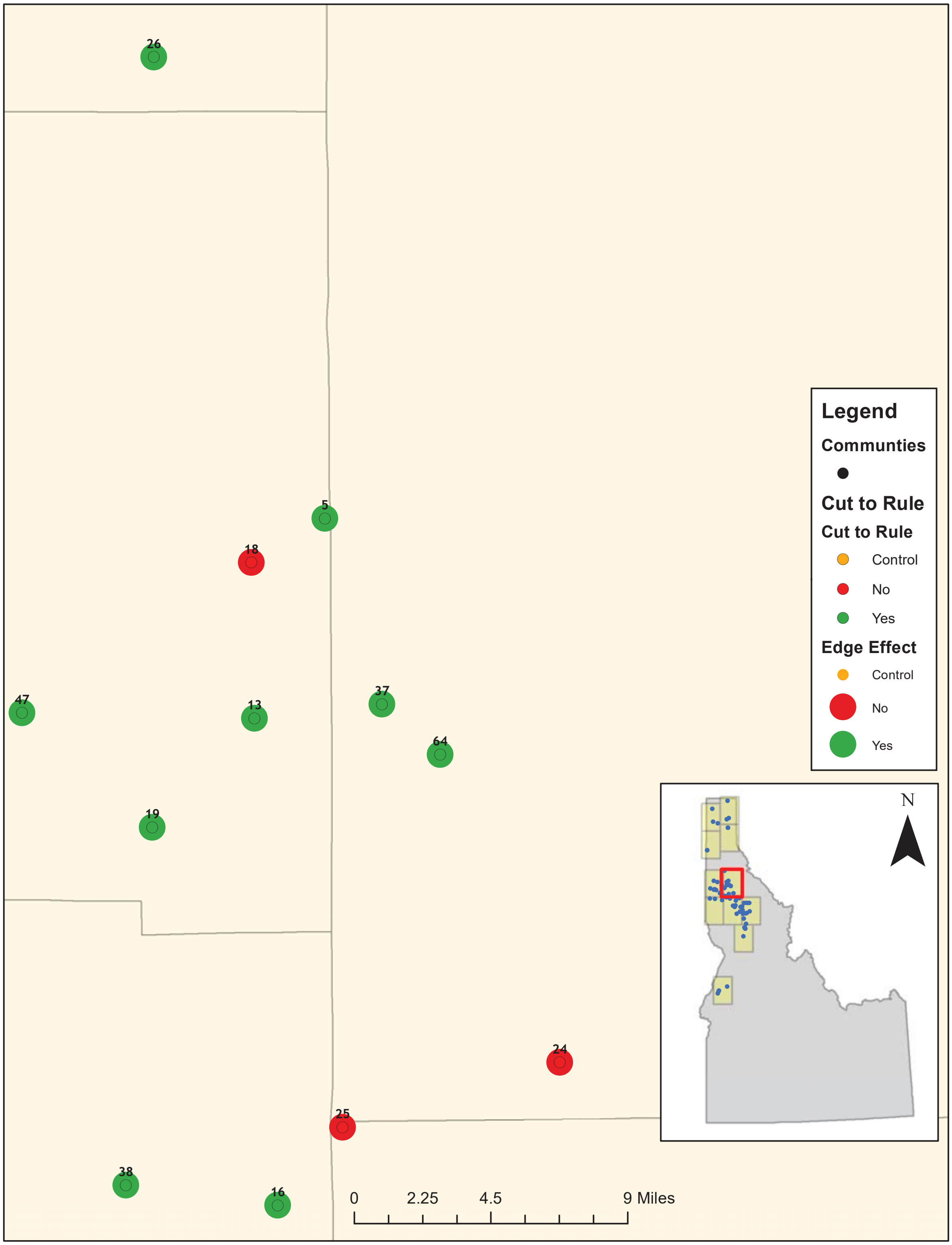

Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
15
53
10
N
0
2.25
4.5
9 Miles

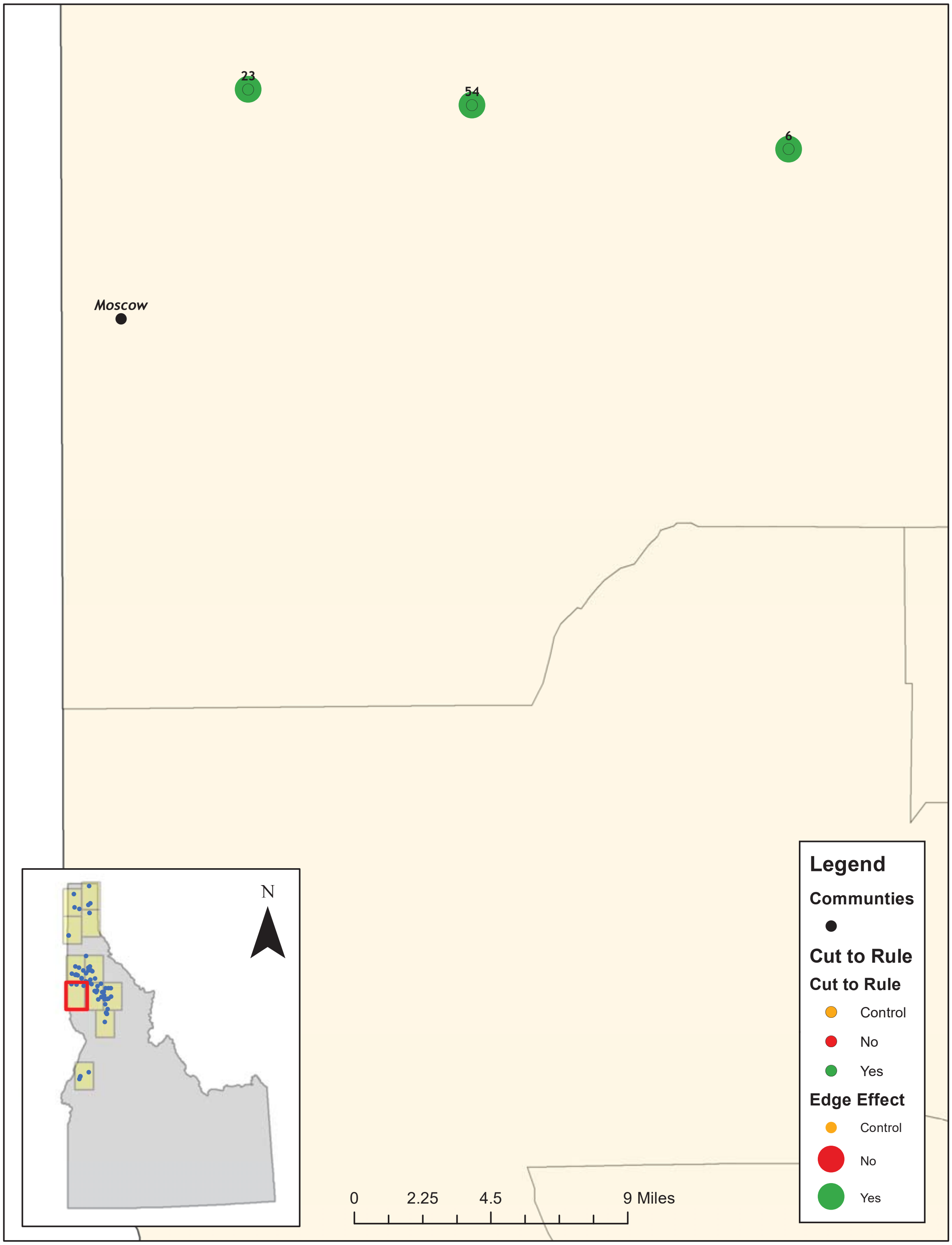

Legend
Communties
●
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
33
Bonners Ferry
48
60
N
0
2.25
4.5
9 Miles

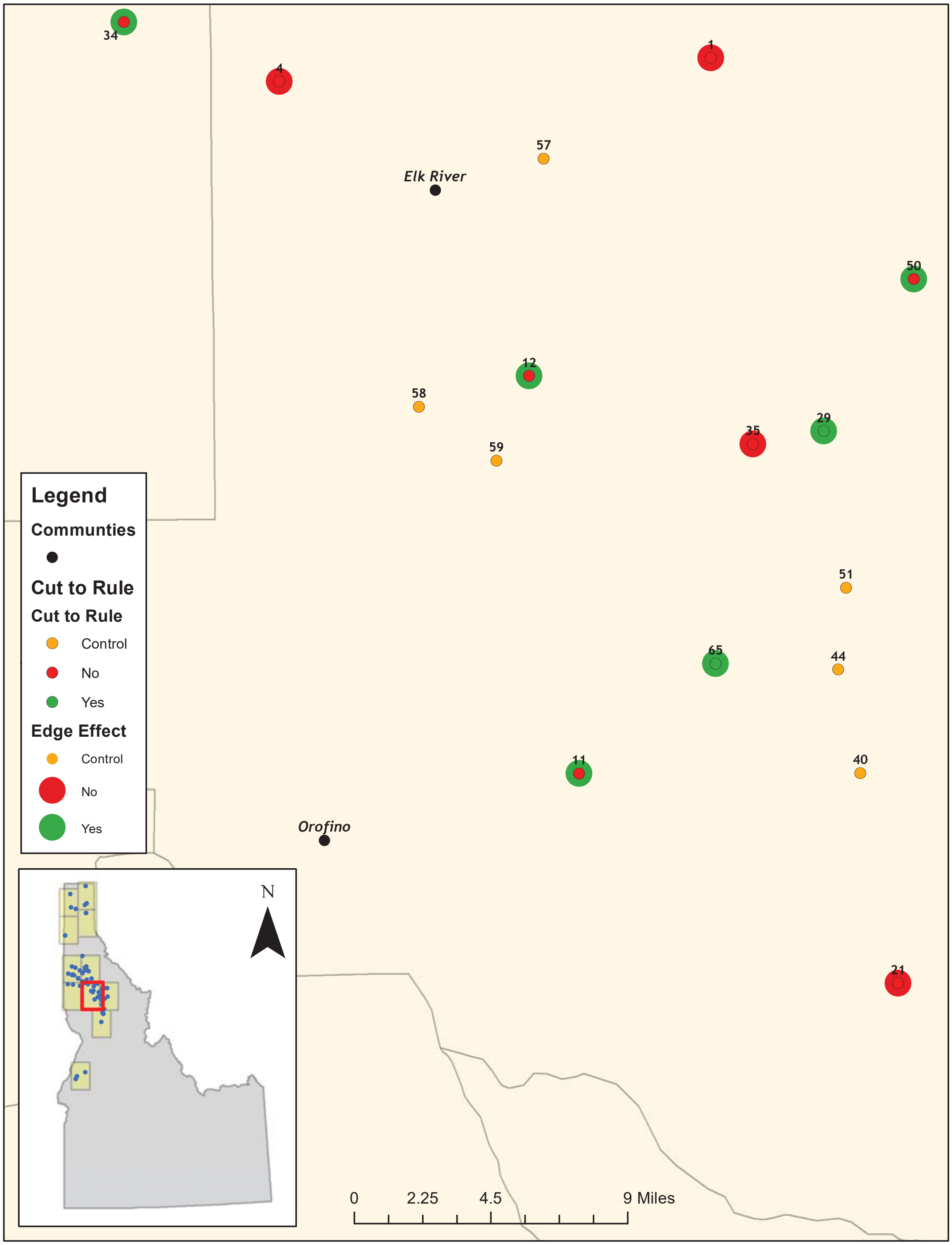

Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
20
32
Coeur d'Alene
N
0
2.25
4.5
9 Miles

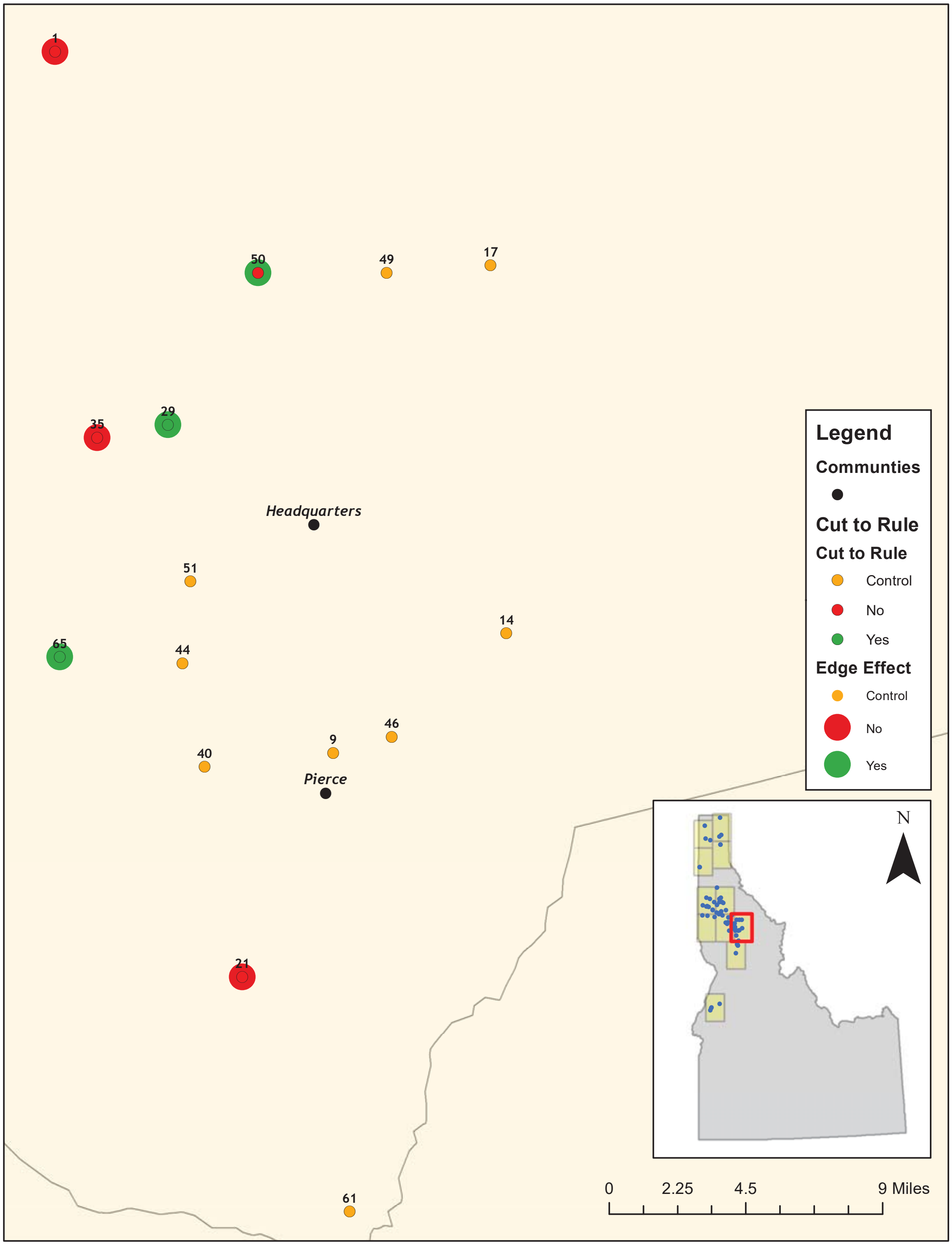

Legend
Communties
●
Cut to Rule
Cut to Rule
● Control
● No
● Yes
Edge Effect
● Control
● No
● Yes
55
56
Sandpoint
N
0
2.25
4.5
9 Miles

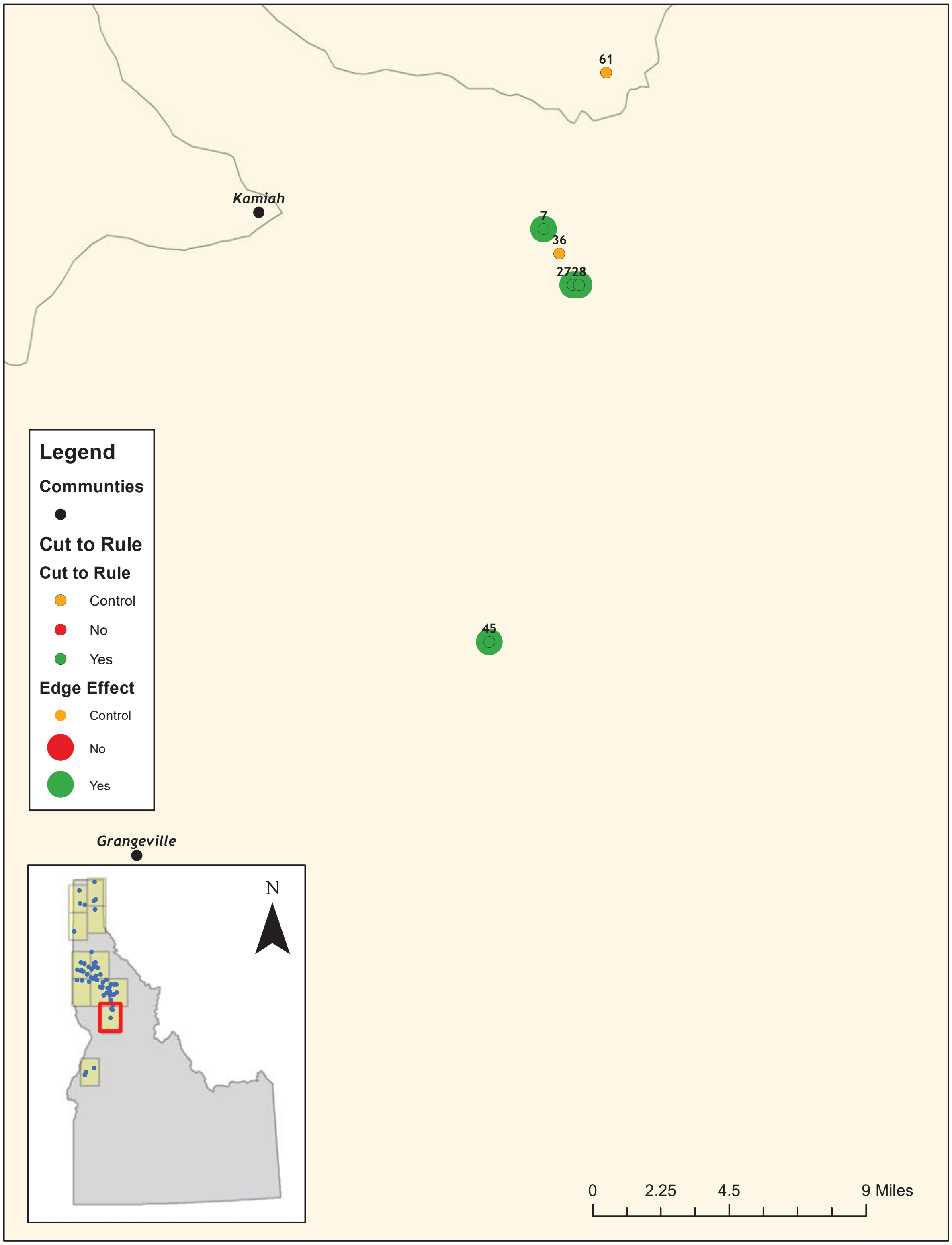

Legend
Communties
●
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
Plummer
St.Maries
26
2
52
47
19
42
30
62
31
8
41
3
38
N
0
2.25
4.5
9 Miles

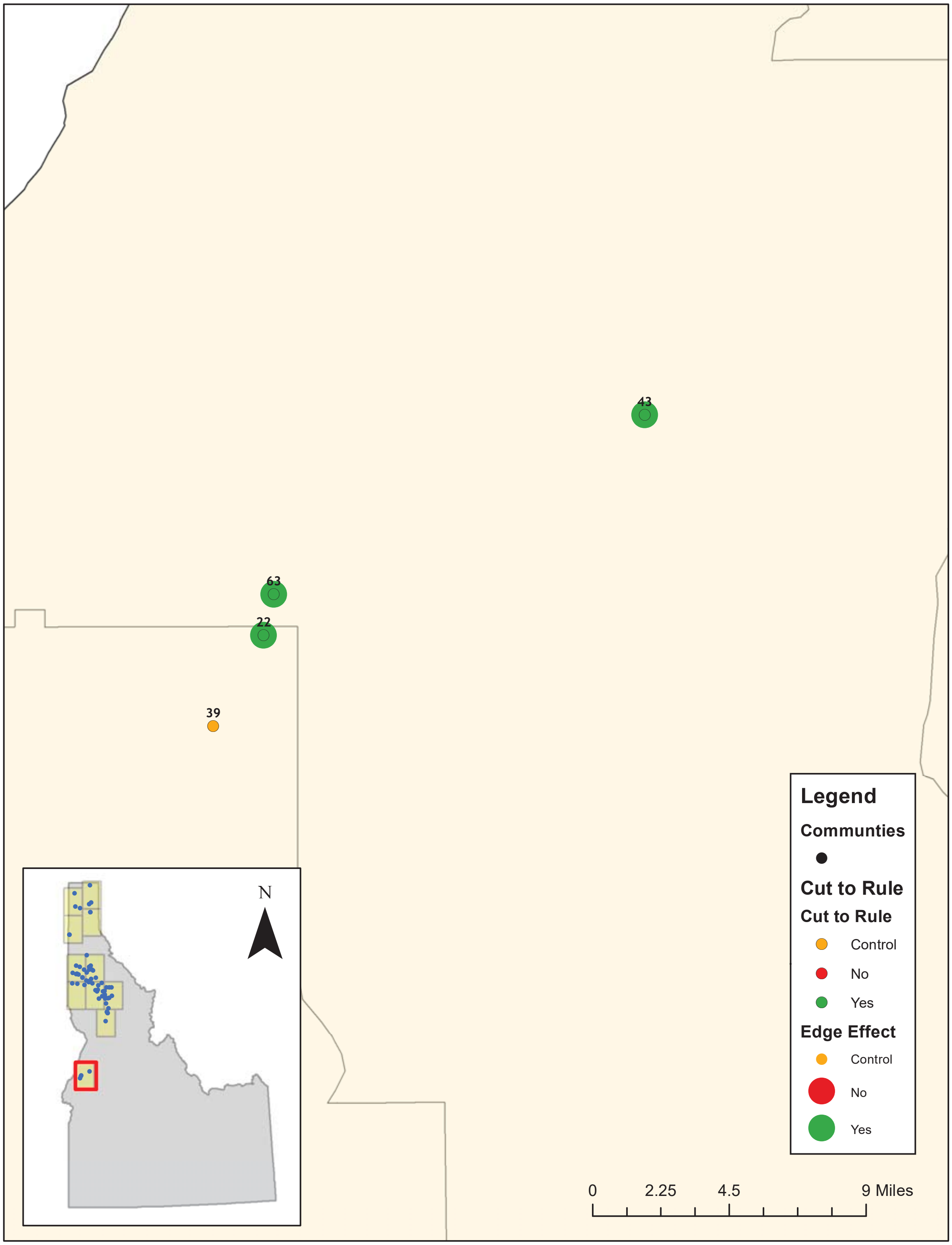

26
5
18
47
13
37
64
19
24
25
38
16
Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
N
0
2.25
4.5
9 Miles


23
54
6
Moscow
N
0
2.25
4.5
9 Miles
Legend
Communties
●
Cut to Rule
Cut to Rule
● Control
● No
● Yes
Edge Effect
● Control
● No
● Yes

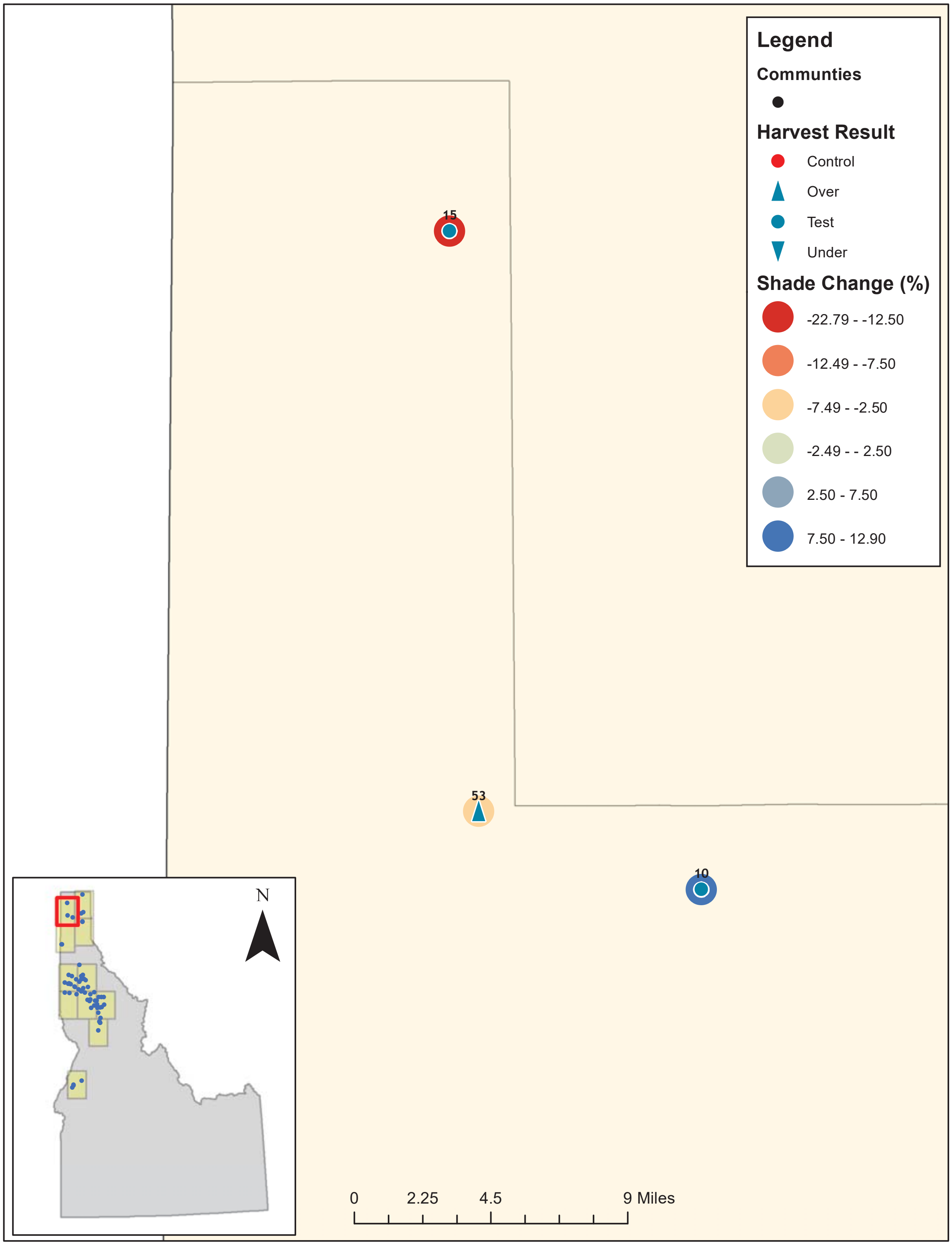

34
4
1
57
Elk River
50
12
58
29
35
59
51
65
44
11
40
Orofino
21
Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
N
0
2.25
4.5
9 Miles

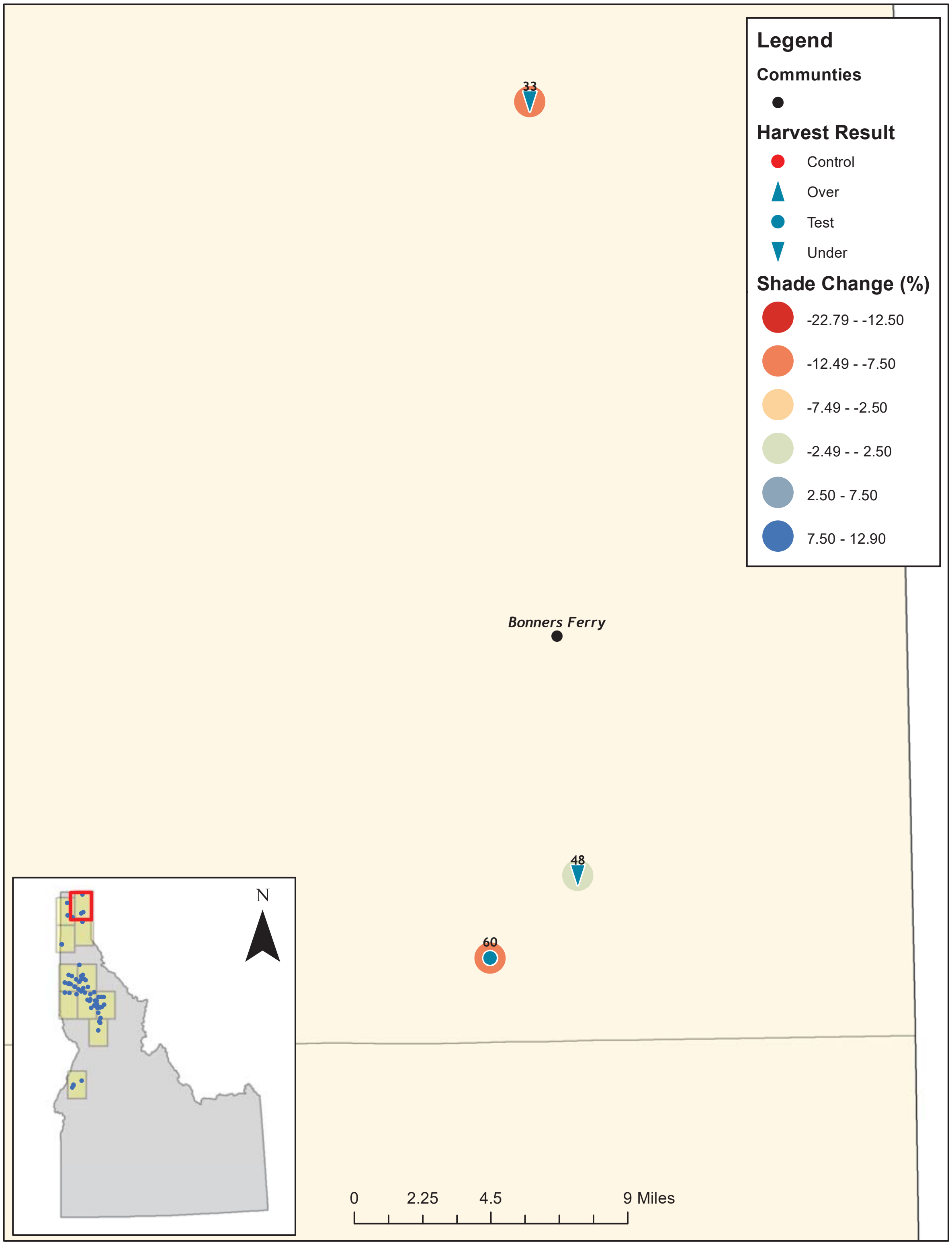

1
50
49
17
35
29
Headquarters
51
14
65
44
46
9
40
Pierce
21
61
Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
N
0
2.25
4.5
9 Miles

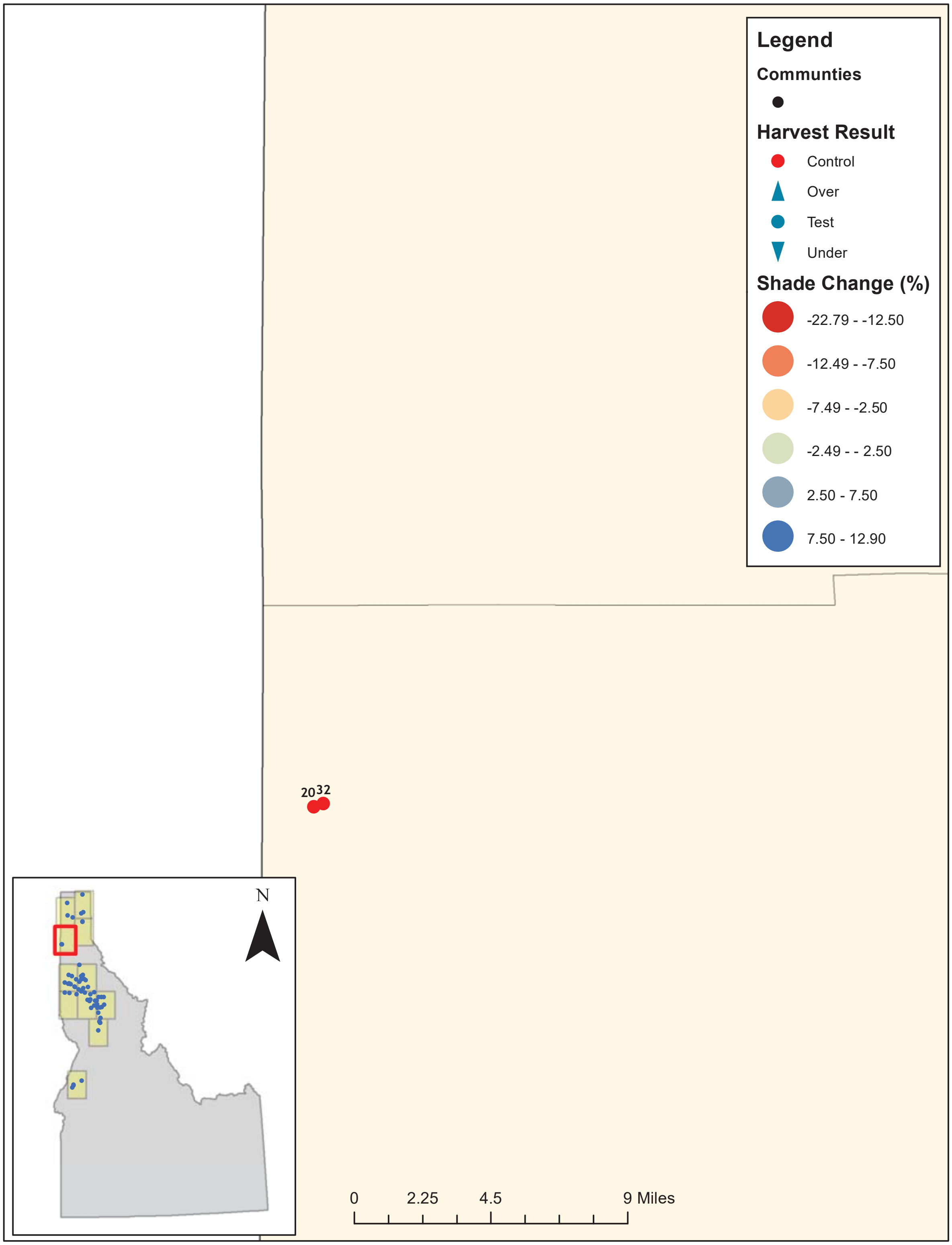

61
Kamiah
7
36
2728
45
Legend
Communties
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
Grangeville
N
0
2.25
4.5
9 Miles

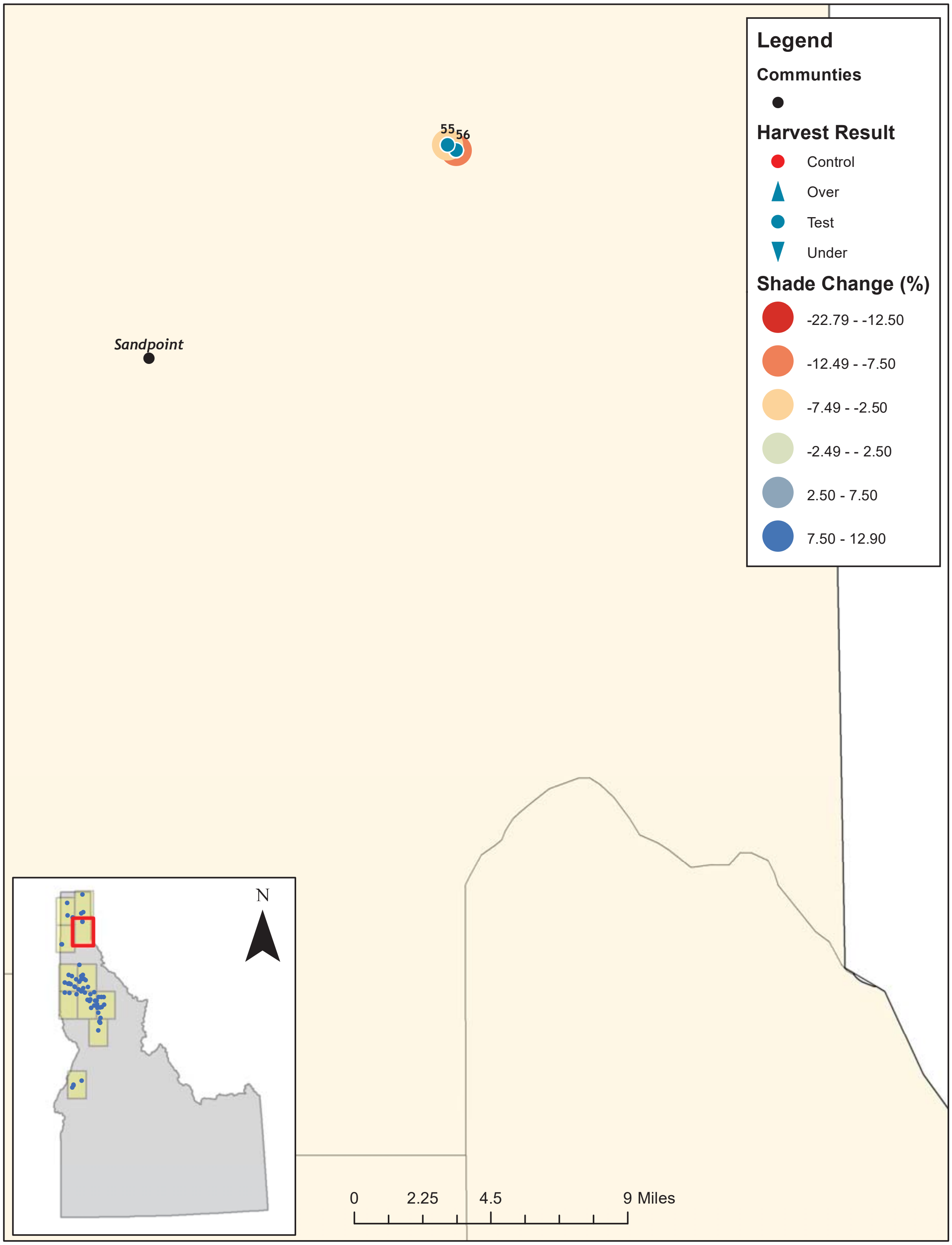

43
63
22
39
N
Legend
Communties
●
Cut to Rule
Cut to Rule
Control
No
Yes
Edge Effect
Control
No
Yes
0
2.25
4.5
9 Miles

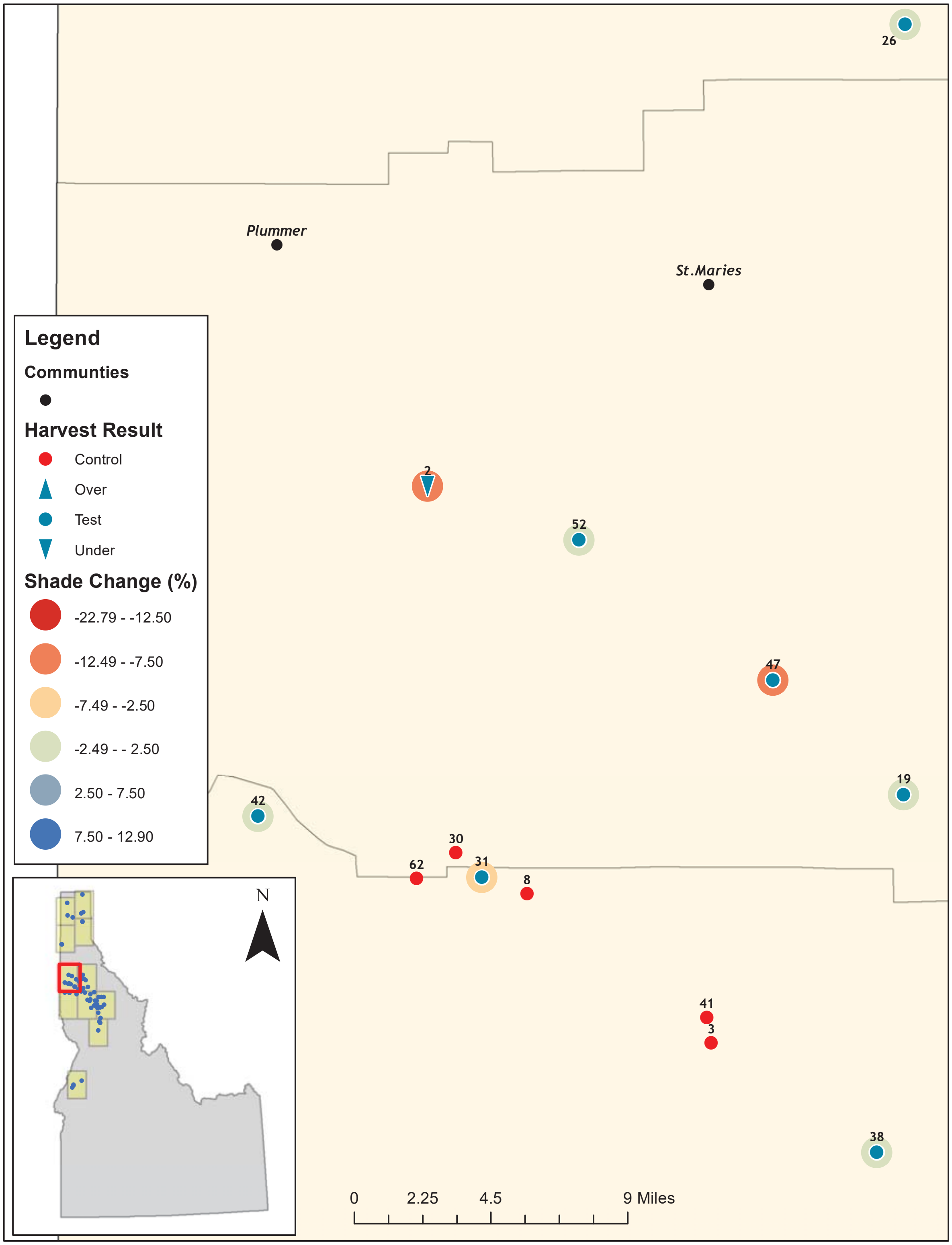
Appendix B4: Effective Shade Change Maps

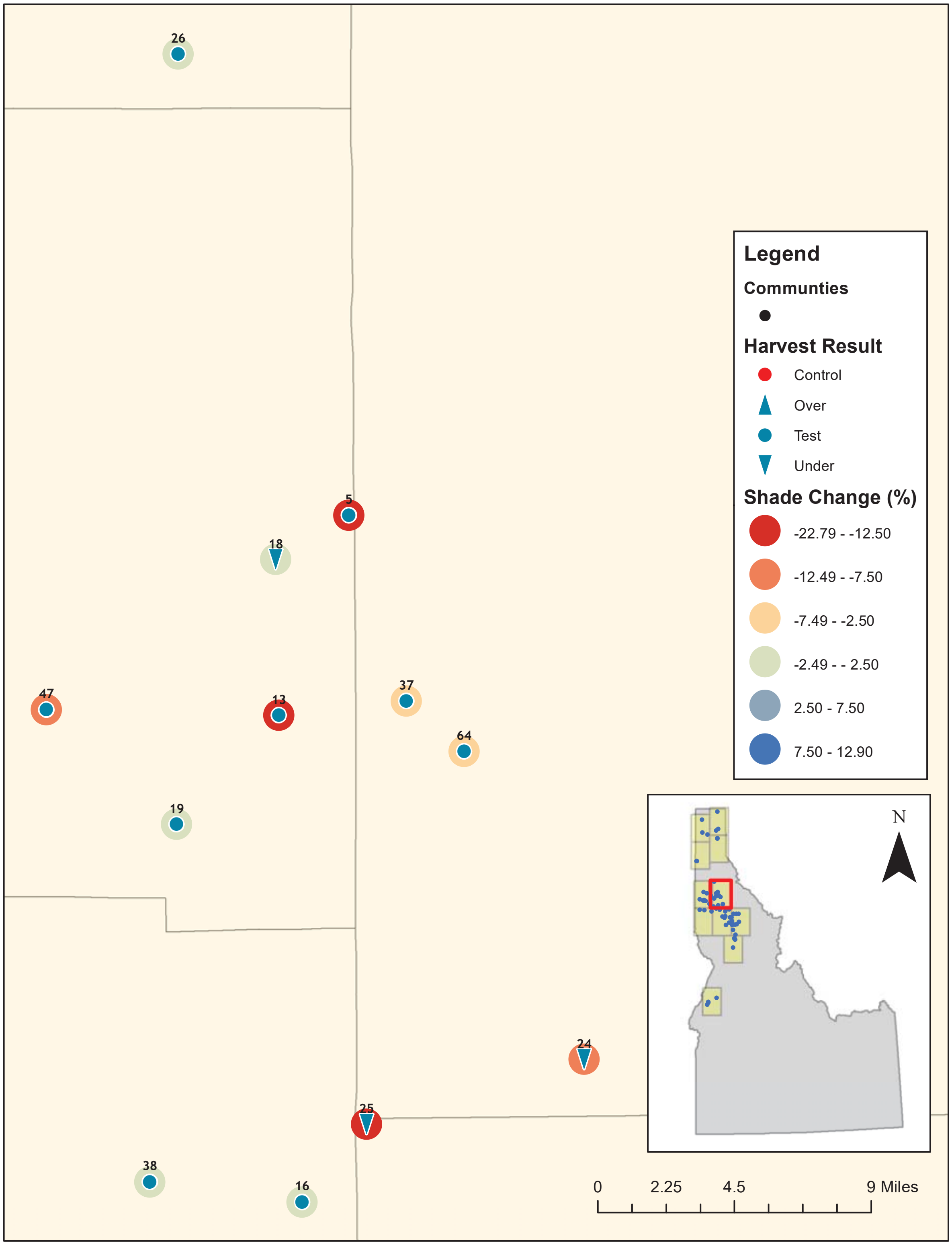

Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
15
53
10
N
0
2.25
4.5
9 Miles

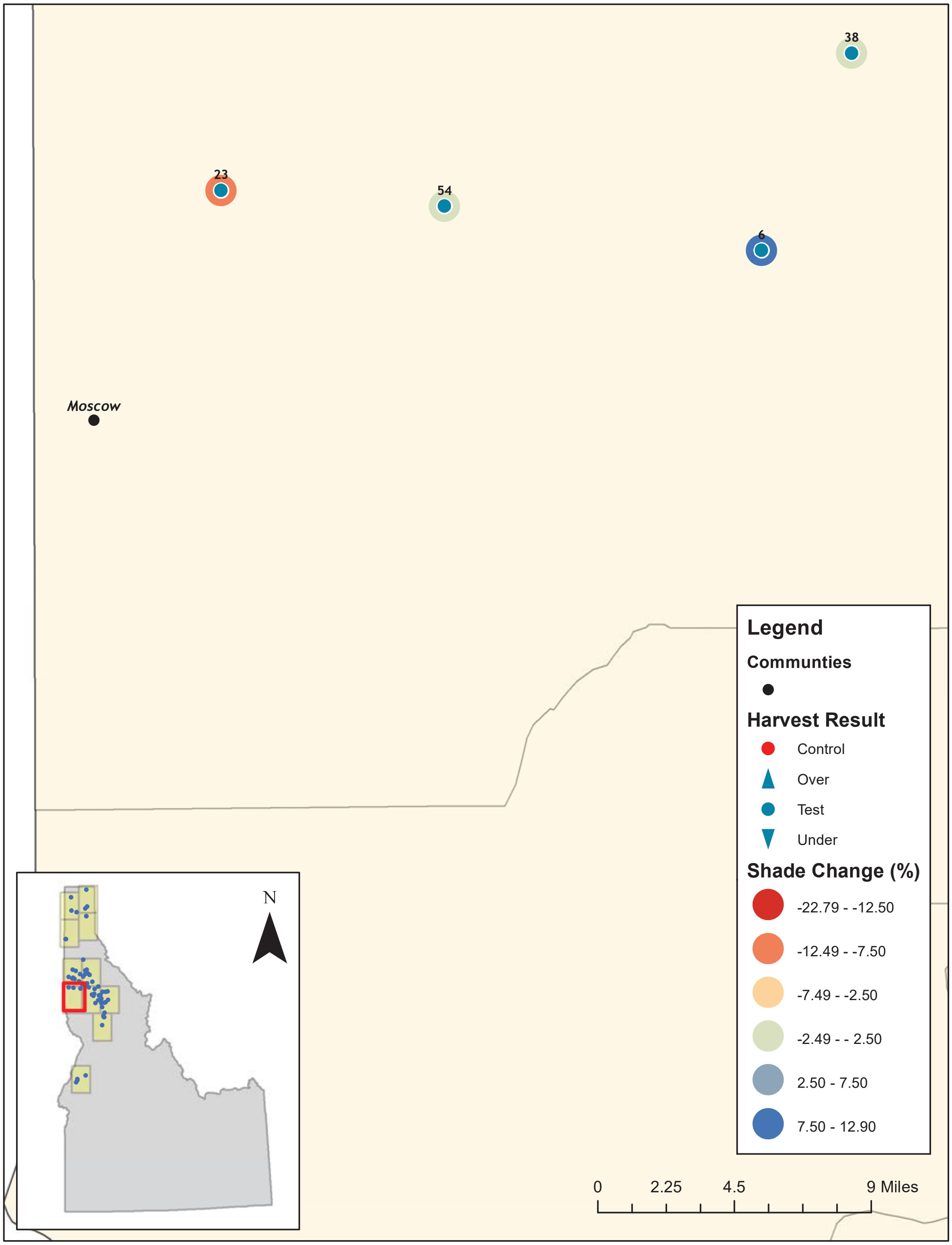

Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
33
Bonners Ferry
48
60
N
0
2.25
4.5
9 Miles

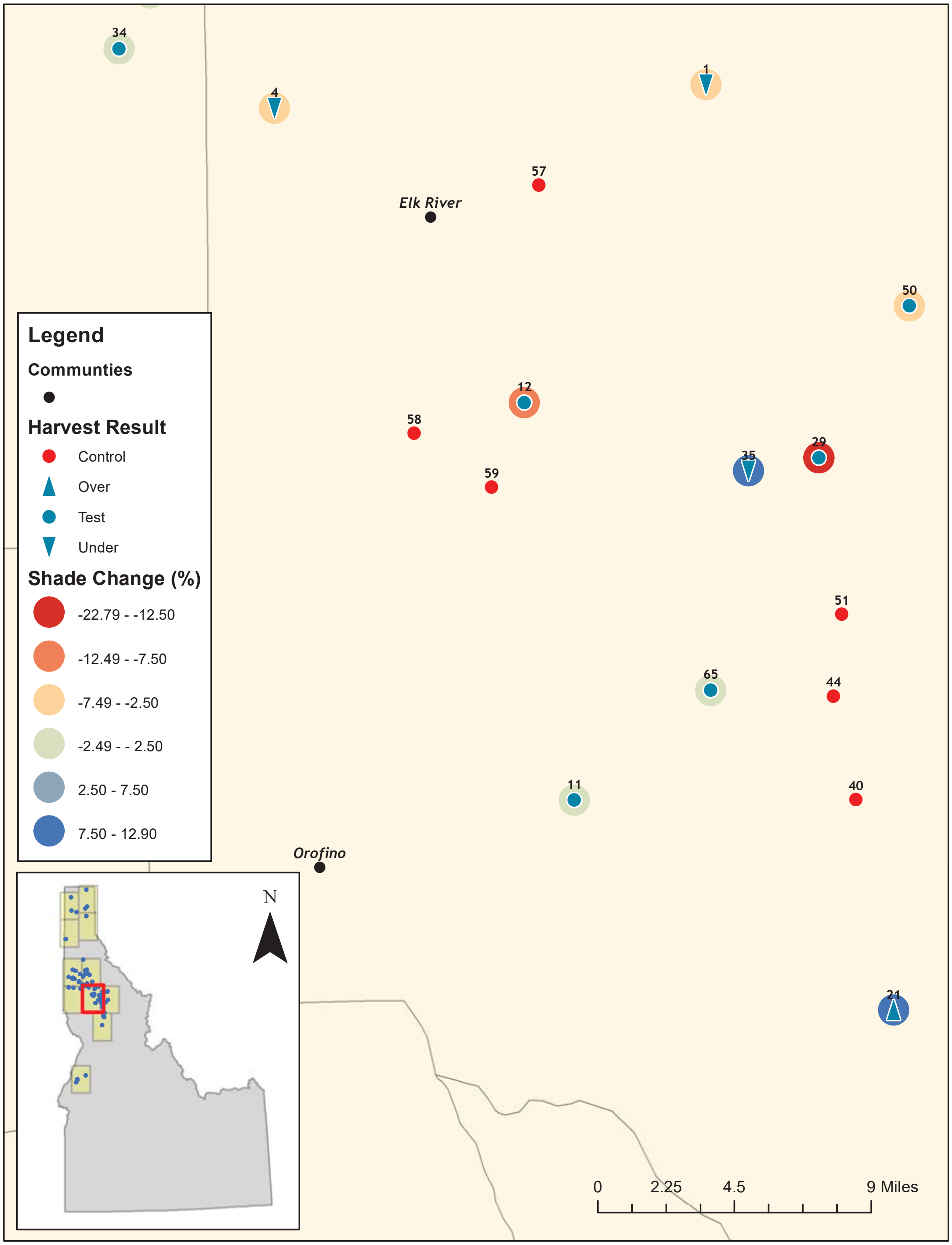

Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
20
32
N
0
2.25
4.5
9 Miles

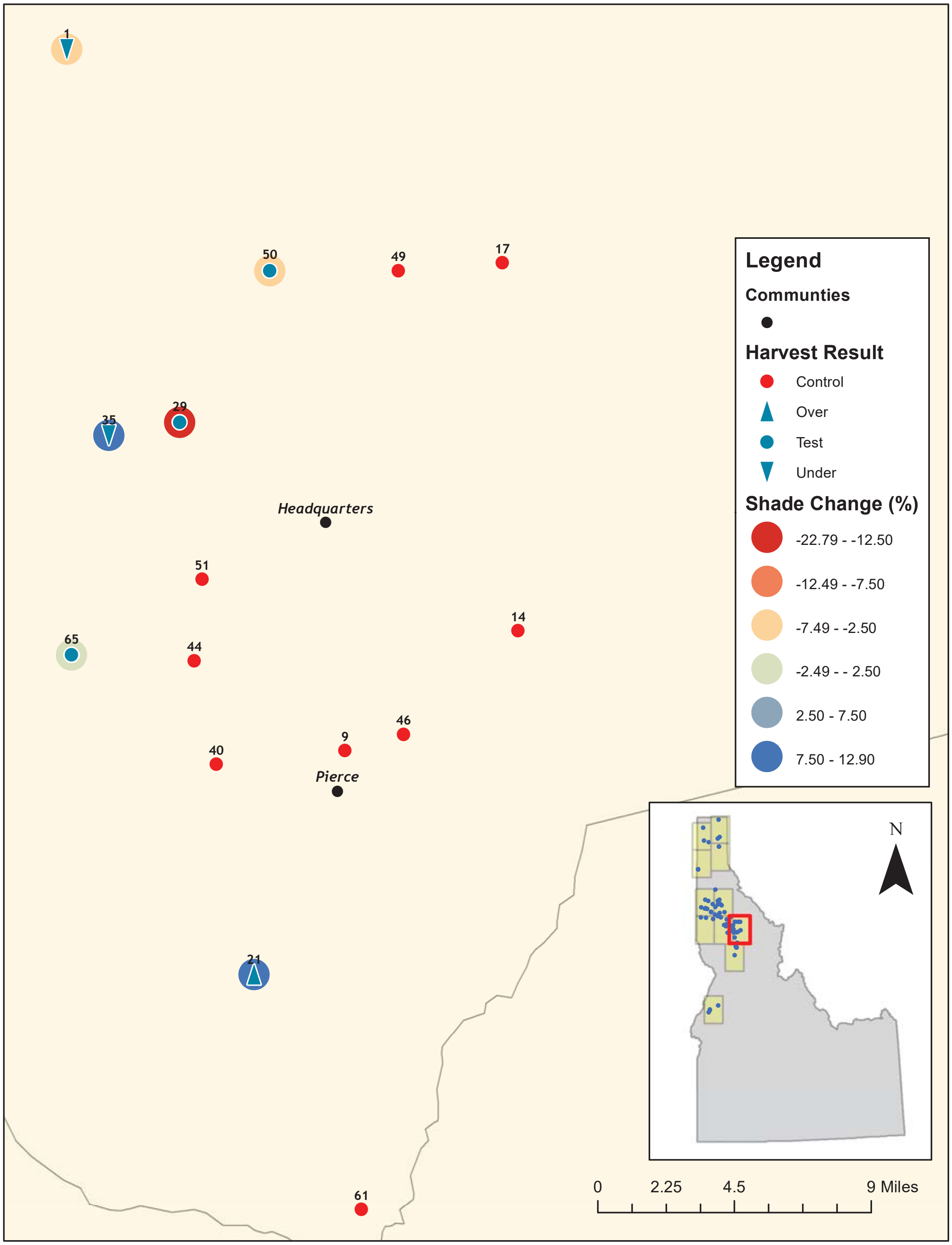

55
56
Sandpoint
Legend
Communties
●
Harvest Result
● Control
▲ Over
● Test
▼ Under
Shade Change (%)
● -22.79 - -12.50
● -12.49 - -7.50
● -7.49 - -2.50
● -2.49 - - 2.50
● 2.50 - 7.50
● 7.50 - 12.90
N
0
2.25
4.5
9 Miles

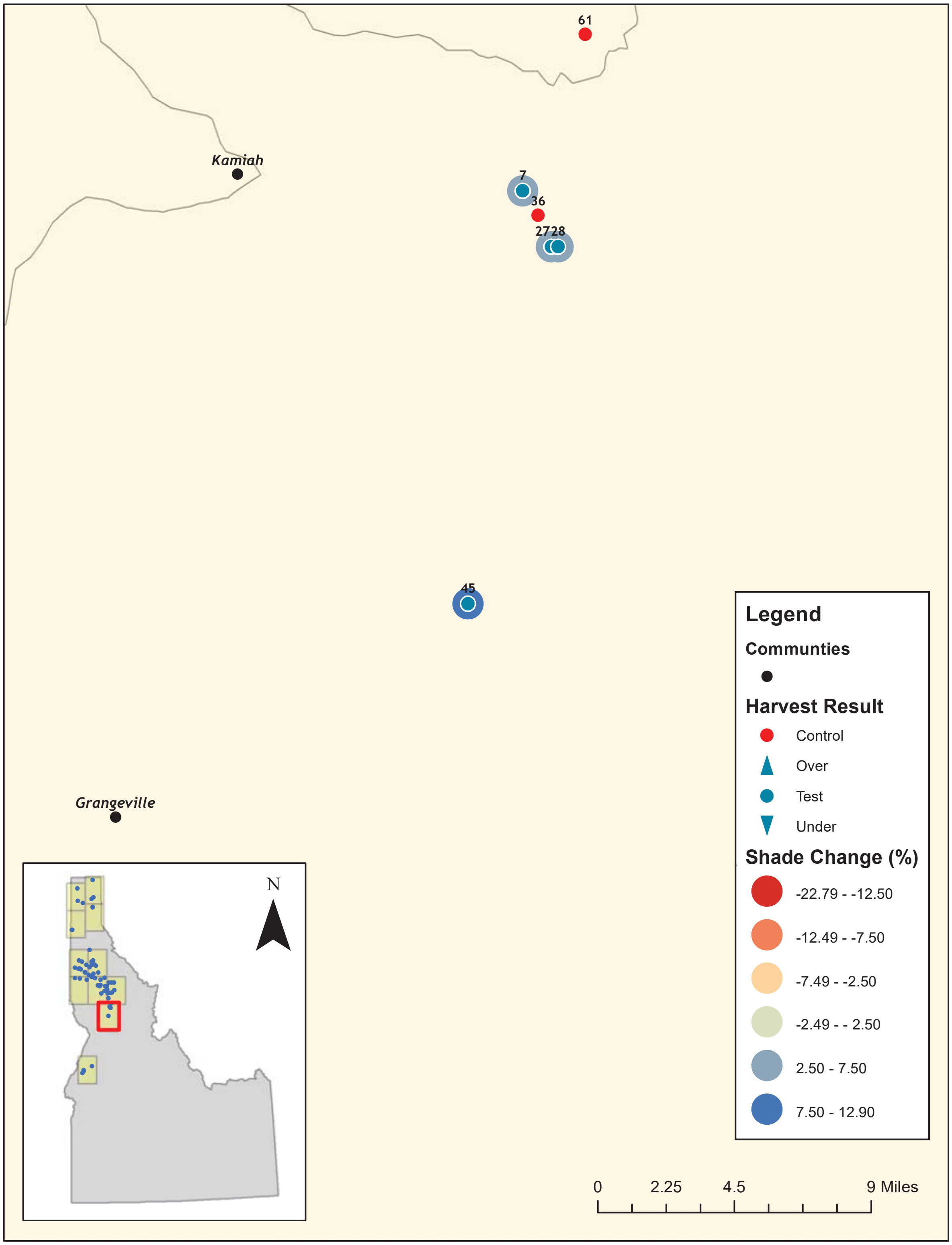

26
Plummer
St.Maries
Legend
Communties
●
Harvest Result
● Control
▲ Over
● Test
▼ Under
Shade Change (%)
● -22.79 - -12.50
● -12.49 - -7.50
● -7.49 - -2.50
● -2.49 - - 2.50
● 2.50 - 7.50
● 7.50 - 12.90
2
52
47
19
42
30
62
31
8
41
3
38
N
0
2.25
4.5
9 Miles

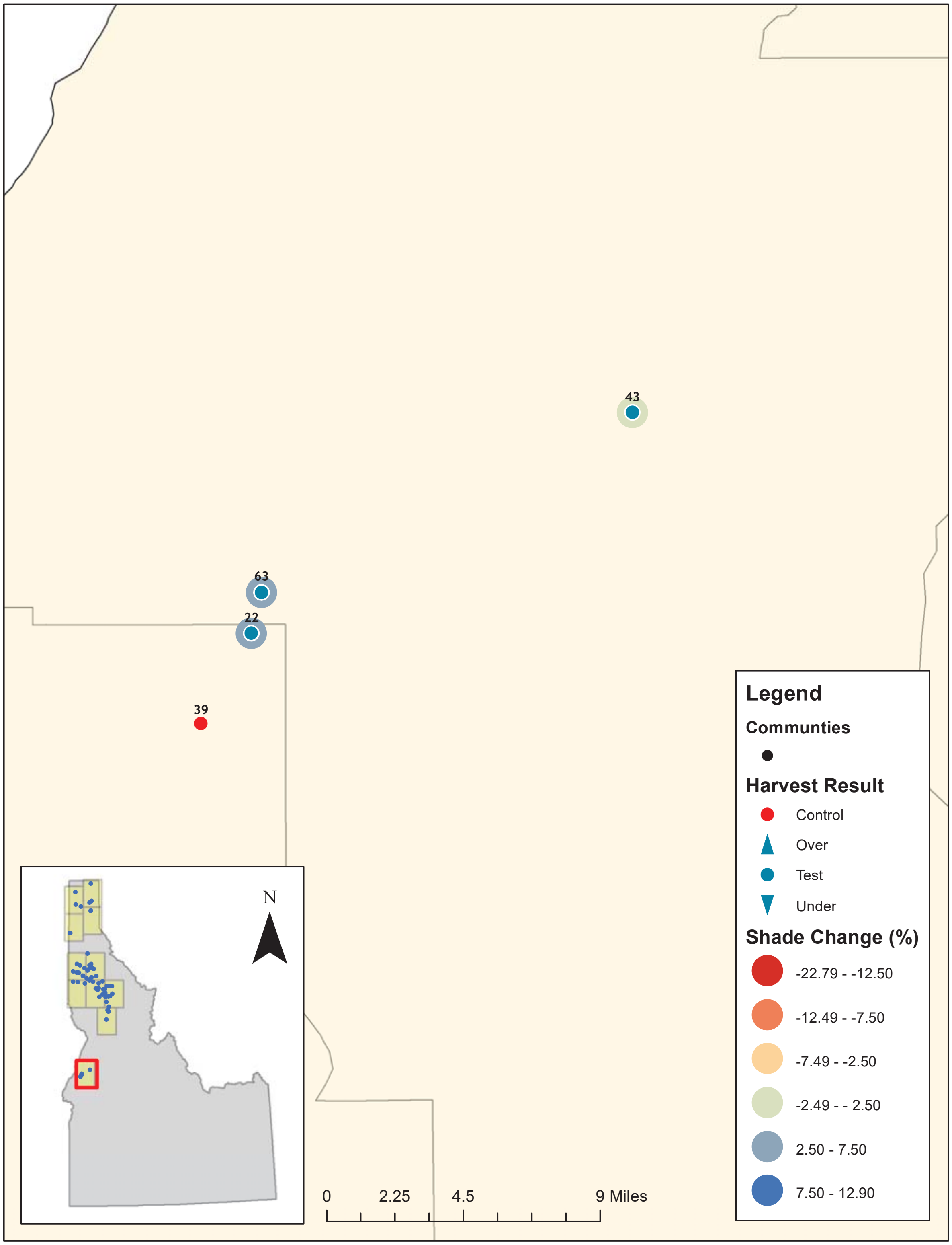

26
5
18
47
13
37
64
19
24
25
38
16
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
N
0
2.25
4.5
9 Miles


38
23
54
6
Moscow
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
0
2.25
4.5
9 Miles
N

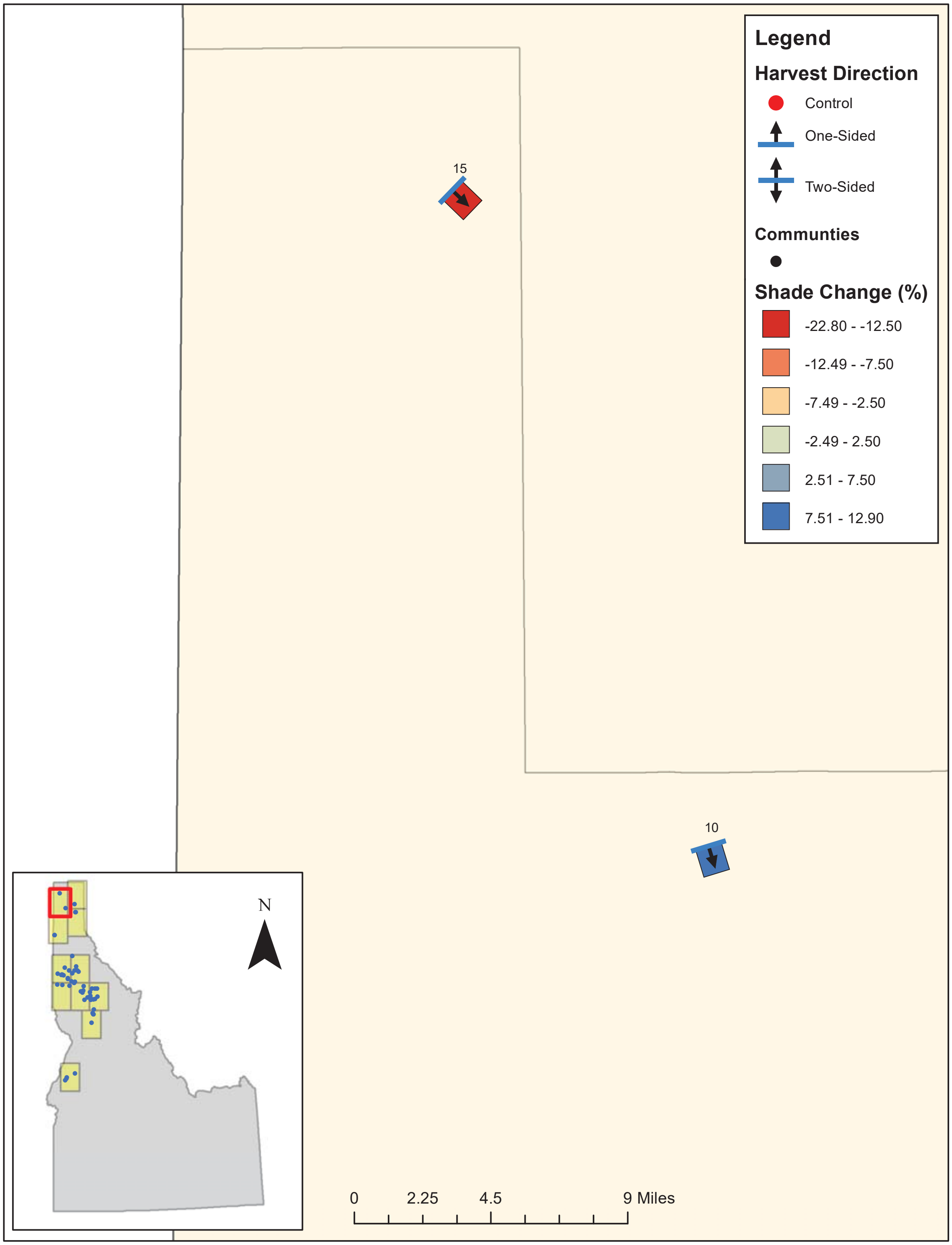

34
4
1
57
Elk River
50
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
12
58
59
35
29
51
65
44
11
40
Orofino
N
21
0
2.25
4.5
9 Miles

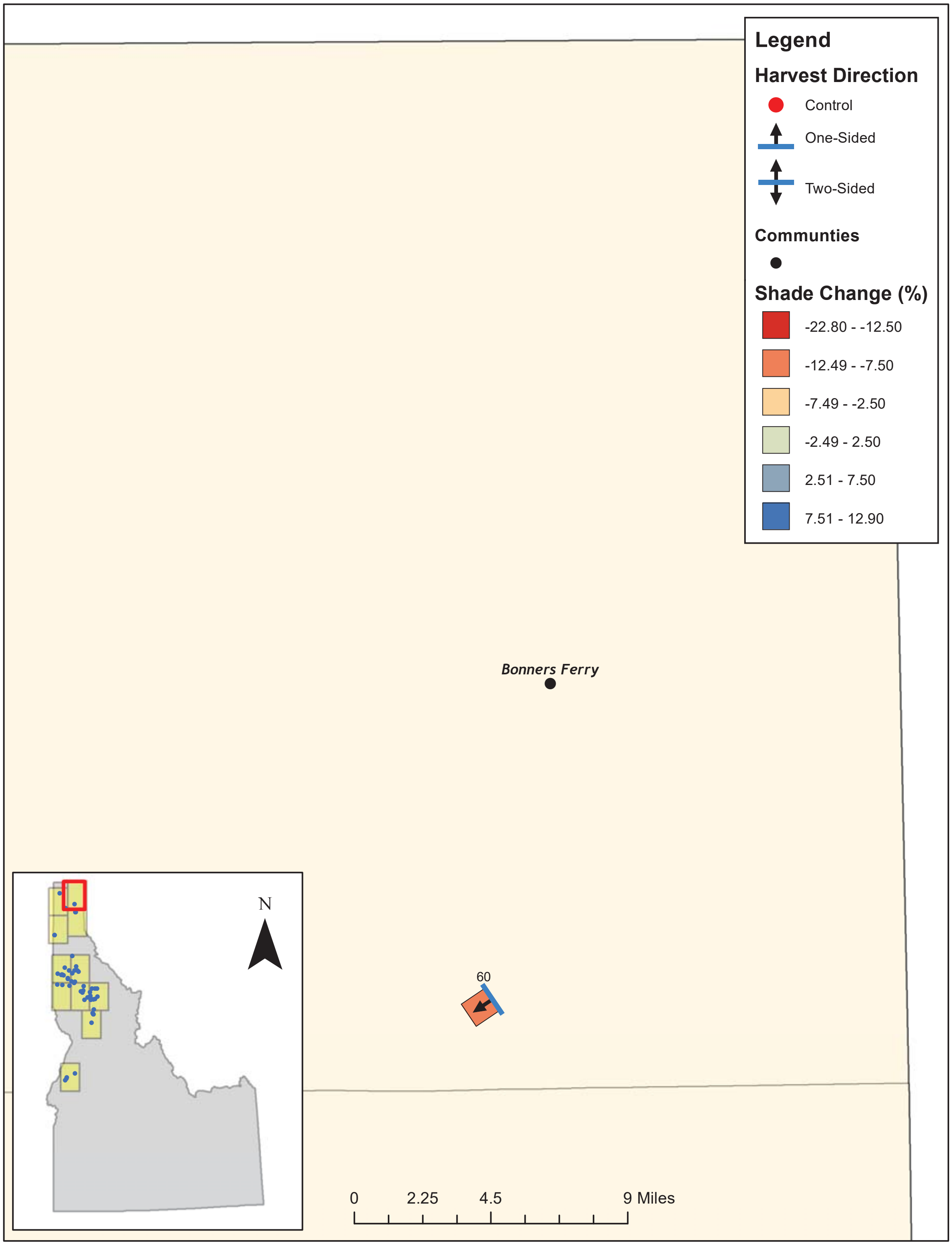

1
50
49
17
29
35
Headquarters
51
14
65
44
46
9
40
Pierce
21
61
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
N
0
2.25
4.5
9 Miles

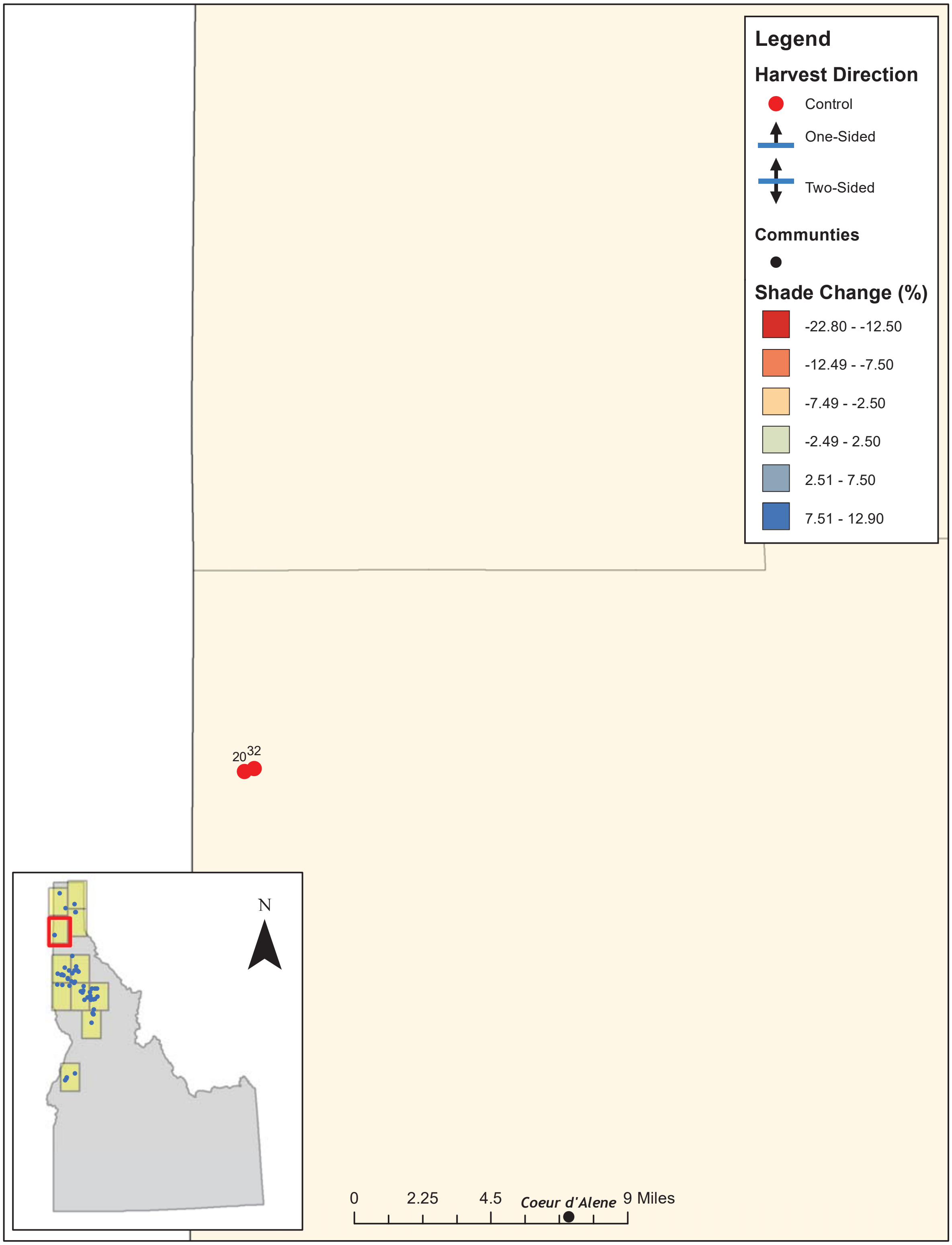

61
Kamiah
7
36
2728
45
Grangeville
N
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90
0
2.25
4.5
9 Miles

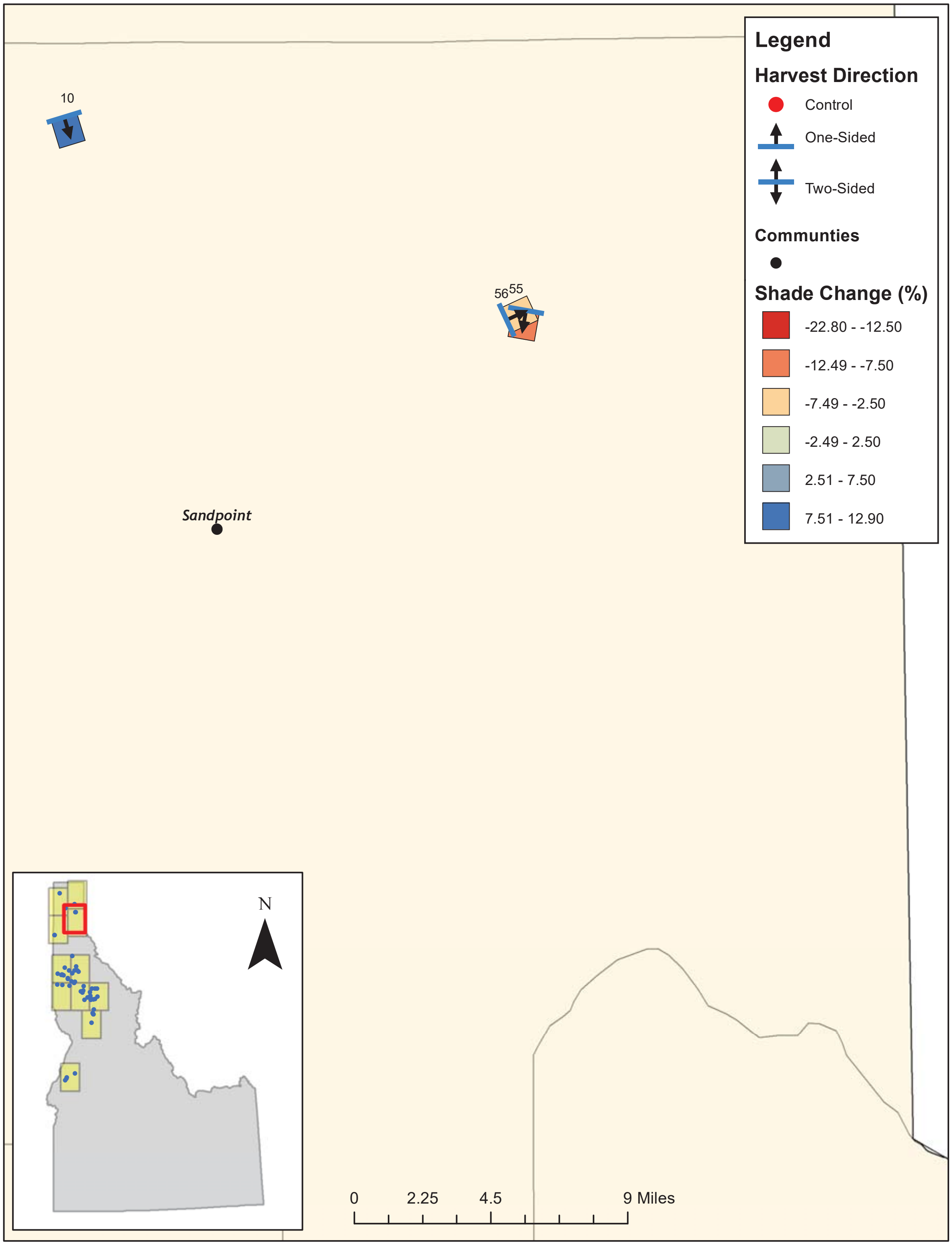

43
63
22
39
N
0
2.25
4.5
9 Miles
Legend
Communties
Harvest Result
Control
Over
Test
Under
Shade Change (%)
-22.79 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - - 2.50
2.50 - 7.50
7.50 - 12.90

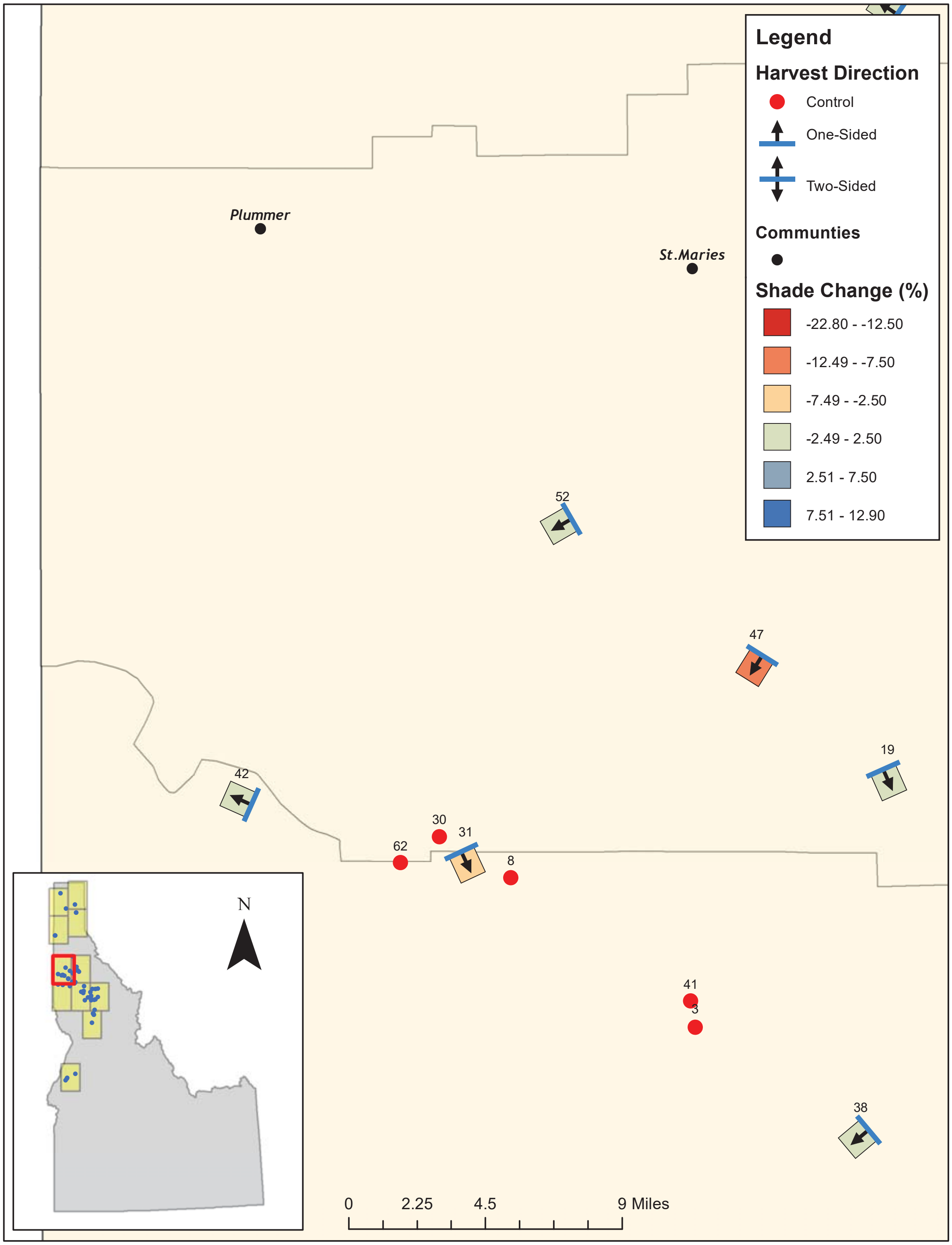
Appendix B5: Harvest Azimuth and Shade Change Maps

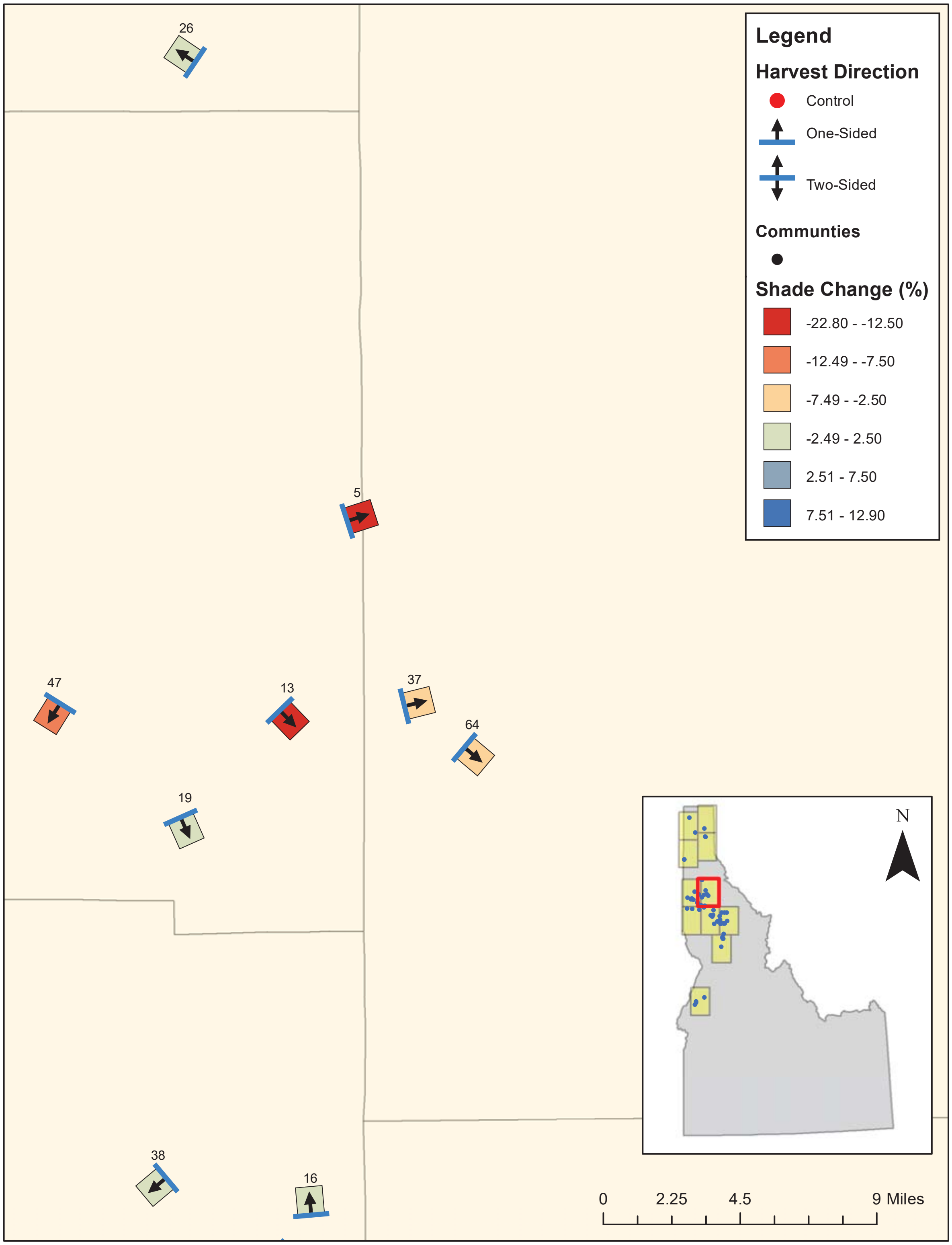

15
10
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
2.25
4.5
9 Miles

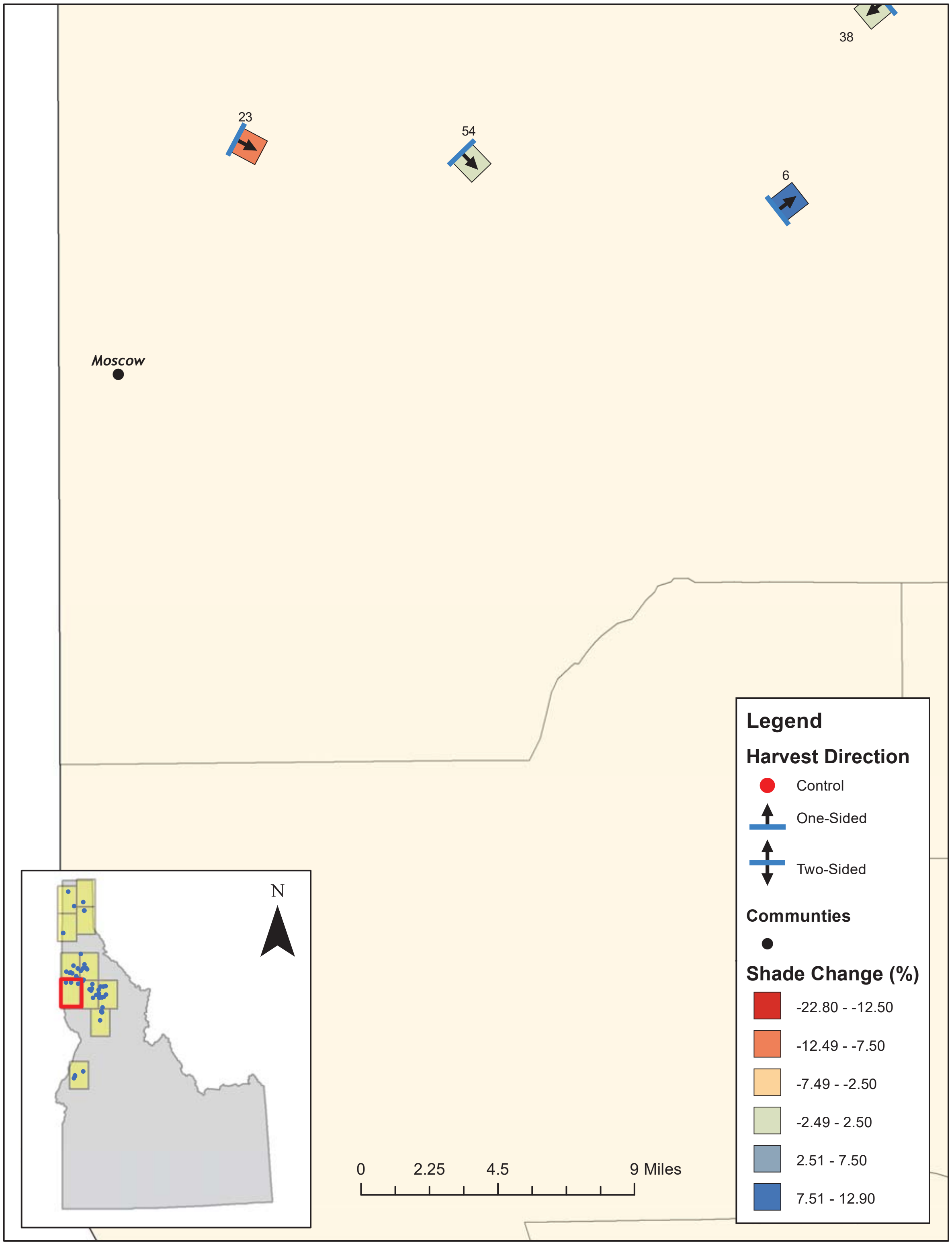

Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
Bonners Ferry
60
N
0
2.25
4.5
9 Miles

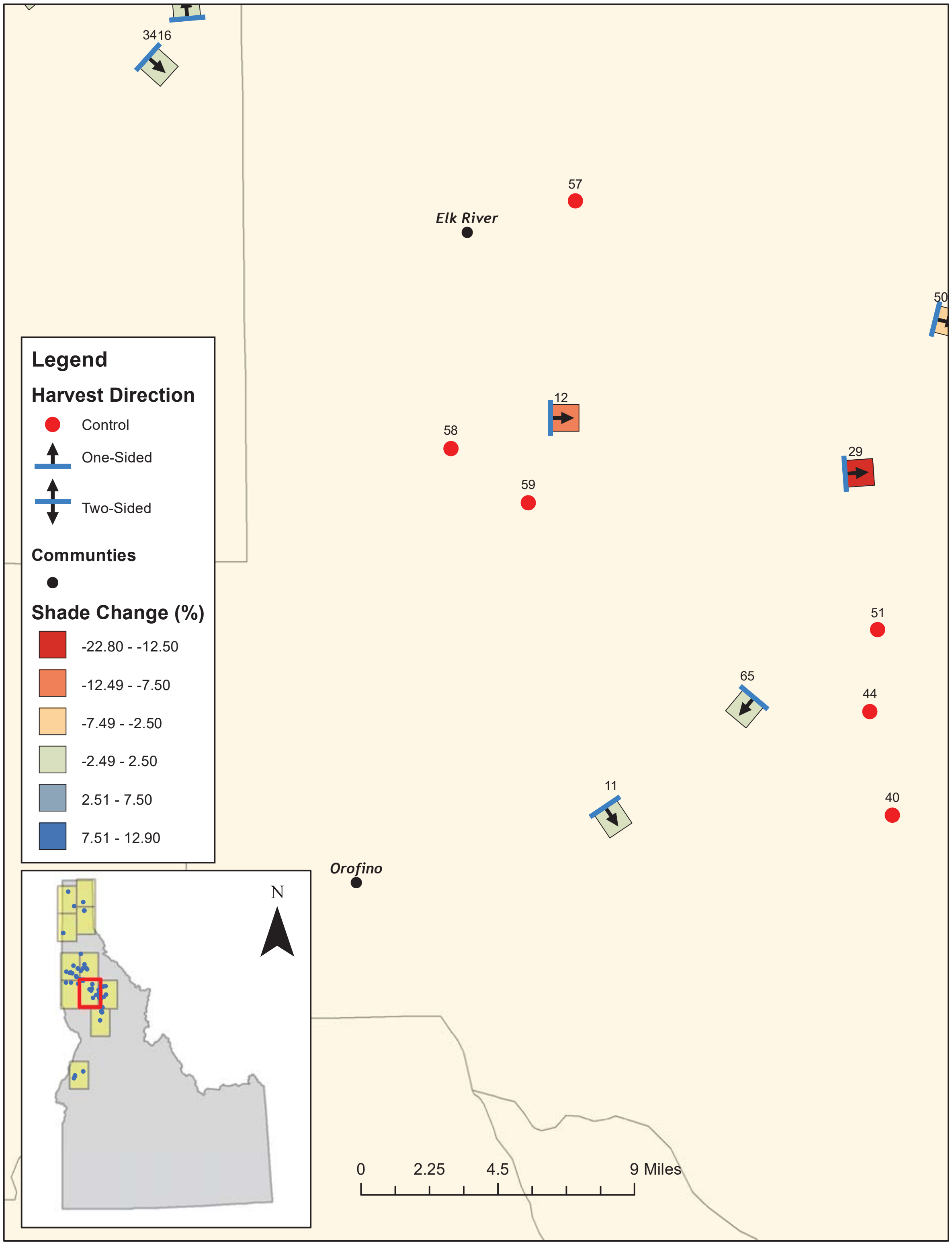

Legend
Harvest Direction
● Control
One-Sided
Two-Sided
Communties
●
Shade Change (%)
🟥 -22.80 - -12.50
🟧 -12.49 - -7.50
🟨 -7.49 - -2.50
🟩 -2.49 - 2.50
🟦 2.51 - 7.50
🟦 7.51 - 12.90
20
32
N
0
2.25
4.5
Coeur d'Alene
9 Miles

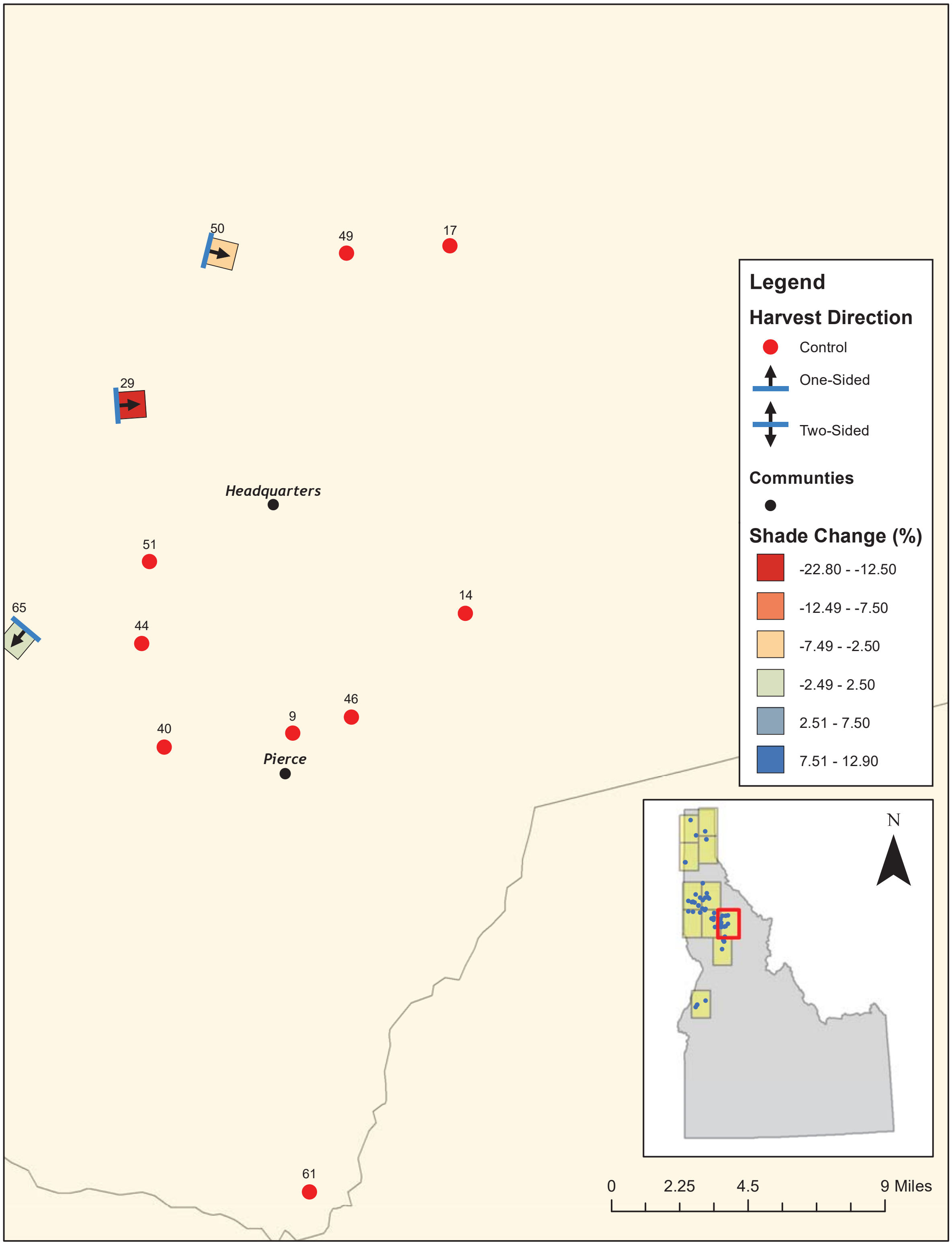

10
56
55
Sandpoint
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
2.25
4.5
9 Miles

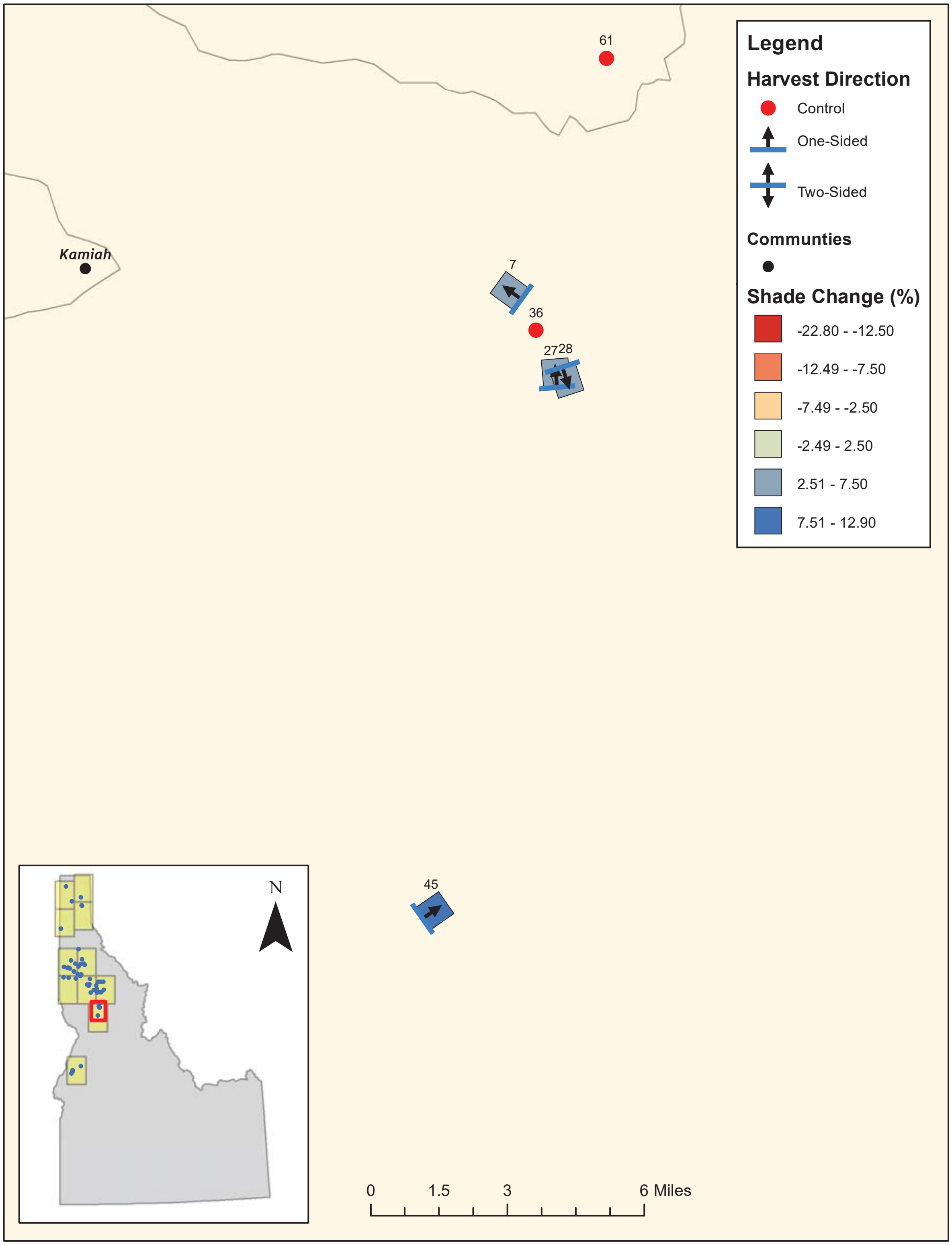

Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
Plummer
St.Maries
52
47
19
42
30
31
62
8
41
3
38
N
0
2.25
4.5
9 Miles

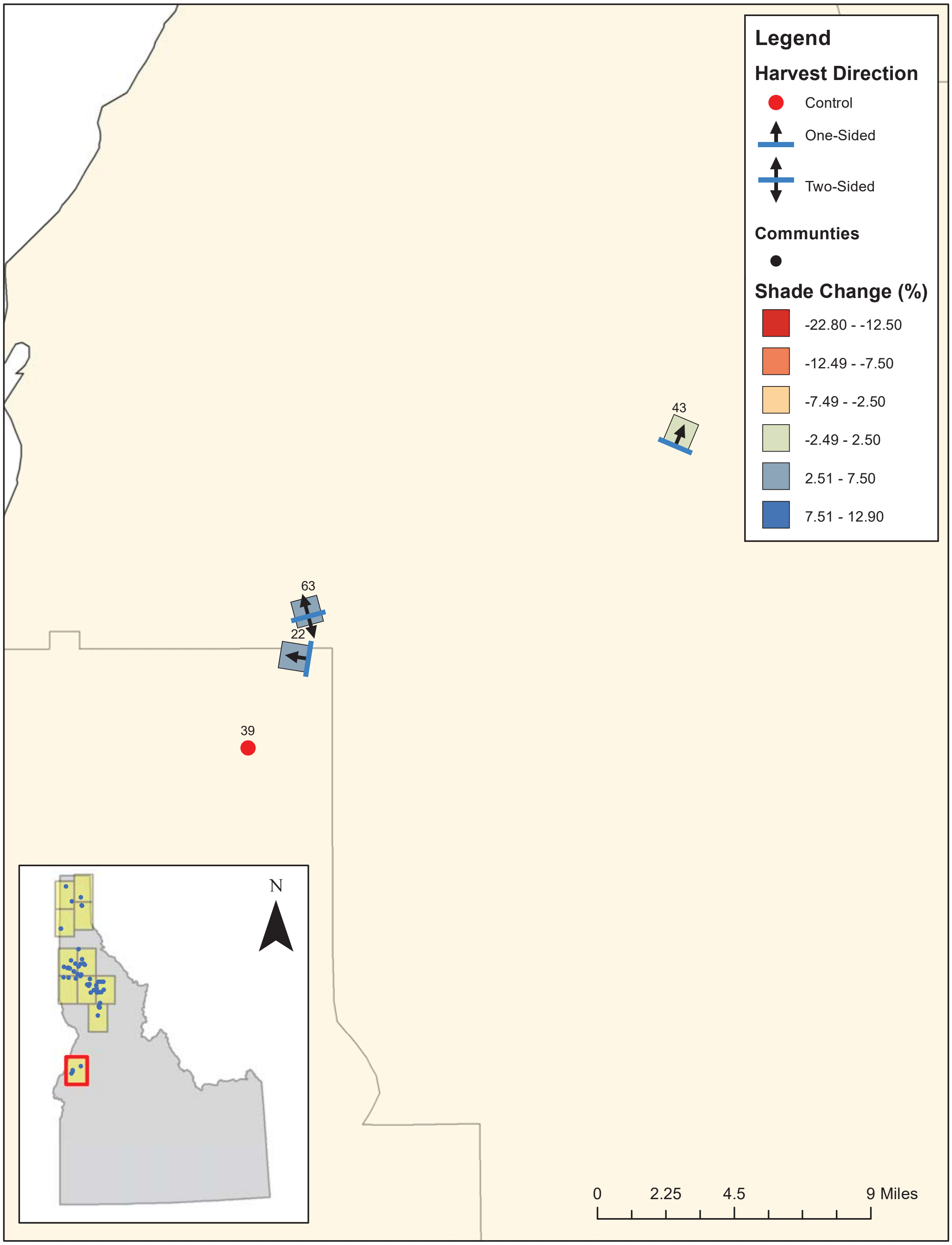

26
5
47
13
37
64
19
38
16
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
2.25
4.5
9 Miles


38
23
54
6
Moscow
N
0
2.25
4.5
9 Miles
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90


3416
57
Elk River
50
12
58
29
59
51
65
44
11
40
Orofino
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
2.25
4.5
9 Miles


50
49
17
29
Headquarters
51
14
65
44
46
9
40
Pierce
61
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
2.25
4.5
9 Miles


61
Kamiah
7
36
27
28
45
Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
N
0
1.5
3
6 Miles


Legend
Harvest Direction
Control
One-Sided
Two-Sided
Communties
Shade Change (%)
-22.80 - -12.50
-12.49 - -7.50
-7.49 - -2.50
-2.49 - 2.50
2.51 - 7.50
7.51 - 12.90
43
63
22
39
N
0
2.25
4.5
9 Miles