Boise National Forest

Aquatic Management Indicator Species

2013 Monitoring Report

Prepared by

Ralph G. Mitchell – Aquatics MIS Crew Leader
Herbert M. Roerick – Forest Fish Program Manager

Introduction

In order to evaluate the effects of management practices on fisheries and wildlife resources, the U.S. Forest Service monitors select species whose population trends are believed to reflect the effects of management activities on Forest ecosystems. These species are termed "management indicator species" (MIS) and the rationale for MIS monitoring is outlined in federal regulation 36 CFR 219.19.

> *"In order to estimate the effects of each alternative on fish and wildlife populations, certain vertebrate and/or invertebrate species present in the area shall be identified and selected as management indicator species and the reasons for their selection will be stated. These species shall be selected because their population changes are believed to indicate the effects of management activities."*
>
> *"Population trends of the management indicator species will be monitored and relationships to habitat changes determined."*

An important criterion integral to the MIS foundation is that monitoring results must allow managers to answer questions about population trends. Historically, monitoring of habitat was used a surrogate for direct quantification of MIS populations. However, recent court cases (*Sierra Club v. Martin*, 168 F.3d 1 (11th Cir. 1999)) have ruled that assessing changes in habitat will no longer be accepted as a substitute for direct monitoring of populations. The Forest Service has an obligation to collect and analyze quantitative population trend data at both the forest-plan and project level.

In response to issues raised by court challenges, the Sawtooth, Boise, and Payette National Forests revisited aquatic MIS species for the Draft Forest Plan EIS to determine if the population data were sufficient to determine trend at the Forest scale.

Following this reevaluation, bull trout was selected as the aquatic MIS species (for a full explanation of the MIS review, see Aquatic Management Indicator Species for the Boise, Payette, and Sawtooth Forest Plan Revision, 2003). Bull trout were selected because the species is sensitive to habitat changes, dependent upon habitat conditions that are important to many aquatic organisms, relatively well understood by Forest biologists, and widely distributed across the Ecogroup. Except for historic stocking of brook trout (*Salvelinus fontinalis*), a species known to hybridize with bull trout (Markle 1992, Leary et al. 1993), forest bull trout populations are probably not heavily influenced by activities occurring outside Forest domains, and therefore changes in bull trout populations will more likely reflect local management activities.

Methods

Development of MIS Sampling Protocol for Bull Trout

An approach to monitoring MIS bull trout was developed with the Boise National Forest, Regional Office, and the Boise Rocky Mountain Research Station in 2004. The following provides a summary of this monitoring approach.

A key question that this approach addresses is how does one monitor trend? For aquatic species, trend is typically monitored using relative abundance estimates over time in a select set of streams. However, the challenge with abundance data is that it is often influenced by sampling error and natural variation (Platts and Nelson 1988; Maxell 1999; Dunham et al. 2001).

Given these well-known limitations, an alternative population trend monitoring approach was developed that focuses on monitoring the spatial patterns of occurrence (distribution) through time. Monitoring distributions can be particularly appropriate for bull trout because it has very particular habitat requirements. Specifically, bull trout distributions are limited to cold water (Dunham et al. 2003), and suitably cold habitats are often patchily distributed throughout river networks (Poole et al. 2001). Dunham and Rieman (1999) found that bull trout populations in the Boise River basin were linked closely to available habitat "patches" or networks of cold water. A patch is defined for bull trout as the contiguous stream areas believed suitable for spawning and rearing (Rieman and McIntyre, 1995). Rieman and McIntyre (1995) analyzed bull trout in the Boise River basin and found occurrence to be positively related to habitat size (stream width) and patch (stream catchment) area, as well as patch isolation and indices of watershed disruption. Patch size (area) was the single most important factor determining bull trout occurrence.

Spatial patterns can also provide information on population persistence, local extirpations, and recovery (recolonization). The stability and persistence of metapopulations are related to the number, size, degree of isolation, and relative distribution of populations (Dunham and Rieman 1999). Bull trout populations in larger, less isolated, and less disturbed habitats appear more likely to persist over time.

Based upon the above approach the following metrics for determining trend were used:

(1) The proportion of habitat patches that bull trout occupy within each subbasin across time.
(2) The spatial pattern of occupied bull trout patches within each subbasin across time.

It was assumed in the forest plans that as restoration and conservation activities are implemented, constraints on watershed processes and habitat condition would be reduced. This in turn would maintain or restore properly functioning subwatersheds and slowly improve degraded subwatersheds. However, it was also realized that it would take time for populations to respond to restoration and conservation measures. This might be particularly true for bull trout, which have a relatively long generation time (5-10 years). Therefore, it was assumed that the number and distribution of strong or depressed bull trout populations would change relatively slowly over the 15 years of the forest plan.

We anticipate that important changes in the distribution and proportion of occupied bull trout patches will only be apparent over time scales approximating the life of the forest plan. Bull trout may become more widely distributed in occupied patches as populations begin to expand, and recolonization of unoccupied patches may occur as barriers are removed. However, only with sustained restoration and sufficient time for natural recovery, are we likely to see substantial changes in the portion of occupied patches or increases in bull trout distributions within occupied patches.

The trend of occupied patches and spatial pattern will not explain why changes have occurred. As the CFR states, "Population trends of the management indicator species will be monitored and relationships to habitat changes determined." Therefore, an approach is currently being developed to tie MIS monitoring with forest plan implementation and effectiveness monitoring to determine how habitats and individual populations change in relation to management activities.

Initial Determination of Bull Trout Patches

Bull trout patches were identified in two ways. First, several subbasins (e.g. Boise and Payette) already had patches delineated by existing work following Rieman and McIntyre (1995) and Dunham and Rieman (1999). For these subbasins, district and forest biologists reviewed patch designations to determine if they included all known or potential streams that could support bull trout. Second, for subbasins where patches had not been established, a consistent set of criteria was applied to delineate patches.

Forests used criteria similar to those used by the RMRS in the Boise and Payette subbasins. Patches were initially defined based on major physical gradients (patch size, as it related to stream size and elevation). Patches were identified as catchments above 1600 meters (m) and were delineated from U.S. Geological Survey 10 m Digital Elevation Models (DEM). The 1600 m elevation criteria was used because data from the Boise basin indicated that the frequency of juvenile bull trout (<150 mm) occurrence increased sharply at about 1,600 m (Rieman and McIntyre 1995; Dunham and Rieman 1999).

Subwatersheds that were above 1600 m, but less than 500 hectares, were not included because they rarely supported perennial streams large enough to support bull trout. Watson and Hillman (1997) only found bull trout in streams greater than two meters in width and studies in western Montana (Rich 1996) and southwest Idaho (Rieman and McIntyre 1995; Dunham and Rieman 1999) show bull trout are less likely to occur in streams less than two meters in width. We assumed that patches less than 500 hectares would have streams with a wetted width smaller than 2 m at 1600 m in elevation.

We initially assumed that 1,600 m elevation approximated the lower limits of habitat suitable for spawning and early rearing of bull trout. Because of the association with temperature, elevation should define habitat patches that are at least partially isolated by distance across warmer waters (Rieman and McIntyre, 1995). The 1600 m elevation in the Boise and Payette subbasins currently forms the downstream boundary of each patch. However, in subbasins in higher latitudes, there may not be a clear elevation threshold. Therefore, further verification described below was completed.

Once delineated, district and forest biologists reviewed patch designations and made refinements based on stream temperature and presence of bull trout smaller than 150 mm. Patches were defined as areas generally not isolated from the larger subbasin by a yearlong barrier (physical, chemical, etc.) to fish movements and by water temperatures no higher than 15°C (7-day average summer maximum, MWMT). Recent analysis of stream temperatures and bull trout occurrence indicates juvenile bull trout are unlikely to be found in stream sites with maximum summer temperatures of 18-19°C (Dunham et al. 2003).

Observations used to define patch boundaries were also based on the more restricted movements of small (less than 150 mm) bull trout. Although some bull trout may exhibit seasonal movements from natal habitats to wintering or foraging areas (e.g. larger rivers, lakes or reservoirs), fidelity to the natal environments is likely during spawning and initial rearing. Because spawning salmonids home to natal streams and even reaches (Quinn 1993), occupied patches separated by thermally unsuitable habitat are likely to represent populations with some reproductive isolation. Other information (e.g. genetic, mark-recapture, radio-telemetry, etc.) may be collected over time to determine distinctiveness of the populations associated with the patches we define.

Classification of Patches and Stratification of Sampling

Once bull trout patches were identified, they were classified into four categories to further focus sampling efforts over the life of the forest plan (2003 – 2018). These categories included: (1) patches known to support a bull trout population (i.e., spawning and/or early rearing has been documented) as indicated by past surveys (within the last 7 years); (2) patches that have been surveyed and baseline conditions likely will support a bull trout population, but they have not been detected or patches where bull trout have been detected, but observations are older than 7 years; (3) patches that have been surveyed and baseline conditions (i.e., stream temperature, etc.) likely will not support a bull trout population and bull trout have not been detected (i.e. we assume these patches are unsuitable and unoccupied); and (4) patches that have not been surveyed.

Based on the 2013 update, there are 179 bull trout patches that occur within three basins (nine subbasins) on the Boise National Forest; 62 patches in strata 1; 54 patches in strata 2; 63 patches in strata 3; and 0 patches in strata 4 as of the end of the 2008 field season (Tables 1a & 1b).

Changes to Bull Trout Patches

Expansion, contraction, or shifting distributions of bull trout within patches are likely to be influenced by changing environmental conditions. Water temperature is one of the most significant habitat parameters for bull trout and therefore will be important when evaluating patch boundaries over time. All patches falling into strata 1 and 2, will be sampled for bull trout at least twice over the life of the forest plan (e.g. at least once within the first and second 7-year periods). In the year prior to sampling of a patch, at least one thermograph will be installed at the downstream patch boundary and at several other points upstream.

Annual temperature monitoring will also be conducted within specific patches in each strata (e.g. 1, 2, and 3) over the life of the forest plan. With this information we can examine natural variation in stream temperatures, evaluate whether patch boundaries should be changed (e.g.

elevated temperature due to an unusually hot summer) based on one year's monitoring, and determine if temperatures in select strata 3 patches are improving enough to justify future sampling for bull trout.

The thermograph data will also help us evaluate whether a patch is still suitable for bull trout (i.e., whether a strata 1 or 2 patch is actually strata 3 or whether the downstream (temperature-based) boundary of the patch is pushed upstream so far as to eliminate [because of the area criterion] the subject drainage from consideration as a patch). Thermograph data may also be used to determine if conditions within selected strata 3 patches have improved enough that the patch strata needs to be redefined to a strata 2.

Patch Sampling Frequency

How frequently a patch is sampled is dependent upon how many patches fall within each stratum and if some patches require more intensive sampling to establish presence or absence to the level of detection allowed by the methodology. All patches that fall within categories 1 or 2 will be sampled at least twice over the life to the forest plan (2003 – 2018), while patches that fall within stratum 3 will be sampled at least once.

Within the first half of the forest plan (2003-2009), all patches in strata 1, 2 and 4 would be prioritized for inventory. Patches in strata 1 would be sampled no later than 7 years from the last documented bull trout observation. For example, if bull trout were last documented in 1999, then the patch would need to be sampled again no later than 2006. Patches within strata 2 and 4 would also be surveyed to help establish bull trout presence or absence to the level of certainty allowed by the methodology.

Depending on the survey results, patches may be reclassified. For example, once all patches in stratum 4 are surveyed, they would be reclassified (e.g. 1, 2, or 3). Likewise, if no bull trout were found where previously observed (strata 1 patch), it would be reclassified. If bull trout were still present then the patch would remain in strata 1.

In the second half (2010-2016) of the forest plan, all patches in strata 1 and 2 would be sampled. Patches in stratum 3 (degraded baselines with high stream temperatures, high amount of fine sediment, etc.) would only be sampled if environmental conditions or limiting factors (e.g. culvert barrier removed) improved, increasing the likelihood that the patch might support bull trout or if a neighboring patch were colonized by bull trout.

Informal and Formal Surveys

To maximize effort and facilitate fieldwork, we plan to use a combination of informal and formal surveys. Informal surveys may use any fish sampling method, but if informal surveys fail to detect bull trout, formal surveys must be completed. Formal surveys will follow a consistent protocol, sampling intensity, sampling effort, etc. designed to estimate the probability that bull trout actually occur in a site or patch given that they are not detected (i.e. a false absence).

The sample design (delineation of patches and sample sites within patches) attempts to focus on habitat that has the highest probability of supporting bull trout. While this design increases the probability of detecting bull trout, it does not guarantee it. Determination of bull trout presence is

certain only when a bull trout is detected or captured (Peterson and Dunham 2002). Absence can never be certain (unless perhaps the stream is dewatered). Many patches within the Boise and Sawtooth National Forests are either believed to be unoccupied or have very low bull trout densities. If a species is not detected, then either it is truly absent or it is present but not detected during the survey. The goal is to sample in a way that allows the estimation of the probability of presence or absence in a patch given sampling effort and site characteristics that will influence the probability of detection when bull trout are actually present.

The general methods outlined by Peterson et al. (2002) or their extension by Peterson and Dunham (2003) will be used to estimate probability of bull trout presence in sampled patches. The probability of bull trout detection for each site will be estimated from Appendix 1, Table 3, in Peterson et al. 2002 or with empirical methods as discussed by Wintle et al. 2004. This protocol provides forest biologists with a pseudo-quantitative measure assessing the likelihood that sampling efforts were intensive enough to detect bull trout, assuming that they are present in the patch. If habitat conditions in a patch are known, biologists can determine the extent of sampling required to reach a predetermined level of confidence that bull trout are not present. In addition, calculating probabilities of detection following sampling efforts helps biologist to determine whether future sampling is necessary.

Selecting Sites within Patches

To focus sampling within a patch, only suitable habitat will be inventoried. Suitable habitat is defined according to wetted width (greater than 2 meters), stream gradient (less than 20%), water temperatures (15°C or less, 7-day average summer maximum, MWMT), and access (no natural or anthropogenic barriers). All suitable habitats in each patch that meet these criteria will be identified prior to surveying. For formal surveys, sites within each patch will be located by randomly selecting elevations within the extent of the suitable habitat. Randomizing sample sites within a patch will allow us to make conditioned inferences to all perennial streams greater than 2 meters within the patch.

Sampling within each site

Informal surveys will be done in all stratum 1 patches where bull trout have been found in the past; if bull trout are not found, formal surveys will be done. Formal sampling will be based on a standardized electrofishing method selected to maximize the probability of detection within a patch by balancing the effort within a site against the number of sites within a patch. The minimum formal sampling will consist of a 100 m double-pass transect with block nets. Additional electrofishing passes can be completed if an index of abundance, sampling efficiency data, or other information is desired. If juvenile bull trout (i.e., less than 150 mm) are found within any site, bull trout will be declared present within that patch. If bull trout are not detected in the first sample site, additional sites will be sampled in each patch until bull trout are detected, until a desired probability of detection in the patch is reached, or until maximum allowable effort given logistical constraints is reached, whichever comes first. Additional sites can also be surveyed to describe distribution within the patch.

Sampling sites within a patch will be 100 m in length. In models used by the Rocky Mountain Research Station, 100 m sites had slightly higher densities of bull trout; thus, detectability of bull trout is greater, assuming equal sampling efficiencies.

Results and Discussion

MIS monitoring for bull trout on the Boise N.F. occurred in 25 patches in 2013 (Figure 4a-4b and Table 1). Bull trout were detected in 9 out of the 25 patches surveyed this year. For the 16 patches sampled in 2013 where no bull trout were captured, probability of patch occupancy ranged from 0.38-0.255 (Table 2). The probability of detection calculations do not include sites where no fish were detected above natural barriers. The probability of detection estimates are based on equations from Peterson et al. (2002) and observed detection rates from 101 single-pass electrofishing sites and 76 multiple-pass electrofishing sites sampled on the Boise N.F. during 2004-2006. Follow up visits in 2013 to strata 1, occupied by juvenile bull trout, sites used previously known sample locations to increase the possibility of encountering bull trout and are not selected randomly. Detection rates in 2013 where no bull trout were captured were based on observed detection rates from 2004-2006.

North Fork / Middle Fork Boise subbasin

In the N.F./M.F. Boise subbasin, eleven patches were surveyed(Big five Creek, China Fork Creek, Cottonwood Creek, Phifer Creek, Queens River, Roaring River, Bear Creek, Crooked River, Trail Creek, Bear River, Yuba River). Juvenile bull trout were detected in Queens River, Roaring River, Crooked River and Bear River, previously strata 1 , maintaining them as strata 1 occupied by juvenile bull trout. Yuba River was a stratum 1, occupied by juvenile bull trout, no bull trout were captured. There were not enough surveys completed to change the strata. More surveys will need to be conducted on the Yuba River patch to reach probabilities of detection high enough to support changing strata. Bear Creek, previously strata 1, juvenile bull trout detected, changed to a stratum 2, suitable habitat conditions but bull trout were undetected in 2012 with 6 surveys and in 2013 with 3 surveys. Big Five Creek, China Fork Creek, Cottonwood Creek each strata 2 suitable habitat conditions exist but bull trout were undetected, had only rainbow trout captured in the 2013 surveys.

Boise-Mores subbasin

One patch was surveyed in the Boise-Mores subbasin in 2013 (Clear Creek). Rainbow trout and brook trout were the only fish captured in the Clear Creek surveys.

South Fork Boise subbasin

Four patches in the S.F. Boise subbasin were surveyed in 2013 (Rattlesnake Creek, Parks Creek, S.F. Deer, and Aden Creek). Juvenile bull trout were detected in Rattlesnake Creek previously strata 1, maintaining it as strata 1 occupied by juvenile bull trout. Parks Creek was a strata 1 occupied juvenile bull trout in 2005. During the MIS sampling in 2011 with 5 informal surveys and in 2012 with 3 formal surveys and 3 informal surveys, and 3 formal surveys in 2013, no bull trout were captured in the Parks Creek patch changing the patch designation from a strata 1 occupied by juvenile bull trout to strata 2 suitable habitat conditions exist but bull trout were undetected. S.F. Deer Creek was a strata 2 suitable habitat conditions exist but bull trout were undetected. S.F. Deer Creek will remain a stratum 2 after 2013 surveys. Aden Creek was a stratum 2, suitable habitat conditions exist but bull trout were undetected but changed to a stratum 3, unsuitable habitat, after the 2013 surveys where no fish were captured in 3 separate formal surveys and wetted widths were determined to be less than 2 meters wide failing to meet the 2m minimum width criterion.

South Fork Payette subbasin

During 2013, six bull trout patches were sampled in the S.F. Payette subbasin (Bear Creek, Box Canyon Creek, E.F. Eightmile Creek, W.F. Eightmile Creek, Whitehawk Creek and Wilson Creek,). In 2013 no bull trout were captured in any of the patches surveyed in the South Fork of the Payette River. Bear Creek and W.F. Eight mile Creek were strata 3 unsuitable for bull trout before the 2013 sampling and will remain strata 3, unsuitable for bull trout. Box Canyon Creek was a strata 2, suitable habitat exists but no bull trout were captured, changed to a strata 3, unsuitable for bull trout, based on a geologic fish barrier that was documented at 1670 meters in elevation. E.F. Eightmile Creek, Whitehawk Creek and Wilson Creek were each strata 2, suitable habitat exists but no bull trout were captured, prior to 2013 surveys and will remain strata 2, suitable habitat exists but no bull trout were captured. Rainbow trout were the only salmonids captured in the S.F. Payette surveys.

Middle Fork Payette subbasin

No surveys took place in the Middle Fork of the Payette River subbasin during the 2103 field season.

North Fork Payette subbasin

No sampling occurred in the N. F. Payette subbasin during the 2103 field season.

Payette subbasin

No sampling occurred in the Payette subbasin during the 2103 field season.

Middle Fork Salmon

One patch was surveyed in the Middle Fork of the Salmon River subbasin in 2013. Fir Creek had one survey completed in 2013. Fifteen bull trout X brook trout hybrids were captured and no pure bull trout were captured. More surveys will have to be completed before any patch designation changes can be made. Fir Creek patch will remain a stratum 1, occupied by juvenile bull trout.

South Fork Salmon

Three patches were surveyed in the South Fork Salmon subbasin in 2013 (Warm Lake Creek, Trapper Creek and Bear Creek).Trapper Creek was previously strata 1 occupied by juvenile bull trout. Trapper Creek had juvenile bull trout captured in the 2013 surveys and will remain a strata 1 occupied by juvenile bull trout. Warm Lake Creek was previously a stratum 3, unsuitable habitat conditions exist. 2008 surveys had only brook trout in the samples. In the 2013 surveys, 1 juvenile bull trout and 2 bull trout/brook trout hybrids were captured in Warm Lake Creek changing its designation to strata 1, occupied by juvenile bull trout. Bear Creek was a stratum 2, suitable habitat exists but no bull trout were captured. After the 2013 surveys no fish were captured and a geologic barrier was discovered at 1686 meters in elevation preventing fish access to the upper reaches. Bear Creek will change to a stratum 3, unsuitable habitat conditions exist.

Bull Trout Detection

Juvenile bull trout (<150 mm) were detected in 8 of the 24 patches sampled on the Boise National Forest in 2013. Juvenile bull trout were detected at the first sample site in 8 of the 8 patches that juvenile bull trout were observed. At 7 of 8 sites where juvenile bull trout were detected, they were observed during the first electrofishing pass. Follow up visits in 2013 to strata 1, occupied by juvenile bull trout, sites used previously known sample locations to increase the possibility of encountering juvenile bull trout and are not selected randomly. In 2013 strata 2, suitable bull trout habitat exists but bull trout are undetected, were selected randomly within the patch. Of the 12 strata 2 sites surveyed in 2013 Warm Lake Creek and Phifer Creek were the only patches that had juvenile bull trout captured in the 2013 surveys.

Patch Stream Temperature Monitoring

Monitoring stream temperatures allows forest biologists to assess the influence of management practices on water temperatures (Meehan 1991), predict species distributions (Dunham 2003), and update MIS patch strata. As such, stream temperature monitoring plays a critical role in this aquatic MIS approach. Because maximum water temperatures on the Boise N.F. tend to occur between mid-July and mid-September (Boise NF unpublished data), water temperature loggers are deployed in early summer (June) and recovered in early fall (after Sept 1). Gamett (2002) found that mean water temperature (July 1 to September 30) appeared to be the most effective in describing bull trout abundance in the Little Lost drainage. Maximum daily maximum temperature (MDMT) and maximum weekly maximum temperature (MWMT, the mean of daily maximum water temperatures measured over the warmest consecutive seven-day period) were calculated for each patch and provide important information for managers when classifying patches into strata or assessing the presence or absence of bull trout. Dunham (2003) found that the probability of bull trout occurrence was relatively high (>0.50) in streams with a maximum daily maximum temperature (MDMT, the warmest daily water temperature recorded during a given year or survey) <14-16° C.

Factors other than water temperatures (i.e. groundwater inputs, over-wintering habitat, and habitat connectivity) are also likely influencing bull trout distribution. The perceived absence of bull trout could be related to other factors including passage barriers and sampling error. It is likely that a larger sample size of patches is needed before associations between bull trout occurrence and stream temperature can be better defined.

Rocky Mountain Research Station (RMRS) in Boise and Pacfish Infish Biological Opinion Effectiveness Monitoring Program (PIBO/EMP) have provided an abundance of stream temperature information that is relative to the BNF MIS program. Using the RMRS sentinel stream temperature database and PIBO/EMP stream temperature database has reduced the total number of stream temperature probes that the BNF MIS has to deploy and retrieve. There is still the need to place stream temperature probes in specific locations within patches to discern the temperature effects of stream inputs higher in patches while still maintaining 500 hectares of watershed drainage.

During 2013, the Boise N.F. crew deployed temperature loggers at the lowest elevation in the patch (usually 1600m) and at other various elevations within certain patches. Fourteen temperature loggers in fourteen patches were deployed on the Boise N.F (Figures 5a-b). A total

of 13 were retrieved at the end of the field season. One temperature logger malfunctioned possibly due to static electricity. Bear Creek NFB had a temperature probe deployed in 2013 after changing from a strata 1, occupied by juvenile bull trout to a strata 2, suitable habitat but no bull trout detections in 2012 or 2013. The summary data indicate an MWMT of 16.6°C and 29 days where the temperature exceeded 15.5°C. Rammage Meadows had a temperature probe deployed in 2012 and 2013 after changing from a stratum 1, occupied by juvenile bull trout to a stratum 2, suitable habitat but no bull trout detections in 2011. The summary data indicate an MWMT of 19.83°C and 24 days in excess of 19°C. The summary data from these sites are presented in Figures 1.

Barriers

MIS results will also help managers assess the influence of fish passage barriers on bull trout populations. Passage barriers can have a strong influence upon species distributions as well as the life-history expression of fish populations. Several of the patches sampled during 2013 contained barriers that could influence the presence or persistence of bull trout.

Fish passage barriers can provide positive or negative influences on bull trout populations, depending upon a variety of factors, including the presence of exotic species, the size of the isolated population, habitat conditions above and below the barrier, etc. Further MIS monitoring will assist in the evaluation of the influence of barriers on the persistence of bull trout populations on the Boise N.F.

The U.S. Bureau of Reclamation supported studies of adult migratory bull trout from Arrowrock Reservoir in 1996 and 1997 (Flatter 1998) and from the Middle and North Fork Boise rivers in 2001 through 2003 (Monnot et al. 2008, Salow and Hostettler 2004). Radio-tagged adults captured in the reservoir and at weirs on the Middle and North Forks were tracked on the ground and using aircraft. The data from these studies are voluminous, but some of the key points of the research are 1) the adults migrated upstream from the reservoir as early as March but by mid-June, entered tributaries between late July and early August. Adults reaching tributaries in July find barriers to passage that might be passable to rainbow trout earlier in the year with higher flows. Other barriers restrict passage to all fish. The summary information on barriers can be seen in Figure 2.

Hybridization

MIS monitoring detected a variety of game and non-game species across the Boise N.F. (Table 3) including brook trout (*Salvelinus fontinalis*), a species known to hybridize with bull trout (Markle 1992, Leary et al. 1993). Warm lake Creek and Fir Creek had bull trout/brook trout hybrids phenotypically confirmed in the 2013 surveys. During the 2013 sampling season, two patches were found to have both bull trout and brook trout (Bear River NFB and Warm Lake Creek. 12 patches that have had phenotypically identified bull trout / brook trout hybrids include Lodgepole Creek SFS, Warm Lake Creek, Baron Creek, Crooked River, Bear River NFB, Bear Creek NFB, Bearskin Creek, Rice Creek, Wyoming Creek, Bear Valley Creek, Elk Meadows Creek and Fir Creek. DNA studies have been done in the past by the USBR showing a high percentage (29%) of bull trout were actually hybrids in Bear Creek NFB (Whiteley et al. 2003).

Recent research indicates that bull trout/brook trout F1 generation hybrids can reproduce, though less successfully than pure crosses between parent species (Kanda et al 2002). Bull trout hybridization with *S. fontinalis* is recognized as a major threat to the persistence of bull trout, largely as a result of population-scale wasted reproductive effort and genetic introgression (Markle 1992, Leary et al. 1993, Kanda et al. 2002).

Strata Changes

A variety of factors influences the distribution of bull trout populations across the Boise National Forest. As has been reported in the literature, results from our MIS sampling indicate that patch size, stream temperature, patch connectivity, habitat condition, and the occurrence of brook trout can all influence the presence or absence of reproducing bull trout populations. Information collected over the past ten years has better defined bull trout distributions within patches and across each subbasin. At the subbasin scale it appears bull trout local populations have remained stable since 2003. We have also found more occupied patches than previously thought. However, this doesn't imply bull trout have expanded their range only that we have confirmed their presence in streams that likely supported them all along. Still, the data indicates that bull trout presence is more robust than previously thought.

Strata changes that have the most importance to the MIS monitoring are changes from strata 1, occupied by juvenile bull trout to strata 2 suitable habitat but undetected juvenile bull trout. As the CFR states, "Population trends of the management indicator species will be monitored and relationships to habitat changes determined." In the case where a stratum 1 patch was known to occupy juvenile bull trout then in subsequent surveys juvenile bull trout are undetected and the patch designation changes to a strata 2, suitable habitat but bull trout were undetected, relationships to habitat changes need to be addressed individually with the best available scientific information.

Bear Creek NFB changed from a stratum 1, occupied by juvenile bull trout, to strata 2, suitable habitat but bull trout undetected. In 2012 Bear Creek NFB had 3 formal surveys and 3 informal surveys with no bull trout detections. In 2013 the MIS crew returned to Bear Creek NFB and conducted 3 formal and 1 informal surveys with no bull trout detections. Brook trout were captured in 3 of the six formal surveys on Bear Creek NFB in 2012. DNA studies have been done in the past by the United States Bureau of Reclamation showing a high percentage (29%) of bull trout were actually hybrids in Bear Creek NFB (Whiteley et al. 2003). Brook trout/bull trout hybrids were phenotypically identified in the 2012 surveys on Bear Creek. Stream temperature data on Bear Creek NFB include datasets for summer maximum temperature profiles from 1994, 2000 and 2013. The temperature data as it relates to bull trout is best summarized by using Maximum Weekly Maximum Temperatures (MWMT) and days exceeding 15.5 °C. MWMT for the 1994 dataset was 15.21 °C and within the range of bull trout tolerances. The 2000 temperature data had MWMT at 19.86 °C which is above the known tolerance for bull trout. The 2013 dataset had MWMT at 16.6 °C with 29 days exceeding 15.5°C. The stream temperature data suggests that conditions exists that violate bull trout temperature requirements. Bear Creek NFB is fed by Jennie Lake at the headwaters and has a surface outflow.

Parks Creek SFB changed from a stratum 1, occupied by juvenile bull trout to a strata 2, suitable habitat and undetected bull trout with 4 informal surveys in 2011 and 4 formal surveys in 2012 and 3 more formal surveys in 2013. The one and only bull trout observed in Parks Creek patch

was in 2005 at the confluence with Trinity Creek and < 30m from the downstream boundary with the Trinity Creek patch. The two patches almost touch each other at the confluence of the two rivers. The observed bull trout from Parks Creek patch in 2005 was likely a part of the Trinity Creek patch.

Phifer Creek MFB was a stratum 3 and changed to a stratum 1 after 2013 surveys. Phifer Creek had been surveyed in 2005 with no fish being detected. In 2013 in an attempt to identify the exact location of the barrier, the MIS fish crew captured all life stages of bull trout. There is a culvert blocking upstream access to the occupied reach on Phifer Creek. Juvenile bull trout were captured above and below the culvert.

Other strata changes were made by the use of information from the geologic fish barrier data being collected by the MIS fish crew. Most of these changes are from strata 2, suitable habitat but no bull trout detections, to strata 3, unsuitable habitat, from inaccessibility. Where possible electrofishing surveys above and below possible geologic fish barriers were conducted to validate the determination of fish barriers. East Fork of Stevens Creek SFP, Box Canyon SFP, Bear Creek SFS and Aden Creek SFB changed from strata 2 suitable habitat but no bull trout detections, to strata 3, unsuitable habitat, based on geologic fish barrier information.

References

Bayley, P. B., and D. C. Dowling. 1993. The effects of habitat in biasing fish abundance and species richness estimates when using various sampling methods in streams. Polskie Archiwum Hydrobiologii 40: 5-14.

Bonar, S.A., M. Divens, and B. Bolding. 1997. Methods for sampling the distribution and abundance of bull trout/ dolly varden. Research Report RAD97-05. Washington Department of Fish and Wildlife, Olympia, Washington.

Dunham, J., B. Rieman and G. Chandler. 2003. Influences of temperature and environmental variables on the distribution of bull trout within streams at the southern margin of its range. North American Journal of Fisheries Management 23:894-904.

Dunham, J.B., and B.E. Rieman, 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

Dunham, J.B., Rieman, B.E., and Davis, K. (2001). Sources and magnitude of sampling error in redd counts for bull trout. North American Journal of Fisheries Management. 21:343-352.

Fausch, K. D., C. L. Hawkes, and M. G. Parsons. 1988. Models that predict standing crop of stream fish from habitat variables: 1950-1985. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-213, Portland, Oregon.

Gamett, B. L. 2002. The relationship between water temperature and bull trout distribution and abundance. Master's thesis. Utah State University, Logan.

He F., and K.J, Gaston. 2000. Estimating species abundance from occurrence. American Naturalist. 156: 533-559.

Kanda, N., R.F. Leary, and F.W. Allendorf. 2002. Evidence of introgressive hybridization between bull trout and brook trout. Transactions of the American Fisheries Society. 131:772-782.

Kunin, W.E., S. Hartley, and J.J. Lennon. 2000. Scaling down: on the challenge of estimating abundance from occurrence patterns. The American Naturalist. 156:560-566.

Leary, R.B., F.W. Allendorf, and S.H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath River drainages. Conservation Biology 7:856-865.

Markle, D.F. 1992. Evidence of bull trout x brook trout hybrids in Oregon. Pages 58-67 *in* P.J. Howell and D.V. Buchanan, editors. Proceeding of the Gearhart Mountain bull trout workshop. American Fisheries Society, Oregon Chapter, Corvallis.

Maxell. 1999: A Power Analysis on the Monitoring of Bull Trout Stocks Using Redd Counts. North American Journal of Fisheries Management: Vol. 19, No. 3, pp. 860–866.

Meehan, W.R., ed., 1991, Influences of forest and rangeland management on salmonid fishes and their habitats, Special Publication 19, Bethesda, MD: American Fisheries Society, 751 p.

Partridge, F., K. Frank, and C. Warren. 2000. Southwest Idaho bull trout restoration (South Fork Boise River) completion report. Idaho Department of Fish and Game, Threatened and Endangered species report, Project E-21-1, Section 6, Endangered Species Act, August 2000.

Peterson et al. 2004. An Evaluation of Multipass Electrofishing for Estimating the Abundance of Stream-Dwelling Salmonids. Transactions of the American Fisheries Society 133:462–475, 2004

Peterson, J. T. and Dunham, J.B. 2002. Combining Inferences from Models of Capture Efficiency, Detectability, and Suitable Habitat to Classify Landscapes for Conservation of Threatened Bull Trout. Conservation Biology, Pages 1070–1077, Volume 17, No. 4.

Peterson, J., J. Dunham, P. Howell, R. Thurow, and S. Bonar. 2002. Protocol for detecting bull trout presence. Western Division of the American Fisheries Society. Available at http://www.fisheries.org/wd/committee/bull_trout/bull_trout_committee.htm (accessed 26 August 2002).

Peterson, JT., Banish, N.P, and Thurow, R.T. In Press. Are blocknets necessary ? Movements of stream-dwelling salmonids in response to three common survey methods.

Platts, W.S. and R.L. Nelson, 1988, Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8:333-345.

Poole, G., J. Dunham, M. Hicks, D. Keenan, J. Lockwood, E. Materna, D. McCullough, C. Mebane, J. Risley, S. Sauter, S. Spalding, and D. Sturdevant. 2001. Scientific issues relating

to temperature criteria for salmon, trout, and charr native to the Pacific Northwest. U.S. Environmental Protection Agency, EPA 910-R-01-007, Seattle.

Quinn, T. P. 1993. A review of homing and straying of wild and hatchery produced salmon. Fisheries Research 18:29-44.

Rich, C. F. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. Master's thesis, Montana State University.

Rieman, B. E., and G. L. Chandler. 1999. Empirical evaluation of temperature effects on bull trout distribution in the Pacific Northwest. Final report to U. S. Environmental Protection Agency, Boise, ID.

Rieman, Bruce E. and John D. McIntyre, 1995, Occurrence of Bull Trout in Naturally Fragmented Habitat Patches of Varied Sizes, *Transactions of the American Fisheries Society*, Vol. 124, No. 3, pp. 285-296.

Riley, S. R. Haedrich and R. Gibson. 1993. Negative bias in removal estimates of Atlantic salmon parr relative to stream size. Journal of Freshwater Ecology 8: 97-101.

Royle, J.A. and J.D. Nichols. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology. 84 (3): 777-790.

Salow, T. and L. Hostettler. 2004. Movement and Mortality Patterns of Adult Adfluvial Bull Trout (Salvelinus confluentus) in the Boise River Basin, Idaho. Summary report submitted to the Arrowrock Bull Trout Advisory Group, U.S. Bureau of Reclamation, Snake River Area Office, Boise , Idaho.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, New York.

Watson, G and T.W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: an investigation at hierarchical scales. North American Journal of Fisheries Management 17:237-246.

Wintle, B. A., M. A. McCarthy, K. M. Parris, and M. A. Burgman. 2004. Precision and bias of methods for estimating point survey detection probabilities. Ecological Applications. 14(3):703-712.

Whiteley, A. R., P. Spruell, and F. W. Allendorf. 2003 Population Genetics of Boise Basin Bull Trout (*Salvlinus confluentus).* Final Report to United States Bureau of Reclamation Contract 1425-01FG107420.

Figure 1. Water Temperature (°C) Monitoring Results for the BNF MIS 2013.

Stream	Basin	Ele (m)	Days	Deployed	Retrived	MWMT	Max	Avg	D>12	D>13	D>15	D>15.5	D>19	D>22
W.F.Eightmile Creek	SFP	1600	91	6/19/13	9/17/13	17.33	18.27	12.03	84	82	59	43	0	0
Rock Creek	SFP	1592	96	6/13/13	9/16/13	14.89	15.92	10.60	72	35	3	1	0	0
Hayfork Creek	BM	1599	96	6/13/13	9/18/13	15.13	16.08	11.48	76	47	5	3	0	0
Boundry Creek	MFS	1784	96	6/20/13	9/23/13	18.51	19.65	12.16	84	80	57	53	2	0
Squaw Creek	PS	1600	237	1/1/13	8/25/13	16.50	17.53	5.16	66	60	43	34	0	0
Rammage Meadows	PS	1609	237	1/1/13	8/25/13	19.83	20.29	5.38	66	63	59	58	24	0
Summit Creek	NFB	1600	91	6/13/13	9/16/13	13.92	14.8	10.47	53	14	0	0	0	0
Little Beaver Creek	NFB	1593	96	6/13/13	9/16/13	16.48	17.6	11.61	81	61	14	8	0	0
Cottonwood Creek	MFB	1598	84	6/18/13	9/9/13	17.36	18.5	13.24	77	77	57	51	0	0
Bear Creek SFP	SFP	1699	90	6/20/13	9/17/13	17.23	18.5	11.32	83	80	50	40	0	0
hird Fork Squaw Cree	PS	1600	237	1/1/13	8/25/13	16.93	17.5	5.22	70	61	49	41	0	0
Renwyck Creek	PS	1606	239	1/1/13	8/27/13	16.08	17.1	4.98	71	61	15	8	0	0
Bear Creek NFB	NFB	1609	91	6/20/13	9/18/13	16.60	17.7	12.22	83	81	49	29	0	0

Figure 2. Barriers excluding or limiting bull trout access.

STREAM NAME	DISTRICT	DRAINAGE	ELE(m)	TYPE	SURVEYS ABOVE	COMMENTS
Bad Bear	ICRD	BM	1592	Geologic	Yes	GIS Gradient + GIS
Bear Creek SFS	CRD	SFS	1686	Geologic	Yes	30% Gradient: Used ARCMAP gradient layer. Could be lower in drainage.
Beaver Creek	LRD	DWR	1649	Geologic	Yes	
Bulldog	ERD	MFP	1152	Geologic	Yes	Used gradient: rough terrain not actually seen.
Dog Creek	MHRD	SFB	1705	Geologic	Yes	Barrier to sculpin: Rainbows present, probably planted upstream from trail.
Dollar	CRD	SFS	1686	Geologic	Yes	10 meter Waterfall
EF Stevens	LRD	DWR	1584	Geologic	Yes	GIS 25.6%: multiple sections.
EF Swanholm	ICRD	MFB	1600	Culvert	Yes	Culvert tag# 227A 0.3: Rainbow Trout Above:
Granite Creek	ICRD	MFB	1414	Geologic	Yes	No fish above, Gradient 27%
Green Creek	MHRD	SFB	1658	Geologic	Yes	GIS 20%: Visual observations. Spot shocking
Hot	ICRD	MFB	1394	Geologic	Yes	No fish in 4 efish sites upstream. Could be higher in drainage.
Hunter Creek	ICRD	NFB	1707	Geologic	Yes	No fish above, Gradient 23%
Johnson Creek	CRD	SFS	1786	Geologic		No Chinook or Bull trout above 21.56% gradient.
Lake Creek	ICRD	MFB	1429	Geologic	Yes	47% gradient: Cutthroat trout coming from lake upstream
Lightning	ERD	MFP	1600	Geologic	Yes	Waterfall @5 meters high
Little Camas Creek	MHRD	SFB	1506	Manmade	No	Little Camas Reservoir
Logging Gulch	ICRD	MFB	1373	Geologic	Yes	Multiple possible gradient barriers from the confluence with MFB to Patch lower boundary
Long Fork Silver	ERD	MFP	1620	Geologic	Yes	10 meter Waterfall
Loosum	CRD	SFS	1550	Geologic	Yes	Channel has moved: Stream bed unstable.
Lorenzo	LRD	DWR	1646	Geologic	Yes	34% gradient. Barrier could be lower
McDonald	LRD	SFP	1513	Geologic	Yes	Could be lower down: 2 other possible locations
Meadow Creek	ICRD	NFB	1176	Geologic	Yes	Numerous high gradient sections above NFB confluence. Only Brook Trout above
MF Big Pine Creek	ERD	SFB	1620	Geologic	Yes	Confirmed by MIS Fish crew 2013
NF Dollar	CRD	SFS	1654	Geologic	Yes	Might be lower down but not much
No Man	LRD	DWR	1574	Geologic	Yes	Might be a barrier to just bull trout. 21% gradient over bedrock.
Onion	ERD	MFP	1594	Geologic	Yes	Waterfall @10 meters high
Phifer	ICRD	MFB	1676	Geologic	Yes	2013, All bull trout life stages present below barrier. End of fish.
Rattlesnake Creek	ERD	MFP	1315	Geologic	Yes	360m of 40%to 55% gradient. IDFG site #1989 above No Fish
Renwyck	ERD	PS	1588	Geologic	Yes	#1 Barrier to Bull Trout: 15% Gradient
Renwyck	ERD	PS	1725	Geologic	Yes	#2 Barrier to Rainbow Trout: End of Fish 17% Gradient
Roaring Creek	CRD	SFS	1550	Geologic	No	33% Gradient
Sams Creek	LRD	DWR	1622	Geologic	Yes	24% gradient for @ 135 meters.
Smith	MHRD	SFB	1125	Geologic	Yes	
Trail Creek	SNF	SFP	1730	Geologic	Yes	Barrier to bull trout may be lower down. 21% for @ 90 m. at N. 4890557 E. 648227:
Wardenhoff Creek	CRD	SFS	1594	Geologic	Yes	Several 56% gradient segments. Fish are coming from transplants upstream.
WF Eightmile	LRD	SFP	1668	Geologic	Yes	Waterfall @ 15m drop, no fish above:

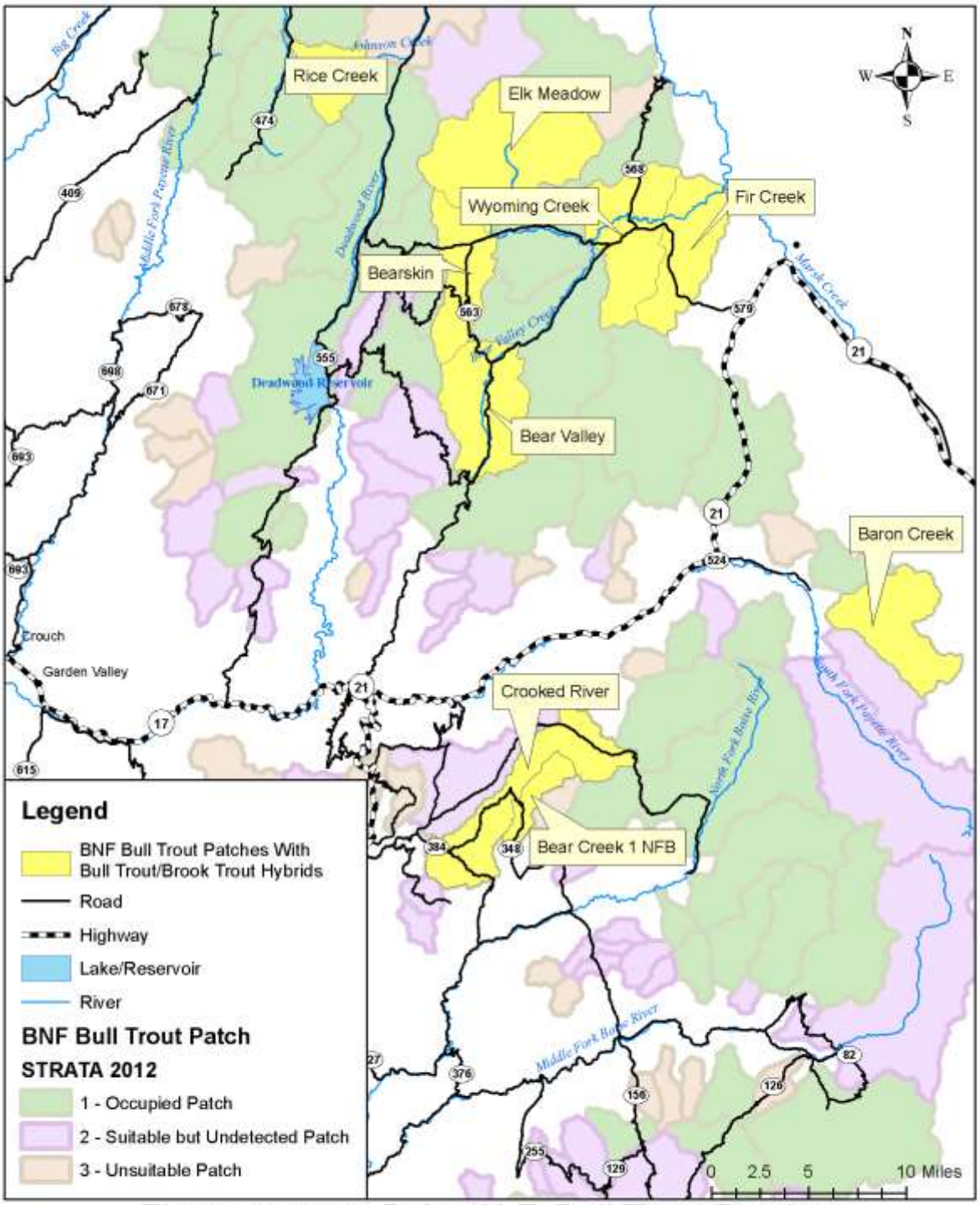


Figure 3, 2012 Boise N.F. Bull Trout Patches With Bull Trout /Brook Trout Hybrids Ralph Mitchell 1/27/2013

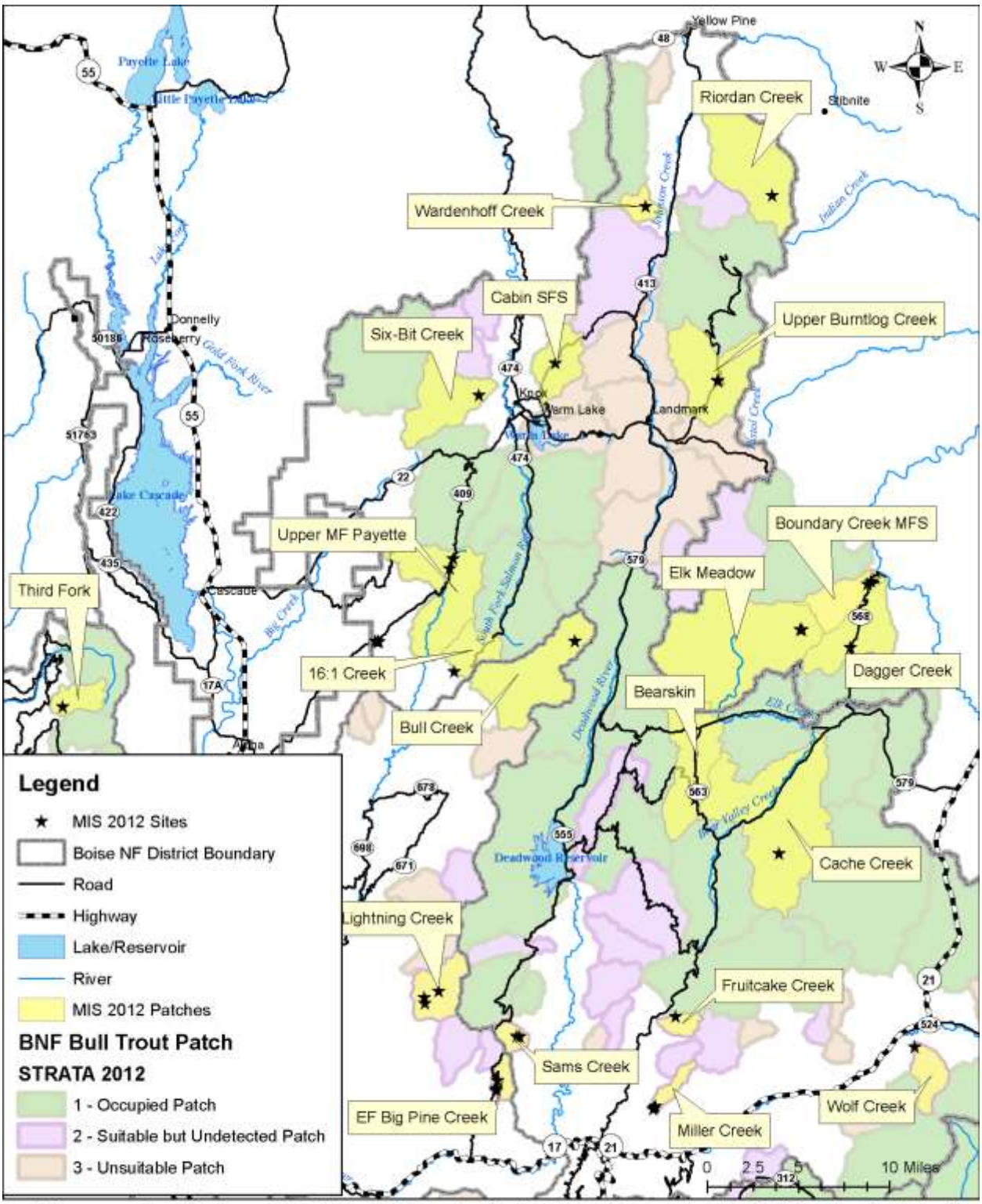


Figure 4a Boise N.F. Bull Trout Patches Sampled 2012 North Half

Ralph Mitchell 1/27/2013

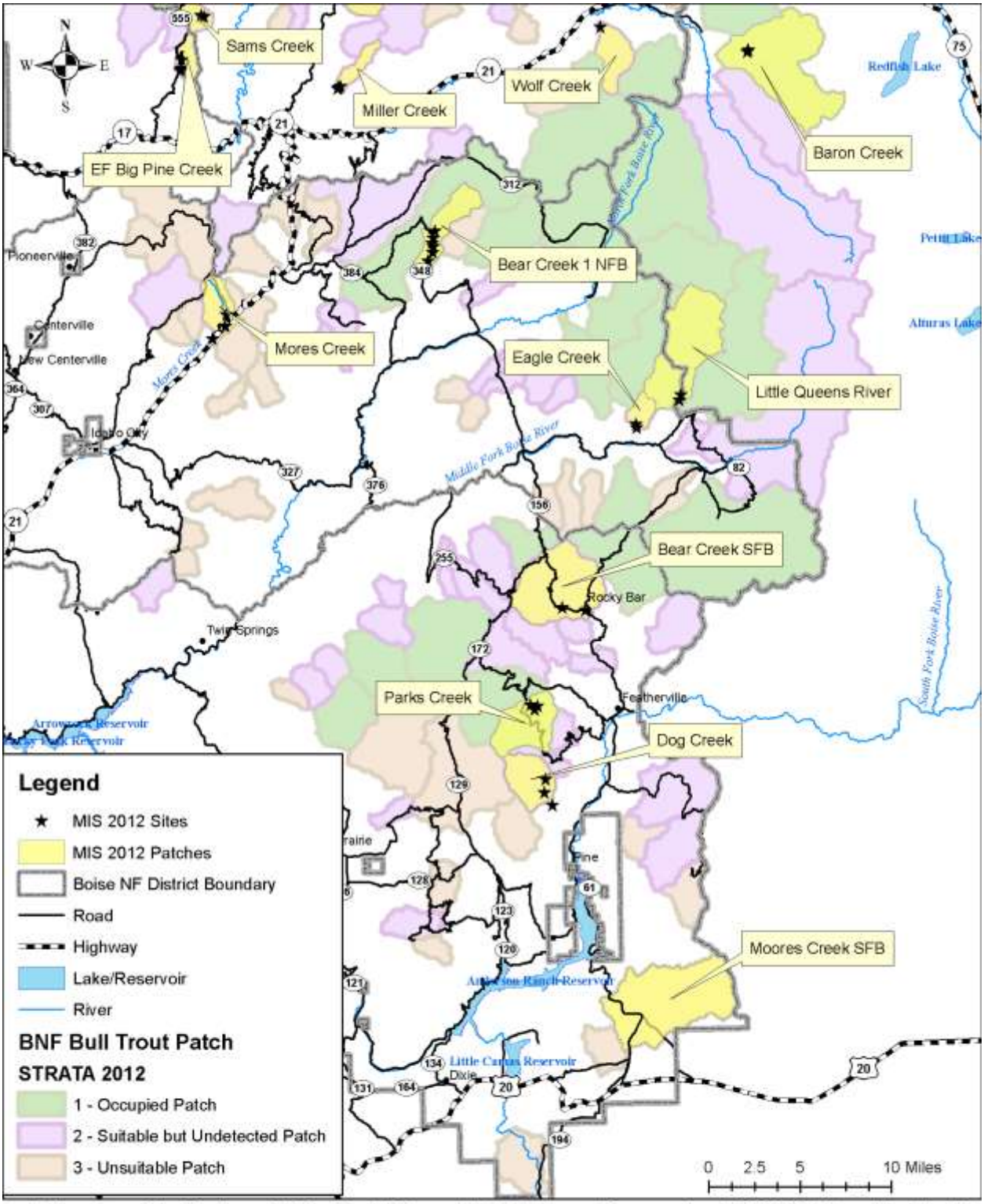


Figure 4b Boise N.F. Bull Trout Patches Sampled 2012 South Half

Ralph Mitchell 1/27/2013

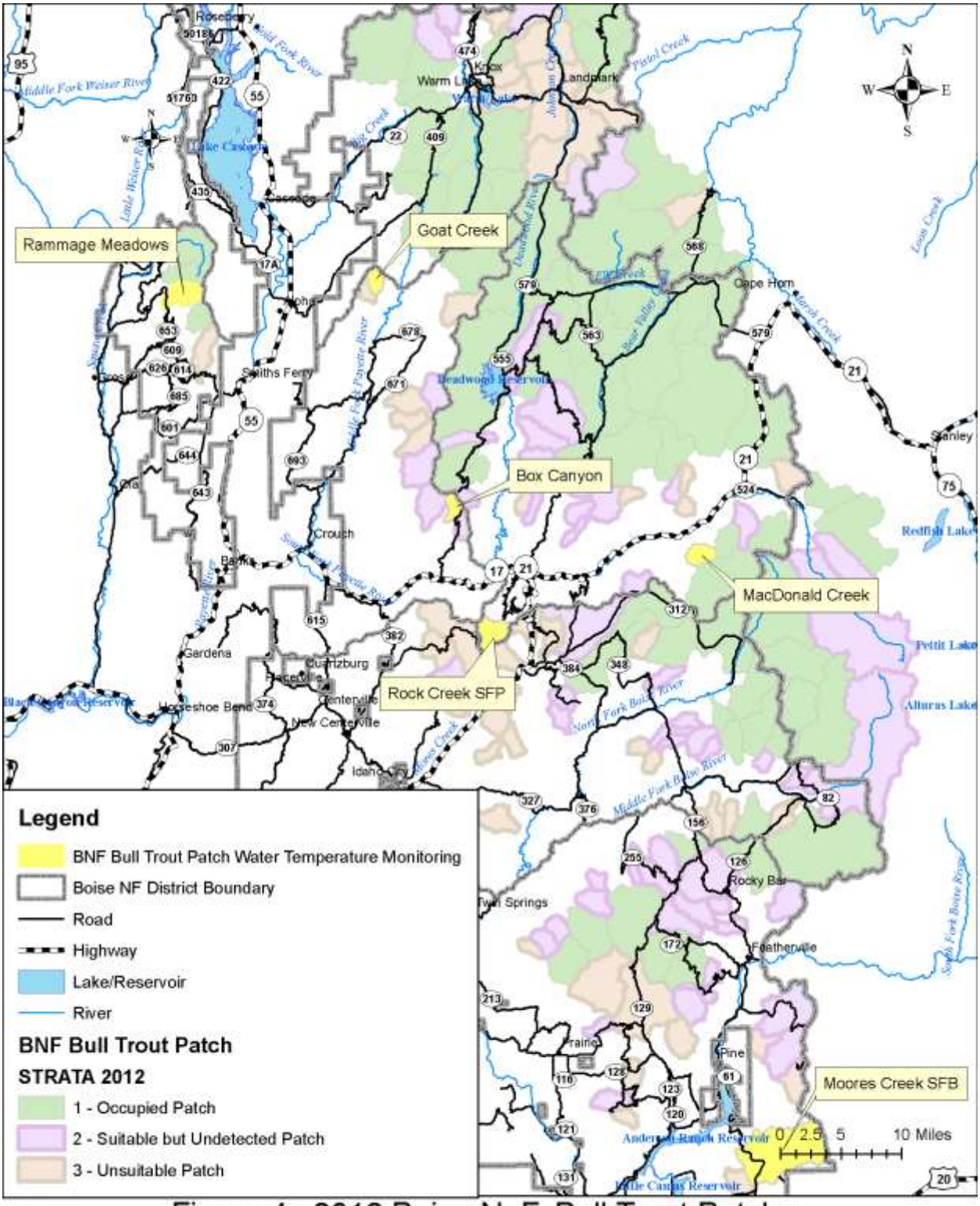


Figure 4c 2012 Boise N. F. Bull Trout Patches
Stream Temperature Monitoring

Ralph Mitchell 1/26/2013

Table 1a. Number of bull trout patches on the Boise National Forest within each basin by strata based on 2013 update.

Stratum	Boise Basin		Payette Basin		Salmon Basin		Forest Total	
	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed
1	18	5	22	0	20	1	60	6
2	34	7	23	4	5	1	62	12
3	34	3	13	2	10	1	57	6
4	0	0	0	0	0	0	0	0
Total	**86**	15	**58**	6	**35**	3	**179**	24

Table 1b. Number of bull trout patches within the Boise basin.

Stratum	S.F. Boise Subbasin		N.F. and M.F. Boise Subbasin		Boise Mores Subbasin		Boise Basin Total	
	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed
1	4	1	13	4	1	0	18	5
2	13	3	16	4	5	0	34	7
3	10	0	16	2	8	1	34	3
4	0	0	0	0	0	0	0	0
Total	**27**	4	**45**	10	**14**	1	**86**	15

Table 1c. Number of bull trout patches within the Payette basin.

Stratum	S.F. Payette Subbasin		Middle Fork Payette Subbasin		Payette (Squaw Creek) Subbasin		North Fork Payette Subbasin		Payette Basin Total	
	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed
1	15	0	3	0	3	0	1	0	22	0
2	19	4	3	0	1	0	0	0	23	4
3	6	2	6	0	1	0	0	0	13	2
4	0	0	1	0	0	0	0	0	0	0
Total	**40**	6	**12**	0	**5**	0	**1**	0	**58**	6

Table 1d. Number of bull trout patches within the Salmon basin.

Stratum	South Fork Salmon Subbasin		Middle Fork Salmon Subbasin		Salmon Basin Total	
	Patches	Surveyed	Patches	Surveyed	Patches	Surveyed
1	11	1	9	0	20	1
2	4	1	1	0	5	1
3	9	1	1	0	10	1
4	0	0	0	0	0	0
Total	**24**	3	**11**	0	**35**	3

Table 2. Summary of results from 2012 aquatic MIS sampling on the Boise N.F.

Subbasin	Patch Name	Category (2012)	Patch Size (ha)	Sampling Method (#of sites)	Bull Trout Detected	Probability of Occupancy Given No Detection*	# Sites where Bull Trout < 150mm were found	Electrofish Site when Bull Trout were First Detected	Electrofish Pass when Bull Trout were First Detected
S.F. Payette	Baron	1	5735	1-pass (2)	Yes	N/A	2	1	1
N.F. Boise	Bear Creek	2	1554	Depletion (3)	No	0.038	0	-	-
S.F.Boise	Bear Creek	1	4191	Depletion (3)	Yes	N/A	1	1	1
M.F. Salmon	Bearskin	1	4549	Depletion (1)	Yes	N/A	1	1	1
M.F. Salmon	Boundary Creek	2	1841	Depletion (2)	No	0.255	0	-	-
M.F. Payette	Bull Creek	1	5264	1-pass (1)	Yes	N/A	1	1	1
S.F. Salmon	Cabin Creek	1	1951	Depletion (1)	Yes	N/A	1	1	1
M.F. Salmon	Cache Creek	1	10349	Depletion (1)	Yes	N/A	1	1	1
M.F. Salmon	Dagger Creek	1	3239	Depletion (1)	Yes	N/A	1	1	1
S.F. Boise	Dog	2	1597	Depletion (3)	No	0.760	0	-	-
S.F. Payette	E.F. Big Pine	2	624	Depletion (3)	No	0.190	0	-	-
M. F. Boise	Eagle	2	522	Depletion (2)	No	0.100	0	-	-
M.F. Salmon	Elk Meadows	1	10571	Depletion (2)	Yes	N/A	2	1	1
S.F. Payette	Fruitcake	2	556	Depletion (1)	No	0.255	0	-	-
M.F. Payette	Lightning	3	2032	Depletion (3)	No	No fish	0	-	-
M.F. Boise	Little Queens	1	4433	Depletion (2)	Yes	N/A	1	1	1
S.F.Payette	Miller	2	527	Depletion (3)	No	0.140	0	-	-
B.Moores	Mores	2	1223	Depletion (3)	Yes	N/A	0	1	1
S.F. Salmon	Riordan	1	5792	Depletion (1)	Yes	N/A	1	1	1
S.F. Payette	Sams	2	580	Depletion (2)	No	No fish	0	-	-
S.F. Salmon	Six Bit	1	3318	1-pass (1)	Yes	N/A	1	1	1
M.F. Payette	Sixteen to One	1	1500	Depletion (1)	Yes	N/A	1	1	1
Payette Squaw	Thirdfork	1	1046	Depletion (1)	Yes	N/A	1	1	1
M.F. Payette	UMF Payette	1	5050	Depletion (2)	Yes	N/A	2	1	1
S.F. Salmon	Upper Burntlog	1	4580	Depletion (2)	Yes	N/A	2	1	1
S.F. Boise	W.F. Parks	2	2162	Depletion (3)	No	0.054	0	-	-
S.F. Salmon	Wardenhoff	2	696	Depletion (2)	No	0.410	0	-	-
S.F. Payette	Wolf	2	1268	Depletion (2)	No	0.255	0	-	-

Note: Probability of detection calculated from Petersen et al. (2002). * Probabilities of detection were calculated only when bull trout were not found. ** Natural barriers were identified. N/A - Bull trout were found so a probability of detection is not needed.

Table 3. Fish species detected during 2013 MIS sampling on the Boise N.F.

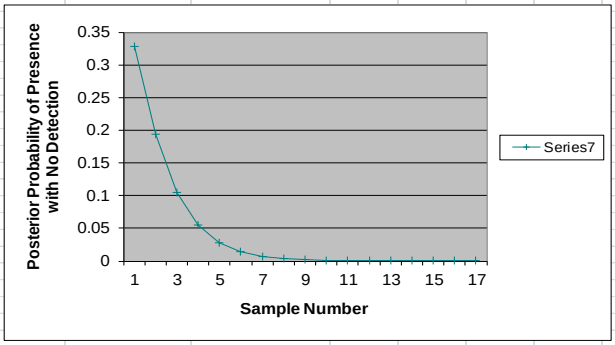
Patch Name	Subbasin	RBT	CTT	MWF	BT	BKT	Chinook	Sculpin	Sucker	BK/BT HYB
Aden Creek	SFB	0	0	0	0	0	0	0	0	0
Bear Creek SFS	SFS	0	0	0	0	0	0	0	0	0
Bear Creek SFP	SFP	x	0	0	0	0	0	0	0	0
Bear Creek NFB	NFB	x	x	0	0	x	0	0	0	0
Bear River NFB	NFB	x	0	0	x	x	0	x	0	0
Big Five	MFB	x	0	0	0	0	0	0	0	0
China Fork	MFB	x	0	0	0	0	0	0	0	0
Clear Creek	BM	x	0	0	0	x	0	0	0	0
Cottonwood	MFB	x	0	0	0	0	0	0	0	0
Crooked River	NFB	0	0	0	x	0	0	0	0	0
E.F. Eightmile	SFP	x	0	0	0	0	0	0	0	0
Fir Creek	MFS	x	x	0	0	x	x	x	0	X
M.F. Big Pine	SFP	x	x	0	0	0	0	0	0	0
Parks Creek	SFB	x	0	0	0	0	0	0	0	0
Phifer Creek	MFB	x	0	0	x	0	0	0	0	0
Queens River	MFB	x	x	0	x	0	0	x	0	0
Rattlesnake	SFB	x	0	0	x	0	0	0	0	0
Roaring River	MFB	x	x	0	x	0	0	0	0	0
S.F.Deer	SFB	x	0	0	0	0	0	x	0	0
Trail	NFB	x	0	0	0	0	0	0	0	0
Trapper	SFS	0	0	0	x	0	0	0	0	0
W.F. Eightmile	SFP	x	0	0	0	0	0	0	0	0
Warm Lake	SFS	x	0	0	x	x	x	0	x	X
Whiskey Jack	SFB	x	0	0	0	0	0	x	0	0
Whitehawk	SFP	x	0	0	0	0	0	0	0	0
Wilson	SFP	x	0	0	0	0	0	0	0	0
Yuba	MFB	x	x	0	0	0	0	0	0	0

Subbasin	**Fish Species**
NFB= North Fork of the Boise River	RBT= Rainbow Trout
MFB= Middle Fork of the Boise River	CTT= Cutthroat Trout
SFB=South fork of the Boise River	MWF=Mountain Whitefish
BM= Boise Moores	BT=Bull Trout
NFP= North Fork of the Payette River	BKT=Brook Trout
SFP= Sout fork of the Payette River	Chinook Salmon
MFP=Middle Fork of the Payette River	Sculpin=Shorthead Sculpin
SFS= South Fork of the Salmon River	BK/BT HYB= Brook Trout X Bull Trout Hybrids
MFS= Middle Fork of the Salmon River	
PS= Payette Squaw Creek	

Appendix 1. Peterson and Dunham (2003)

Multiple Pass

	dj	*d (Eqn 1)*	*P(F)*	*P(~F)*	*P(Co|F) = 1-d*	*P(F|Co) - Eqn 2*
	Unit-Specific I	**Cumulative Probability of Detection Within Patch**	**Prior Probabilit**	Prior Probability o	Probability of Not De	Posterior Probability of Patch Occupancy, Given No Detection
1	0.51	**0.51**	**0.5**	0.5	0.49	0.32885906
2	0.51	**0.7599**	**0.5**	0.5	0.2401	0.193613418
3	0.51	**0.882351**	**0.5**	0.5	0.117649	0.105264712
4	0.51	**0.94235199**	**0.5**	0.5	0.05764801	0.054505856
5	0.51	**0.971752475**	**0.5**	0.5	0.028247525	0.027471522
6	0.51	**0.986158713**	**0.5**	0.5	0.013841287	0.013652321
7	0.51	**0.993217769**	**0.5**	0.5	0.006782231	0.006736542
8	0.51	**0.996676707**	**0.5**	0.5	0.003323293	0.003312285
9	0.51	**0.998371586**	**0.5**	0.5	0.001628414	0.001625766
10	0.51	**0.999202077**	**0.5**	0.5	0.000797923	0.000797286
11	0.51	**0.999609018**	**0.5**	0.5	0.000390982	0.000390829
12	0.51	**0.999808419**	**0.5**	0.5	0.000191581	0.000191545
13	0.51	**0.999906125**	**0.5**	0.5	9.38748E-05	9.3866E-05
14	0.51	**0.999954001**	**0.5**	0.5	4.59987E-05	4.59965E-05
15	0.51	**0.999977461**	**0.5**	0.5	2.25393E-05	2.25388E-05
16	0.51	**0.999988956**	**0.5**	0.5	1.10443E-05	1.10442E-05
17	0.51	**0.999994588**	**0.5**	0.5	5.4117E-06	5.41167E-06



Single Pass

	dj	*d (Eqn 1)*	*P(F)*	*P(~F)*	*P(Co|F) = 1-d*	*P(F|Co) - Eqn 2*
	Unit-Specific I	**Cumulative Probability of Detection Within Patch**	**Prior Probabilit**	Prior Probability o	Probability of Not De	Posterior Probability of Patch Occupancy, Given No Detection
1	0.58	**0.58**	**0.5**	0.5	0.42	0.295774648
2	0.58	**0.8236**	**0.5**	0.5	0.1764	0.149948997
3	0.58	**0.925912**	**0.5**	0.5	0.074088	0.068977588
4	0.58	**0.96888304**	**0.5**	0.5	0.03111696	0.030177915
5	0.58	**0.986930877**	**0.5**	0.5	0.013069123	0.012900525
6	0.58	**0.994510968**	**0.5**	0.5	0.005489032	0.005459067
7	0.58	**0.993217769**	**0.5**	0.5	0.006782231	0.006736542
8	0.58	**0.996676707**	**0.5**	0.5	0.003323293	0.003312285
9	0.58	**0.998371586**	**0.5**	0.5	0.001628414	0.001625766
10	0.58	**0.999202077**	**0.5**	0.5	0.000797923	0.000797286
11	0.58	**0.999609018**	**0.5**	0.5	0.000390982	0.000390829
12	0.58	**0.999835788**	**0.5**	0.5	0.000164212	0.000164186
13	0.58	**0.999931031**	**0.5**	0.5	6.89692E-05	6.89645E-05
14	0.58	**0.999971033**	**0.5**	0.5	2.89671E-05	2.89662E-05
15	0.58	**0.999987834**	**0.5**	0.5	1.21662E-05	1.2166E-05
16	0.58	**0.99999489**	**0.5**	0.5	5.10979E-06	5.10977E-06
17	0.58	**0.999997854**	**0.5**	0.5	2.14611E-06	2.14611E-06