130

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SURVEY METHODS FOR STREAM-ASSOCIATED AMPHIBIANS IN WASHINGTON: RESULTS OF A WORKSHOP

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Abstract: Stream-associated amphibians (SAA) were identified as species of concern in conducting forestry practices near non-fish bearing, headwater streams in the 1999 Forests and Fish Agreement for the State of Washington and in the Northwest Forest Plan for federal forests. Both strategies described the need for monitoring the efficacy of protective forest management strategies, which requires development of standard survey protocols. As a result, a workshop of invited experts was held in May 2000 to discuss extant methods and to recommend standardized survey protocols. The workshop objectives were to recommend methods that could provide a basis for adaptive management by (1) evaluating whether a forest management plan or approach such as the F&F strategy provides for continued occupancy by SAA in headwater streams on a broad geographic scale; (2) assessing the effects of specific forestry practices on SAA at the scale of a stream reach; and (3) clarifying interactions among stream-associated amphibians, forestry practices and the environment. The discussions clarified the distinction between passive adaptive management through effectiveness monitoring and active adaptive management, the latter of which requires more rigorous sampling of responses to potential management alternatives. The group settled on two general methods that are adapted for the three primary objectives, and could be modified to accommodate additional research objectives. First, reconnaissance surveys are recommended for determining presence, as a means of assessing large-scale management effectiveness. Reconnaissance surveys involve "walk-and-turn" surveys, which include irregular search paths to examine specific in- or near-stream substrates that are likely to harbor amphibians. For evaluating the effects of forestry practices on abundance of SAA or for active adaptive management monitoring, the workshop participants recommended area-constrained surveys, in which all habitat substrates that may harbor SAA are overturned. Although additional development appears needed on the size and number of plots, it is recommended that three 5-m sections of headwater streams be surveyed to determine relative abundance of stream-associated amphibians with respect to specific management activities. Meeting research objectives, such as determining amphibian-habitat relationships, requires pre-sampling to identify sample sizes for specified levels of precision. The information should prove useful for a variety of effectiveness monitoring programs and adaptive management experiments.

INTRODUCTION

Both the 1999 Forests & Fish (F&F) Report for the State of Washington and the Northwest Forest Plan for federal forests identified stream associated amphibians (SAA) as species of concern while developing strategies for protecting non-fish bearing streams.

The concerns were related to the fact that amphibians are frequently found in headwater streams with cool, deeply shaded microhabitats and clean gravels (Nussbaum et al. 1983), and are often associated with old-growth forests (Carey 1989, Welsh and Lind 1991). Clearcut timber harvesting and related activities near headwater streams may result in decreases in abundance and diversity of SAA or even local extirpations (Bury and Corn 1988, Conner et al. 1988, Welsh and Lind 1988, Corn and Bury 1989). Such forest management activities may reduce shade and disrupt soils, which may affect SAA by causing increased stream temperatures and sedimentation.

Variation related to the physical environment--. Modest amounts of research have been conducted over the last several decades on SAA species to refine their distribution and taxonomy, and more recently, to describe habitat relationships (e.g., Welsh and Lind 1996). Research on habitat relationships has shown that responses of SAA to timber harvesting vary, depending upon such factors as stream gradient, underlying geological formation and relative percentage of silt, clay, sand, cobble and boulders (Wilkins and Peterson in press). For example, while Bull and Carter (1996) identified a statistically insignificant downward trend in abundance of tailed frogs (*Ascaphus truei*) as the amount of timber harvesting increased along northeastern Oregon streams, they found that physical factors such as substrate size and stream gradient were more important predictors of abundance than was conifer cover. Similarly, Diller and Wallace (1996) found that the distribution and abundance of the southern torrent salamander (*Rhyacotriton variegatus*) in managed, young-growth redwood (*Sequoia sempervirens*) forests were related more closely to geology and stream gradient than to forest canopy cover and stream temperature. SAA responses to timber harvesting might also vary with relative changes in stream chemistry associated with modification of the composition of riparian vegetation. Leaf fall from riparian deciduous vegetation, which results in less acidic conditions than conifer needles, might affect the life-histories of SAA. Also, the amount of small woody debris that remains scattered over the headwater stream after logging can influence stream temperature and sedimentation (R. Jackson, pers. commun.).

Recognition of need for standardized monitoring protocols--. The widespread conservation concerns and regional variability have resulted in a need to clarify relations between SAA (a list of species of interest is found in Appendix-A) and timber harvesting in general (Bunnell et al. 1997) and to assess how SAA respond to the conservation strategies specified in such programs as F&F or the Northwest Forest Plan. Effectiveness monitoring programs have been or will be implemented to evaluate the relative competence of such forest management strategies. Also, some SAA are being monitored as a condition of various state or private forest and land management plans, such as habitat conservation plans (HCPs). Unfortunately, previous administrative and scientific monitoring efforts have employed different survey methodologies for SAA, a result of varying management objectives. The several extant monitoring programs provide an opportunity to quantify factors that influence variation in SAA responses via meta-analyses that would involve combining data from regional surveys. Standardized survey methods would allow greater ability to assess effectiveness of regional forest management strategies and, with rigorous designs, could help clarify habitat-environmental relations among SAA.

The above-mentioned topics were noted at a recent meeting of the National Council for Air & Stream Improvement, Inc. (NCASI) research oversight committee, which suggested that NCASI co-sponsor a workshop to develop standard protocols for surveying SAA species that could be employed in adaptive management and monitoring programs. Concomitantly, the Cooperative Monitoring, Evaluation and Research Committee (CMER) established by the Timber-Fish-Wildlife (TFW) Agreement in 1987 recommended a workshop for similar purposes. Both the NCASI Western Wildlife Task Group and CMER subsequently provided funds for such a workshop.

WORKSHOP OBJECTIVES

The workshop objectives were to recommend standard survey methods that: a) could provide a basis for adaptive management by clarifying interactions among SAA, forestry practices and the environment by aggregating information across multiple scales or over several ownerships; and b) would provide a basis for evaluating whether the F&F refugia strategy (or similar strategy) adequately protects SAA. Adequacy, as suggested by F&F participants from the Washington Department of Wildlife to workshop attendees, meant continued presence of SAA over the long term (apparently, ≥ 10 years) in forests managed under the F&F prescription. Continued presence was inferred to indicate that species which are able to maintain their geographic distributions continuously are assumed to be viable. Formal population viability analysis (PVA) was not considered, which seems justifiable because PVA requires intensive and often longterm data on demography that currently are beyond reach.

This report summarizes the recommendations of the workshop participants, and incorporates numerous comments from reviewers as well as additional suggestions from workshop participants subsequent to the workshop. Although the report is necessarily directed toward contractual objectives that relate to the F&F Report, the information should prove useful for other programs seeking to clarify the relationships among SAA, forestry practices and Pacific Northwest environments. The workshop was held May 9 and 10, 2000 in Olympia, Washington. It brought together expert herpetologists, wildlife biologists and a biometrician from state agencies, universities, federal agencies, NCASI and the forest products industry to discuss experiences and sampling methods for SAA species (the attendees are listed in Appendix-B). The first day was devoted to a field trip, during which attendees participated in sampling SAA in several headwater streams (the field trip stops are described in Appendix-C-I). The field trip helped to familiarize attendees with each other, various methods and challenges, factors that cause variation, and jargon, all of which aided subsequent discussions. The second day involved presentations by several experts and discussions of potential protocols for surveys. After the presentations, the attendees were divided into three groups to: a) determine pros and cons of extant methods; b) identify sources of variation in survey data; and c) describe survey-design considerations. The full workshop group discussed the findings of each sub-group. Appendix-C-II provides brief summaries of the presentations.

SUMMARY OF THE F&F HEADWATER STREAM STRATEGY

The F&F Report specified a series of no-cut buffers and leave-patches to serve as refugia for protecting SAA in Type N waters, which are seasonal and perennial headwater streams without fish. The refugia are expected to increase the likelihood that SAA populations will persist along significant portions of each Type N drainage basin. It is assumed that some or all of these refugia will provide sources for re-colonizing those parts of each basin where SAA may be reduced or extirpated. Type N waters drain basins ≥ 13 acres in the coastal Sitka spruce zone, 52 acres elsewhere on the Westside of the crest of the Cascades, and > 300 acres in Eastside areas. For Type N perennial streams that are ≥ 1000 feet long, the F&F Report specified 50-foot wide buffers on each side of streams for 500 feet from the intersection with Type F (defined in the F&F Report as fish-bearing waters) or with Type S waters. Type S waters include all waters within their ordinary high-water marks, inventoried as "shorelines of the state", but do not include such waters' associated wetlands (F&F Report pp. 13-14). For streams that are 300-1000 feet in length, the buffer is to extend 300 feet or 50% of the length, whichever is greater. If Type N streams are < 300 feet long, the buffer is to extend the entire length. The pattern of buffers and leave-patches (described below) might appear similar to that shown in Fig. 1.

Other protective practices in the F&F Report include no-harvest leave-patches (50 feet in radius) surrounding perennially saturated headwall seeps, at toes of cliffs, or in steep topography and heads of perennial Type N streams (Fig. 1). The 50-foot radius patches also are to include side-slope seeps within 100 feet of Type N perennial streams on side slopes > 20% and side-slope springs within 100 feet of Type N perennial streams. These areas may be used as breeding areas by SAA. Further, there is to be no harvest within 100- by 100-foot leave patches centered on permanent initiation points of perennial Type N waters, within alluvial fans, or within 100- by 100-foot leave patches centered on points of intersection of 2 or more Type N perennial streams.

The F&F Report also requires landowners to identify additional priority areas of 50 feet on each side of streams, such that the total buffers and leave patches include at least 50% of the length of the headwater stream. The priority areas are to be selected in the following order of priority: 1) low gradient streams; 2) perennial stream reaches of non-sedimentary rock with gradients of >20% in the tailed frog habitat range; 3) hyporheic and groundwater influence zones; and 4) areas further downstream from other buffered areas. Additional prescriptions occur for Eastside Type N waters, to include a longterm strategy (through 2051) of clearcuts or partial harvesting, subject to several constraints, such as the basal area of leave trees. Finally, additional approaches may be prescribed following 10 years of research and monitoring, according to adaptive management procedures.

REDUCING BIOLOGICAL & ECONOMIC UNCERTAINTY VIA ADAPTIVE MANAGEMENT

In general, forest managers lack scientific research guidance to predict the efficacy of the F&F refugia strategy, or any other forest management strategy for protecting SAA in Type N waters. For example, for the more-mobile species and those that display biphasic life histories (Duellman and Trueb 1986), it is not known whether the buffer widths are adequate or whether the pattern of buffers and leave-patches will be sufficient. Longterm survival of such species may depend upon terrestrial habitats, not just the aquatic and streamside habitats. As a result, viability of SAA might be linked to the watershed-scale pattern of refugia and surrounding forest mosaic (deMaynadier and Hunter 1995).

Additionally, there is interest within the forest management community in minimizing the economic consequences of surrounding such headwater streams with no-cut buffers and leave-patches. The F&F buffer widths were not based upon documented needs of SAA, and smaller buffers may be as effective in maintaining SAA on harvested sites. Indeed, non-managed buffers may not be necessary if a threshold level of management within the buffer results in little or no impact to the amphibian community. For example, Ross et al. (1999) found that stands containing >15m^2/ha live tree basal area appeared to be a threshold for high salamander abundance in northeastern Pennsylvania. Potential management practices that could meet the objectives of timber production and regeneration while protecting SAA habitats and populations are undefined.

Passive adaptive management--. As noted above, the F&F prescription could ultimately prove insufficient for some species or in specific situations. If so, there may be a need for increasing the level of protection, which is why the F&F report recognized the need for effectiveness monitoring. However, if indeed the F&F prescription subsequently is found to be ineffective, simple monitoring of continued presence is unlikely to identify the specific cause of the apparent failure. For example a long-term decline in amphibians could be related to a watershed-scale effect or to some other factor unrelated to the F&F strategy. Similarly, if the F&F buffers provide more protection than necessary, monitoring will not identify a more cost-effective management direction. Thus, simple monitoring will not necessarily reveal which direction to take in new management, which is why this process is known as passive adaptive management (Walters 1986).

Active adaptive management--. Carefully-crafted, rigorous manipulative experiments are needed that integrate small- and large-scale environmental factors and judicious forest management practices so as to ensure longterm protection of SAA and a healthy forest-based economy. Such "active adaptive management" experiments should involve simultaneous implementation of a variety of feasible forest management options (Walters 1986, Irwin and Wigley 1993). Doing so would allow, for example, comparisons of SAA abundance among wider buffers than prescribed by the F&F Report, current F&F buffers, managed buffers (i.e., partial harvest within buffers), or no buffers. Such an experiment would need to account for interactions between physical environmental influences that cause variation in responses by SAA and the various protective designs.

WORKSHOP RECOMMENDATIONS

General topics--. The workshop attendees noted the importance of adequate training in identifying SAA, classifying stream habitats and in applying field methods. Scientific collection permits must be obtained from the Washington Department of Fish and Wildlife (Enforcement Division, 600 Capitol Way N., Olympia, WA 998501). Such permits are needed to search actively for state sensitive species, such as Van Dyke's salamander (*Plethodon vandykei*), as well as to retain specimens for subsequent expert identification and research on taxonomy. Jones (1999) described the seasonal survey period to be between spring thaw and summer drought and, for near-stream amphibians, after ground-soaking rains in the fall until snowfall occurs. Many amphibians are more active in spring and summer, and fall surveys may fail to find tailed frogs because transforming tadpoles may leave the stream as adults in August and September. Thus, most surveys should be conducted between March and mid-July, but reconnaissance surveys to determine continued presence for other species can continue through September or October.

Potential methods--. Several commonly used survey methods, were discussed: hand-collecting via intensive searches of short (5-15m) stream reaches and adjacent habitats (Bury and Corn 1991); walk-and-turn surveys; electro-shocking; snorkel surveys; time-constrained searches; and nocturnal visual surveys. Walk-and-turn surveys, most helpful for reconnaissance surveys for presence/not-detected, involve irregular search paths, with frequent changes in direction to examine specific substrates (boulders, cobbles, coarse woody debris, moss, etc.) that are likely to harbor amphibians.

For most species, a single reconnaissance survey was considered sufficient to determine presence, although there is considerable uncertainty, as described below. For the more rare species, such as Van Dyke's salamander, a species that does not require flowing water for breeding but often occupies habitats adjacent to streams, Jones (1999) suggested 3 survey visits to a stream. Surveys should be conducted according to a specified protocol (at least 4 days apart) before Van Dyke's salamander is considered "not detected" in a headwater stream zone. Jones (1999) also noted that environmental conditions are important in surveys for Van Dyke's salamander. For example, soils under surface objects (rocks, logs, woody debris), must, be moist or wet down to 30 cm, when measured 10 m from the wetted edge of a stream or seep. Soil temperatures should be within 4-14° C, and air temperatures should be above freezing continuously the previous 3 days prior to surveys.

The recommendations described below are generally supported by Bury and Corn's (1991) seminal work, which provided summaries of the biology of SAA, described methods of capturing and measuring amphibians, listed useful field tools & materials and provided data forms. They also described an analysis showing probability of capture for SAA. In that analysis, Bury and Corn (1991) found that a single 10-m sample in a headwater stream in western Oregon had < 1% chance of failing to detect tailed frogs that were present, and that the likelihood of failing to detect this species in a single 5-m sample, when in fact it was present, was 5.5%. The probability of not detecting Olympic salamanders (*Rhyacotriton olympicus*) that were actually present was 20% for a 5-m sample, but only 4% for a 10-m sample. They concluded from their analyses that a 10-m sample was the minimum acceptable length for a single survey within a headwater stream, and that such a survey would be appropriate for describing aquatic amphibian communities in headwater streams over a wide geographic area.

Surveys can also be used to estimate density or monitor trends in relative abundance within and among streams. After sampling 23 streams in unlogged forests in the Oregon Coast Range, where average density was 3.8 amphibians/m^2, Bury and Corn (1991) concluded that 22 streams would need to be sampled (using single 10-m belt samples) if the acceptable error rate was 1/m^2, and about 90 streams would need to be sampled if an error of 0.5/m^2 was the accepted level. Similarly, MacCracken (pers. commun.) provided unpublished power analyses based upon 2-m belt transects. His data indicated that detecting a 20% difference in abundance, such as between two stages of forest development, would require 50 samples and detecting an 80% difference would require 6 such samples per stream reach. Thus, the available information suggests that there is considerable variability in abundance of SAA, such that large sample sizes are needed to detect small changes in abundance. As a result, sampling always involves tradeoffs among 1) the costs of sampling a single stream vs. characterizing a watershed; 2) the level of difference that an investigator or agency wishes to detect; and 3) the number of streams that can be surveyed during a season.

The workshop participants suggested two primary methods can be used in three designs for SAA surveys under the F&F strategy. Which survey design is chosen will depend upon tradeoffs discussed above relative to meeting objectives that are considered sufficient for making decisions about policy. The first design involves reconnaissance surveys that are intended for documenting continued presence/not-detected (P/ND) in headwater stream networks as part of a large-scale F&F monitoring system, acknowledging that not all streams need be surveyed. Second, area-constrained searches should be considered for estimating abundance of SAA relative to specific management practices in selected stream segments over time. The first two designs can be applied to passive adaptive management monitoring programs for evaluating the relative effectiveness of management strategies under a goal of documenting continued presence. Third, for active adaptive management, which will require higher-precision estimates of abundance, more-intensive sampling via area-constrained searches is suggested. For some applications, the two basic methods could be combined.

Reconnaissance surveys for presence--. The group thought that reconnaissance surveys for identifying whether SAA are present should involve walk-and-turn surveys that search all habitat conditions yet subjectively emphasize the best habitats within buffered areas. These include fast and slow waters, overflow pools, log- or rock-jam overhangs, near-stream sites (within 1-m of the stream) seeps and other leave-patches. If the buffered areas are occupied by the species of interest or concern for a particular locality, then a preliminary conclusion may be made that the buffers and leave-patches are indeed serving their intended function as refugia under the F&F monitoring objectives. If such species are not detected, the surveys do not necessarily justify a conclusion that the species are absent and that the buffers do not function as intended—more intensive sampling may discover them, perhaps in low densities. Determining absence is more difficult, and involves repeated surveys and statistical applications associated with the probability of detection relative to survey effort.

Reconnaissance surveys allow numerous streams to be surveyed rapidly, so efficiency and geographic extent of coverage are maximized. Also, the least amount of disruption to stream substrates is anticipated because surveys can be discontinued if the full complement of species is identified. Although field crews should record habitat conditions (percent boulders, cobbles, sediment, or coarse woody debris) and physical environmental features (landforms, stream and side-slope gradients, substrate parent materials, basin drainage area), the entire stream should be considered the sampling unit for comparative purposes, such as comparing presence of SAA in stream segments before and after they are managed under the F&F prescription.

The workshop group did not address the question of how frequently that reconnaissance surveys should be conducted among years to establish "continued presence", or if the full complement of species is not found after a single survey. That seemed, to us, a matter for research that investigates sources and magnitude of annual variability and subsequently informs policy makers. In many watersheds, if not most, few headwater streams will contain all of the species of concern. Thus, one suggestion involves survey visits to individual streams before and after harvesting under the F&F prescription. If the SAA identified before harvesting are found the first year after harvesting, then follow-up surveys might be conducted at 3- to 5-year intervals. If the pre-treatment complement of SAA is not identified, then surveys might be conducted annually. The group also was uncertain as to how many headwater streams should be surveyed to be representative of overall patterns within a watershed. Recognizing that research is needed on the latter topic, perhaps a 10% sample will serve as a starting point.

For economy and efficiency, and to meet the objective of identifying continued presence, the workshop group suggested that reconnaissance surveys should emphasize (i.e., not necessarily restrict) searches of the "best" habitat, such as riffles and seeps. Such searches should be continued to the beginnings of a headwater stream, if necessary, including that part which is spatially intermittent, until the specified SAA are found. Substrates (e.g., cobbles and boulders) and other cover such as moss or coarse woody debris are overturned and searched for SAA, as described by Bury and Corn (1991).

The reconnaissance method can be modified to extrapolate an index of relative density, as was applied to tailed frogs in northeastern Oregon by Bull and Carter (1996). Doing so involves tallying the numbers of amphibians that are caught in dip nets along a measured stream reach, such as 1000m. Such applications should first determine the minimum stream reach necessary to detect each species locally by conducting efficiency analyses that use incidence- or verification curves developed from preliminary sampling. This involves recording the stream-length searched to reach first detection of a species, 2nd detection, 3rd detection, etc. for a series of streams. It seems likely that verification curves will differ among species and regions. Such applications also should be aware that accuracy may suffer if many amphibians are likely to be missed by dip nets.

Monitoring trends in abundance--. A more formal and intensive level of effort using area-constrained searches should be considered for monitoring or research objectives that may include (1) estimating population densities in selected stream reaches in relation to specific management treatments; and (2) relating presence/absence or abundance to habitat and environmental conditions.

The workshop attendees concluded that Bury and Corn's (1991) and Jones (in prep.) hand-collection techniques, involving detailed, substrate-removal searches of specific areas or sections of streams, would be most effective for monitoring trends in abundance or density. The group recommended surveying several plots or transects in each stream, rather than one as in Burn and Corn (1991). Although a primary objective of the method is to determine presence and diversity of amphibians, the method provides information on abundance (number of animals/m searched), density (number of animals/m^2 searched), or biomass, as well as estimates of variance. Amphibian biomass, which can be determined via regressions that predict mass from total or snout-vent length, may be an even better indicator of amphibian status than density (Bury and Corn 1991). The latter requires capturing and weighing a sample of amphibians to develop separate regressions for larval and adult forms. Subsequently, investigators would only need to measure length of each animal caught.

Briefly, the area sampling method proceeds as follows. First, reflecting the intent of the Jones (in prep.) method, a 1-m wide x 5-m long section of the streambank on each side of the stream (with long axis parallel to the stream) should be searched for woodland salamanders (i.e., *Plethodon* spp.), by over-turning rocks, moss, boulders, woody debris, etc. After sampling the streamside zone and after replacing the habitat structures, a drift-net is then stretched and secured across the corresponding 5-m long section of stream (with width varying by stream width) at the downstream point of the sample site, so as to capture animals that are washed downstream. Beginning at the downstream end of the sample unit, one member of a 2-person team overturns large objects (rocks woody debris) and removes them from the creek. Over-turning large boulders may require both collectors. The remaining gravels and cobble are sifted with a potato rake, and animals encountered are captured by hand. The second person also uses a heavy-duty dip net (shaped in a "D') to capture animals immediately downstream of disturbed cover, to help identify specific habitats occupied. After the search, the substrate is returned to the sampling site, and the objects displaced to the streamside are put back in place in the stream.

In this manner, three (3) 5-m long belts spaced 20-m apart are sampled in each stream, with the starting point determined randomly. The workshop participants did not come to closure on the number of sampling plots, perhaps reflecting different experiences with variability. Participants agreed that more research is needed to identify sample-size and overall survey distance requirements relative to estimating density within and among streams. However, the method does allow comparisons with previous work, and the participants were hesitant to recommend greater sampling effort, cognizant of costs. This method is labor intensive, requiring as much as 5-9 hours per stream for a crew of 2. Also, while this type of sampling might seem destructive, workshop participants noted that stream substrates often are moved annually during periods of high runoff. Bury and Corn (1991) provided a survey form for recording data on amphibians, stream conditions, and other environmental information.

Active adaptive management--. Trends in abundance of SAA populations may provide a useful indicator of the relative effectiveness of several possible scenarios (e.g., no buffer, managed buffer, F&F prescription, wider buffers, etc.) in an active adaptive forest management strategy. Informing large-scale policy decisions, which requires estimating regional population trends relative to a particular management strategy, requires more-detailed surveys. In such decisions and for research involving interactions among habitat conditions, forestry practices and the physical environment, cooperating investigators will need to increase the number of streams sampled and the number of sub-samples per stream. In such cases, a selected number of streams should be assigned randomly to replicates of each treatment x geological formation combination for long-term monitoring. Of course, other covariates could be included, such as time since implementation of the treatment, amount of coarse woody debris in streams, etc. This effort would include a "light touch" effort to minimize extensive disruption of the stream substrate, which would be re-examined at annual intervals.

Sampling under active adaptive management processes should involve pre-samples to acquire empirical estimates of variance, from which investigators can calculate required sample sizes within each habitat stratum to be within a specified level of statistical power. This results in allocating more samples (e.g., 2/3 or more) to better habitats such as fast waters and fewer to poor habitats (e.g., 1/3 or less). Doing so allows researchers to concentrate their efforts where variation is the highest without over-sampling areas with few amphibians. Investigators would subsequently calculate a pooled average density (or relative abundance or biomass by species) and pooled estimate of variance. Minimum landscape variables that should be collected for each surveyed stream segment include the following: geology, latitude, elevation, topography (maximum side slopes, reach-level channel gradient, local channel gradient), aspect, active channel width, basin area, and average annual precipitation.

For some watershed- or landscape-level applications, the greatest efficiency may be obtained using a combined, 2-tiered effort in which the walk-and-turn reconnaissance searches for presence or relative density would be conducted on all or most streams and detailed area-constrained sampling would be implemented to estimate abundance or density of SAA in a few streams, perhaps 10%. Table 1 summarizes the two general methods.

Other topics--. The following items required additional comments from workshop participants and reviewers:

1. Is there any statistical or other advantage to be gained by total removal sampling of the substrate? *Recommendation*: Total substrate removal is not recommended for presence-absence surveys, although this procedure may be needed for population estimation in a research endeavor. New research is needed to determine if the sampling itself affects SAA abundance.
2. Does the number of belts (or transects) searched need to be a function of stream length? That is, what should one do for a 50-m stream? *Recommendation*: For reconnaissance surveys of such small streams, search the entire stream. For monitoring trends in abundance, survey at least 50% of the stream if it is less than 200 feet in length.
3. Is there a recommended minimum distance between transects (for abundance monitoring)? *Recommendation:* The crucial point is that all points along a stream should have an equal chance of being sampled. If the first plot to be sampled is chosen randomly under a "random start" technique, then a minimum distance could be specified, 20-m was described above.
4. Should the width of the bank transects be a function of the width of the riparian zone (i.e, vary among various parts of a stream), or distance to side-slope change? *Recommendation*: The distance from the stream should be as consistent as possible, unless constrained by a cliff or other obstruction. If such constraints are present, they should be recorded.
5. Should the workshop summary report describe how to conduct captures and measurements (mass, snout-vent length, etc.) and how to identify neotenic adults from larvae for *Dicamptodon*? *Recommendation:* This information, which is beyond the scope of the workshop, is available in other reports. Readers are encouraged to acquire a set of papers developed by R. Bruce Bury: "Stream amphibians of the Pacific Northwest—a collection of papers". It is available at the USDI Geological Survey, Forest and Rangeland Ecosystem Science Center, 3200 Jefferson Way, Corvallis, OR 97331.
6. Is there a reliable way to distinguish between Cope's and Pacific giant salamander in the field? *Recommendation:* Yes, a plastic-coated (or laminated) identification card can be constructed from available publications and carried in the field (see Literature Cited and the report described above).

The workshop group also did not address the applicability of belt-transect surveys to seep habitats. Seeps are protected under the F&F guides, but seeps are not always linear, and where they are linear, defining a 5-m long belt in a seep may prove challenging. Reviewers and participants suggested using 3 x 3-m plots, where possible, such that either 50% of the seep is searched or 15 minutes pass, whichever occurs first.

Finally, while it seems intuitive to compare amphibian species' presence in streams before and after harvesting, additional discussion was needed on whether to conduct reconnaissance surveys in non-buffered sections of streams prior to harvest. Such areas may be quite difficult to re-survey after harvest due to logging debris (slash), and under the recommendations for reconnaissance surveys described above, harvested areas would not likely to be emphasized. Maintaining presence of SAA in streams that are buffered at a rate of 50% or more is the objective, which means that the stream is the sampling unit, not specific parts of the stream. As such, it may prove valuable to distribute pre-harvest survey-belts on areas most likely to be buffered during harvest operations. Over the long term, possibly beyond 10 years, it may be important to determine if harvested areas are re-colonized, and reconnaissance surveys may commence in harvested areas after slash decomposes or if it is washed downstream. On the other hand, surveys in sections of streams that receive harvest may be especially revealing in a research design that stratifies surveys by vegetation treatment, parent materials, stream gradient, or special features such as seeps or headwalls.

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DISCLAIMER

The opinions, findings, conclusions, and recommendations expressed in this report are those of the author and do not necessarily reflect the views of the participants or any committee of the Timber/Fish/Wildlife Agreement, the Washington Forest Practices Board, or the Washington Department of Natural Resources.

TABLE. 1. SUMMARY OF RECOMMENDED SURVEY METHODS

I. Presence-Not Detected Surveys

Survey Period	Spring thaw to end of July for in-stream species; through September or October for upland species
Environmental conditions	Moist, above freezing
Survey method	Walk-and-turn, emphasizing best habitats
No. surveys to conclude "not detected"	1 per season, except 3 per season for Van Dyke's salamander at least 4 days apart
Survey design	Search entire stream length, or until target species are found
Distance from streambank searched	1m, or change in side slope, whichever occurs 1st, as well as seeps, log-jams or pools
Data acquired	Species presence, diversity (index of abundance if constrained to stream reach (e.g., 1000m)

II. Area constrained searches

Survey Period	Spring thaw to end of July for in-stream species; through September or October for upland species
Environmental conditions	Moist, above freezing
Survey design	3 5-m belts; for habitat relationships, at least 6 5-m belts, 4 allocated to fast water, 2 allocated to slow water
Distance from streambank searched	1m, or change in side slope, whichever occurs 1st, as well as seeps, log-jams or pool
No. surveys to conclude "not detected"	One
Data acquired	Species presence, diversity, abundance, density (#/linear meter), biomass

LITERATURE CITED

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APPENDIX

A. STREAM-ASSOCIATED SPECIES OF INTEREST

COMMON NAME	LATIN NAME
Cascade Torrent Salamander	*Rhyacotriton cascadae*
Columbia Torrent Salamander	*Rhyacotriton kezeri*
Cope's Giant Salamander	*Dicamptodon copei*
Dunn's Salamander	*Plethodon dunni*
Olympic Torrent Salamander	*Rhyacotriton olympicus*
Pacific Giant Salamander	*Dicamptodon ensatus*
Tailed Frog	*Ascaphus truei*
Van Dyke's salamander	*Plethodon vandykei*
Western red-backed salamander	*Plethodon vehiculum*

B. LIST OF WORKSHOP ATTENDEES

Aitkin, Kevin—U.S. Fish & Wildlife Service, Olympia, WA
Burgdorf, Shirley—U.S. Fish & Wildlife Service, Olympia, WA
Bury, R. Bruce—USGS, Corvallis, OR
Diller, Lowell—Simpson Timber Company, Korbel, CA
Eskow, Jessica—Champion Pacific Timberlands, Puyallup, WA
Hayes, Marc—Washington Dept. Wildlife, Hillsboro, OR
Irwin, Larry L.—NCASI, Stevensville, MT
Jackson, Rhett—University of Georgia, Athens, GA
Jones, Lawrence—USFS, PNW Research Station, Olympia, WA
Leuthold, Niels—USGS & Oregon State University, Corvallis, OR
Loafman, Patrick—Olympic National Park, Port Angeles, WA
Lohman, Kirk—University of Idaho, Moscow, ID
MacCracken, Jim—Longview Fibre Company, Longview, WA
McAllister, Kelly—Washington Dept. Wildlife, Olympia, WA
Peterson, Phil—Simpson Timber Company, Shelton, WA
Quinn, Timothy—Washington Dept. Wildlife, Olympia, WA
Risenhoover, Ken—Port Blakely Tree Farms, Tumwater, WA
Rochelle, Jim—Consultant, Olympia, WA
Russell, Kevin—Willamette Industries, Dallas, OR
Stabins, Henning—Plum Creek Timber Company, Seattle, WA
Van Deusen, Paul—NCASI, Medford, MA
Varland, Dan—Rayonier, Hoquiam, WA
Vogel, William—U.S. Fish & Wildlife Service, Olympia, WA
Wilkins, Neal—Texas A&M, College Station, TX

C. SUMMARIES OF PRESENTATIONS AND FIELD TRIP

I. Field trip, 9 May 2000

Workshop participants visited stream sites along the South fork of the Skokomish River. This location was chosen because of its proximity to Olympia, it contains the full array of stream-associated amphibians known to occur on the Olympic Peninsula, and because one of the field-trip leaders, Larry L.C. Jones, conducted stream surveys in this area.

Stream-associated amphibians that occur in the streams that were visited include Cope's giant salamander, Olympic torrent salamander, tailed frog, and Van Dyke's salamander. Western red-backed salamanders are actually the most common streambank species, although it is usually considered an upland species. All are relatively common in the area, except Van Dyke's salamander, and only Van Dyke's salamander was not observed during the field trip. The workshop group also identified a rough-skinned newt during the tour.

Specific drainages visited included the following:

1. A tributary of Vance Creek, a low-gradient, fish-bearing stream in which previous sampling yielded no amphibians and an opportunistic observation yielded a single Cope's giant salamander.
2. Tributary of South Fork of Skokomish River, a steep, bedrock dominated stream known to harbor Olympic torrent salamanders and western red-backed salamanders.
3. Another tributary of the South Fork of the Skokomish River, in which Cope's giant salamander and tailed frogs are found. This stream had a substantial area between the wetted edge and break-in-slope, and had numerous logjams, boulders, and areas of bedrock.
4. A third tributary of the South Fork of the Skokomish River, in an amphibian-bearing stream within an old-growth forest. It is a relatively high-gradient, step-pool stream with plentiful cobbles and wood. Cope's giant salamander, the Olympic giant salamander, and tailed frogs are found in this stream, as is the western red-backed salamander.

II. Presentations by Invited Speakers (in alphabetical order, as presented)

1. R. Bruce Bury discussed a variety of potential methods:
   A. One method is called R-10, as it involves a bank-to-bank ten-belt inventory. In this method, a 100-m stretch of a headwater stream is searched via ten 1-m belt transects. Seeps are searched for 15 minutes

or until 50% of the seek is searched. Perched water tables should be searched.

B. Other methods involve 1 belt 10-m long, 3 5-m belts, 10 2-m belts, 20 m apart, 3 30-m belts, and electro-shocking, the latter of which is usually used for larger waters (i.e, fish-bearing streams).

2. Lowell Diller discussed his experiences and preferences for SAA sampling:
    A. In first- and 2nd-order streams, 300m are searched for presence/absence (P/A) of torrent salamanders, and 1000 m for tailed frogs. Most time is spent in the "best" habitat for P/A, continuing upstream to the beginning, even if intermittent.
    B. For monitoring abundance, using adult tailed frogs as indicators, although it is helpful to acquire estimates of larvae abundance. Sampling is stratified, with 1 out of every 3 samples allocated to fast water, and 1 out of each 10 is allocated to slow water. Thirty belt transects are sampled, 3 m each.
3. Rhett Jackson provided a perspective from his research in western WA.
    A. There is a great deal of annual variability, which hampers comparisons among and within streams. A possible predictor of tailed frogs is "unit stream power" index, determined as the flow x channel slope.
    B. In some applications, such as developing models to predict P/A or abundance, it should prove useful to determine substrate particle-size distribution, using a zig-zag technique to count pebbles embedded in sediments.
4. Larry L.C. Jones described an integrated sampling design.
    A. It may be important to sample in adjacent uplands (Van Dykes' and W. red-backed salamanders), using 30 1-m belt transects in 300 m of stream length.
    B. A visual survey method was described, which involves observations in 10-m transects of stream within 300 m of a stream reach. A 200,000 candle-power spotlight is used at night, along with binoculars to identify eye-shine from amphibians. This technique is not well developed.
    C. Time-constrained searches may be a cost-effective method for finding Van Dyke's salamanders.
5. Patrick Loafman described sampling for SAA in Olympic National Park.
    A. Removal sampling is used for monitoring creek-dwelling amphibians, using a Random 10m technique, and area-constrained surveys.
    B. There is high variability among years; consdequently, density may not be a useful indicator because the size of plot varies with flow and with volume.
    C. Removal sampling is not considered good for P/A surveys, because one can never confirm absence.
6. Kirk Lohman described studies of tailed frogs in northern Idaho.
    A. There is high variation in relative abundance between adjacent streams and among years.

   B. Study area was logged 40 years ago, and streambeds were hydraulic-mined; yet, there are high densities of tailed frogs.
   C. Abundance appears less in young vs. intermediate vs. old forest structure.
   D. There was not much variation in relative density (#/m) among age-classes within a year.
   E. Substrate removal (aka "rubble-rousing) is probably not destructive.

7. Neal Wilkins described topics of scale and differences between refugia-type SAA and species that are more vagile, based upon a study in 50-60 year-old Douglas-fir forests in SW Washington.
   A. There may be different interpretations from data gathered at 5-m scale and landscale-level.
   B. Differences in SAA abundance were noted for parent materials (basalt vs. marine sediments) and topography (flat gradient, southerly aspects vs. steep gradient on north aspects).
   C. Should not expect to find all species of concern in every stream—competition among SAA may be an influence.

Figure 1. F&F Buffer Strategy for N Waters