Indicators and Methods for Effectiveness Monitoring of White-headed Woodpecker WHA's

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SUMMARY

The purpose of this report is to discuss monitoring questions, indicators, and sampling designs that can be used by researchers and managers to quantitatively assess if white-headed woodpecker wildlife habitat areas (WHAs) are achieving their goals. As outlined in British Columbia’s Identified Wildlife Management Strategy, the goal for white-headed woodpecker WHAs is to "maintain historic, current and future suitable nesting habitat." We assume this to mean habitat where at least one pair of white-headed woodpeckers can survive and successfully reproduce, and habitat where dispersal can successfully occur. As of March, 2004, 3 white-headed woodpecker WHAs had been established near Penticton (totaling 179 ha) with another 10 awaiting approval.

The current abundance of white-headed woodpeckers in British Columbia is estimated at less than 100 birds. As a result, they are listed as federally endangered in Canada and as red-listed in British Columbia. Mature and old-growth ponderosa pine stands in British Columbia are critical for white-headed woodpeckers and provide at least 2 key life history requirements: nesting habitat and foraging habitat. Ponderosa pine stands in British Columbia do not appear to provide suitable nesting or foraging habitat until they are at least 100 years of age; the suitability of ponderosa pine stands increases as stands age beyond 100 years. As little as 35% of ponderosa pine habitat in south Okanagan and lower Similkameen valleys may be suitable for white-headed woodpeckers.

We developed a list of 6 general effectiveness monitoring questions at 3 spatial scales to focus effectiveness monitoring of white-headed woodpecker WHA’s. At the landscape scale, we asked how landscape structure is likely to affect white-headed woodpecker WHAs. The amount and distribution of suitable habitat in a landscape can affect the ability of white-headed woodpeckers to locate, (re)colonize, and persist in and around WHAs. At the home range scale, we ask if there is enough suitable foraging habitat available to maintain at least one pair of white-headed woodpeckers in and around WHAs. Smaller WHAs will probably not be used by white-headed woodpeckers unless there is suitable ponderosa pine habitat within 1km of the WHA. Finally, we ask 4 questions relating to the WHAs themselves: 1) will the presence of white-headed woodpeckers in WHAs increase through time? 2) will WHAs maintain stable or increasing populations of surrogate indicator bird species that depend on mature ponderosa pine habitat? 3) is white-headed woodpecker nesting and summer foraging habitat being maintained in white-headed woodpecker WHAs? 4) and is white-headed woodpecker winter foraging habitat being maintained in the WHAs? These questions are concerned with changes to core nesting and foraging habitat attributes that are likely to affect individual woodpeckers within a WHA.

Seventeen potential indicators for effectiveness monitoring of white-headed woodpecker WHA’s were identified using these monitoring questions and a conceptual model. Selected from the same 3 spatial scales, these indicators are cost effective to measure and have direct relevance to effectiveness monitoring in WHAs. At the landscape scale, the most critical indicators are the amount and distribution of age class 6+ ponderosa pine dominated forest within 10km of a WHA. Similarly, the amount of age class 6+ ponderosa pine dominated forest within 1km of a WHA is the most important indicator at the home range scale. WHA scale indicators important for a white-headed woodpecker effectiveness monitoring program include: the abundance and trend of surrogate indicator bird species, the density of ponderosa pine snags >50 cm DBH, and conifer

seed production in mature ponderosa pine stands. All of these indicators can contribute toward understanding whether white-headed woodpecker WHAs are effectively achieving their intended purpose. In addition, they can be used as guidelines to facilitate the selection of future WHA's.

A detailed description of the sampling design and methodology necessary to implement an effectiveness monitoring program using these indicators is given. Generally, efforts to quantify WHA "effectiveness" would benefit greatly by having a spatial comparison against which WHAs can be assessed. Specifically, a WHA monitoring program would be strengthened and made more efficient by comparing WHAs to ponderosa pine stands in the managed landbase, and by comparing WHAs that use at least 2 management systems. For example, these management systems might include using improvement cutting or controlled burning to thin mature ponderosa pine stands in WHAs. These comparisons would allow WHAs to be assessed relative to the rest of the ponderosa pine ecotype and relative to each other.

Finally, a small one year pilot project is recommended to evaluate if these methods are providing sufficiently precise data to meet the specific objectives of the WHA effectiveness monitoring program. This pilot project will provide useful, short-term information on the status of white-headed woodpecker WHAs, as well as improve the long-term study design so that costs are lowered and precision increased. It should focus on implementing a comprehensive effectiveness monitoring program in at least 6 existing or proposed WHAs and 6 ponderosa pine stands in the managed landbase. This approach will keep costs low and allow the methods to be evaluated and improved before committing to a larger program.

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1 GLOSSARY

Indicator: a measurable attribute with known or predicted relevance to white-headed woodpeckers that could be used to measure the effectiveness of wildlife habitat areas (WHAs) and associated general wildlife measures (GWMs; *e.g.*, ponderosa pine seed availability or presence/absence of white-headed woodpeckers).

Effectiveness: management practices or decisions can be considered effective when they achieve the goals and objectives established for white-headed woodpecker WHAs.

Goals: broad statement describing the overall desired outcome of management actions.

Objectives: specific targets, thresholds, or trends that are used to define effectiveness. For example, a specific objective for white-headed woodpecker WHAs might be to have stable or increasing ponderosa pine seed production.

Trend: changes in an indicator across two or more time intervals.

Status: value of an indicator in one or more locations or management systems at a single time.

Intrinsic disturbance: natural variation in environmental parameters and indicators.

Extrinsic disturbance: human-caused variation in environmental parameters and indicators.

Demography: measurements relating to births and deaths in a population (*e.g.*, white-headed woodpecker survival). For the purpose of this report, density and dispersal are included as demographic parameters.

Parameter: a single environmental measurement (*e.g.*, snag density, distance to nearest old-growth patch, pygmy nuthatch density).

Management systems: refers to different methods of managing for white-headed woodpecker habitat in WHAs. For example, improvement cutting that is intended to create an open canopy vs. low intensity understory burning that is intended to create an open canopy.

2 SCOPE AND DEFINITIONS

Effectiveness monitoring can be defined as the periodic collection of environmental indicators that are used to assess if management strategies are achieving their intended goal. There are 3 important concepts associated with effectiveness monitoring: measurement through time, spatial comparisons, and causation with respect to patterns in data. We briefly discuss these 3 concepts as background.

Monitoring programs typically require the measurement of indicators over time, thereby periodically updating trends in environmental indicators. Monitoring intervals can vary from months to decades, depending on the expected rate of change in environmental indicators. Effectiveness monitoring that uses inappropriate time intervals can be inefficient, ineffective, or both. Trends in indicators are important for predicting future status of environmental indicators such as species/habitat decline or recovery. The end-point for effectiveness monitoring is often indefinite if not tied to administrative goals such as designated species recovery or jurisdictional delisting of a listed species.

Effectiveness monitoring can also be accomplished by simultaneously comparing indicators from several different management systems or landbase types. Measuring the status of an indicator between 2 or more landbase types can be one of the most powerful methods for assessing the effectiveness of WHAs. For example, comparing several WHA management systems (*e.g.*, improvement cutting vs. burning) can reduce overall costs of monitoring while facilitating the ability of managers to select between several options. This process should be designed to increase our understanding of a system and improve future management actions. Similarly, comparing the level of an indicator between WHAs and the managed landbase is an excellent means of distinguishing intrinsic from extrinsic variation.

Finally, an important concept in effectiveness monitoring programs is establishing cause-effect relationships to explain patterns. Monitoring programs can be ineffective when they are not simultaneously designed to record environmental patterns and the causes of those patterns; without cause-effect relationships, it is impossible to link monitoring programs back to management practices. As a result, managers will not know which management practices are effectively contributing to achieving management goals and which need to be altered.

This report is essentially a tool kit that provides information on effectiveness monitoring questions, cost effective indicators, and indicator sampling protocols that are relevant to effectiveness monitoring of white-headed woodpecker WHAs. First, we identify a comprehensive list of questions and biological indicators many of which are impossible to monitor or are not cost effective to monitor in British Columbia. From this comprehensive list we selected a subset of relevant indicators that could be implemented in a cost effective manner. For each cost effective indicator, we made a conscious effort to describe the most comprehensive and conservative sampling design. That is, applying the entire study design described in this report to all of the WHAs is very nearly the best monitoring program that we can implement in a cost effective manner. However, the final monitoring program might not use all of the indicators or it might use all of the indicators but only in a portion of white-headed woodpecker WHAs.

The individual components (tools) that are ultimately implemented and the extent to which they are implemented will depend on financial constraints and the overall definition of WHA "effectiveness". The implementation decision requires setting specific objectives for WHAs. Objectives for declaring a single or all white headed woodpecker WHAs as "effective" can be quite diverse. For example, a white-headed woodpecker WHA may only be considered effective if:

1) a WHA has >6 large (>60 cm dbh) ponderosa pine snags per ha.
2) there are at least 50 large (>60 cm dbh) live ponderosa pine trees per ha.
3) ponderosa pine composes >65% of the mature canopy overstory.
4) a WHA has an average canopy closure of >40% but <70%.
5) 75% the WHA is currently in structural stage 6+ and 25% in structural stage 8+.
6) 50% of the mature ponderosa pine in the WHA are producing conifer cones at least 1 out of every 3 years.
7) the abundance of surrogate bird species in the WHA is stable or increasing.
8) at least one white-headed woodpecker is observed in the WHA.
9) at least one white-headed woodpecker nest is observed in the WHA.
10) there is at least 200 ha (including the WHA) of mature ponderosa pine habitat within a 1km radius of the WHA.
11) no roads are built within 100 m of the WHA boundary.

Similarly, the entire provincial white-headed woodpecker WHA program might only be considered effective if:

1) at least 30% of the WHAs have at least 1 white-headed woodpecker detected within them.
2) the trend in detecting white-headed woodpeckers in WHAs is increasing or stable.

One, several, all, or none of these examples might be used as criteria to assess the effectiveness of white-headed woodpecker WHAs. Decisions about which monitoring questions and study designs to implement cannot be made until specific effectiveness objectives are defined.

Finally, different monitoring objectives do not always provide the same level of insight or utility with respect to improving management practices. Objectives based on specific habitat targets (*e.g.*, age class 7/8 or >6 large ponderosa pine snags per ha) are among the simplest and least expensive to monitor; however, results from monitoring habitat targets alone are limited in the extent that they can be used to evaluate and improve WHA management. Using habitat targets as sole indicators is most effective when there is a strong understanding of the relationship between habitat structure and the species being managed (in this case white-headed woodpeckers). Currently, our understanding of the relationship between white-headed woodpecker and their habitat is incomplete. In contrast, monitoring programs that include measuring the status or trends in species demography are more complex and more expensive. This information, however, can be used in a direct way to evaluate and improve WHA management. Ultimately, measuring a few key indicators in many WHA's and a complete suite of indicators in only a few WHAs will likely prove most cost effective.

3 INTRODUCTION

The current and historical distribution of white-headed woodpeckers (*Picoides albolarvatus*) in Canada is largely restricted to mature ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) forests in the extreme southern interior of British Columbia (Campbell *et al*. 1990). The abundance of white-headed woodpeckers in British Columbia has ranged from a low of 15 observations in the 1950's and 16 observations between 1979-1987 to a high of 112 observations in the 1960's (Campbell *et al*. 1990). Currently the abundance is estimated to be less than 100 birds (Cannings 2000). The white-headed woodpecker is listed as federally endangered in Canada and is red-listed in British Columbia (BC Species and Ecosystems Explorer 2003). As a result, it has been designated as "Identified Wildlife" under British Columbia's Forest and Range Practices Act and is subject to the management guidelines described in British Columbia's Identified Wildlife Management Strategy (IWMS; IWMS 2004).

The purpose of British Columbia's IWMS is to "minimize the effects of forest practices on Identified Wildlife, to maintain their critical habitat throughout their current ranges, and where appropriate, their historic ranges". Currently, the establishment of wildlife habitat areas (WHAs) and the implementation of general wildlife measures (GWMs) are the two primary management strategies being used to achieve these goals. Specifically, the establishment of WHAs are designed to conserve habitat that, if lost, is thought to limit the maintenance or recovery of Identified Wildlife populations in British Columbia. The GWMs are designed to direct management activities in WHAs so that the habitat requirements for Identified Wildlife are being maintained.

The specific goal for white-headed woodpecker WHAs is to "maintain historic, current and future suitable nesting habitat." As of January, 2004, 3 white-headed woodpecker WHAs had been established near Penticton (totaling 179 ha) with another 10 awaiting approval. However, it is likely that WHAs established to protect Lewis' woodpecker (*Melanerpes lewis*), ponderosa pine habitat, and possibly California bighorn sheep (*Ovis canadensis*) and flammulated owl (*Otus flammeolus*) will also contribute toward achieving the white-headed woodpecker conservation and management goals outlined in the IWMS.

The general purpose of this document is to design an effectiveness monitoring program that could be used to quantitatively assess if white-headed woodpecker WHAs and related GWMs are achieving their intended goals. Specifically, we: 1) develop key effectiveness monitoring questions, 2) identify a comprehensive list of relevant indicators designed to address these monitoring questions, 3) select a subset of cost-effective indicators and provide rationale for the use of these indicators in a monitoring program, 4) develop study designs and sampling protocols for the effectiveness monitoring indicators, and 5) identify information gaps, problems and needs as they relate to white-headed woodpeckers in British Columbia. A conceptual pathway is developed as a means of identifying all relevant indicators in the white-headed woodpecker WHA effectiveness monitoring program showing links to the decision-making process.

Although the focus of this report is on monitoring white-headed woodpeckers in WHAs, the questions, indicators, study designs and methods developed herein will have relevance to broader white-headed woodpecker research and monitoring initiatives. Specifically, a recovery strategy for the white-headed woodpecker in British Columbia has been developed by Environment Canada working in conjunction with First Nations, provincial agencies, non-governmental organizations and local forest companies (Krannitz 2004). Much of the information presented in this report can be used to support the goals outlined in this white-headed woodpecker recovery strategy.

The cost of implementing a comprehensive effectiveness monitoring program can be considerable. As a result, the benefits of using a common standardized methodology to measure ecological parameters in white-headed woodpecker habitat throughout the Southern Interior could be substantial. For example, the Canadian Wildlife Service has conducted field sampling to assess ponderosa pine habitat in the south Okanagan. In addition, the BCMWLAP may soon begin implementing field sampling of ponderosa pine habitat in and around WHAs. If, for future sampling, a standardized sampling protocol were adopted by the BCMWLAP and Canadian Wildlife Service and if the needs of the larger study designs were integrated, both organizations could efficiently reduce costs associated with the collection of field data.

4 EFFECTIVENESS MONITORING QUESTIONS

The overall objective of white-headed woodpecker WHAs is to "maintain historic, current, and future suitable nesting habitat" (IWMS 2004). Therefore, the primary question arising with the implementation of white-headed woodpecker WHAs is: do the WHAs provide suitable nesting habitat? We assume this to mean habitat that is suitable for white-headed woodpecker nesting, reproduction, survival, and dispersal.

However, effectiveness is not just dependant upon suitable nesting habitat at the WHA scale. Effectiveness also depends on the presence of suitable habitat characteristics at the landscape-level and home range scales. The amount and distribution of landscape-scale habitat can affect the ability of white-headed woodpeckers to locate, (re)colonize, and persist in the landscape. At the home range scale, many WHAs are unlikely to be effective unless they have adequate foraging habitat within and around the WHA. Therefore, the white-headed woodpecker effectiveness monitoring plan is designed hierarchically (landscape, home range, and within-WHA) and considers both nesting and foraging habitat. The key objectives for effectiveness monitoring are:

1) Evaluate landscape-level parameters that will likely affect white-headed woodpecker persistence in a landscape.
2) Evaluate white-headed woodpecker foraging habitat at the home range scale.
3) Evaluate the presence/absence of white-headed woodpeckers in WHAs.
4) Evaluate the relative abundance of surrogate indicator species that are dependent on habitat attributes important to white-headed woodpeckers.
5) Evaluate nesting habitat attributes at the stand-level (*i.e.*, within the WHA).
6) Evaluate conifer seed productivity at the stand-level.

The following specific questions were developed to focus the approach of the white-headed woodpecker WHA effectiveness monitoring.

4.1 Landscape Scale

1. How does landscape structure affect white-headed woodpecker WHAs? This question relates to population-level dynamics of white-headed woodpeckers and their ability to move in the landscape, (re)colonize, and persist in WHAs. Practically, measures at this scale are most informative when used to explain variation in the presence/absence or relative abundance of birds measured in the WHAs.
   a. Is the landbase surrounding the WHA suitable for white-headed woodpecker movement? Specifically, what is the amount of mature/old ponderosa pine habitat available in surrounding landscape?
   b. How isolated is the white-headed woodpecker WHA? Specifically, how many mature/old ponderosa pine patches are within a 10 km radius of the WHA? What is the average edge-to-edge distance from the WHA to other mature/old ponderosa pine patches within a 10 km radius?

4.2 Home Range Scale

1. Is there enough suitable foraging habitat available to maintain at least one pair of white-headed woodpeckers in a WHA? Many white-headed woodpecker WHAs are unlikely to encompass enough suitable habitat for one home range. Therefore, the area around the WHA will likely be important for meeting white-headed woodpecker foraging requirements. Again, this measure will be most informative when used to explain variation in the presence/absence or relative abundance of birds measured in the WHAs.
   a. Within a 1 km radius centering on the white-headed woodpecker WHA, what area is composed of mature/old ponderosa pine habitat?

4.3 WHA Scale

4.3.1 *White-headed woodpecker population*

1) Will occurrences of white-headed woodpecker in WHAs increase through time? White-headed woodpeckers currently occur in very low densities in British Columbia. If WHAs have any white-headed woodpeckers at all, they will likely not have more

than a single pair in or around them. Therefore, relative abundance will be impossible to measure at the WHA scale. However, an increase in the presence of white-headed woodpeckers in WHAs can be used to evaluate effectiveness.

4.3.2 *Surrogate indicator species*

1) Will white-headed woodpecker WHAs maintain stable or increasing populations of surrogate indicator bird species that depend on mature ponderosa pine habitat? Because it is unlikely white-headed woodpeckers can be monitored directly, surrogate bird species that have similar habitat requirements will be useful in assessing the effectiveness of white-headed woodpecker WHAs.
   a) Is the relative abundance of indicator species stable or increasing in white-headed woodpeckers WHAs?
   b) Is the relative abundance of indicator species higher in white-headed woodpecker WHAs compared to the landbase outside of WHA's?
   c) Does the relative abundance of indicator species differ between WHA management systems?

4.3.3 *Habitat attributes*

1) Is white-headed woodpecker nesting and foraging habitat being maintained in white-headed woodpecker WHAs? Questions focus on WHA-scale habitat attributes that are likely to affect habitat suitability.
   a) Are ponderosa pine trees the dominant overstory canopy species in WHAs?
   b) Are large ponderosa pine snags currently available in WHAs?
   c) Do ponderosa pine snags persist in WHAs long enough for new large snags to be recruited?
   d) What is the density of large live ponderosa pine trees?
   e) Are management actions that are designed to increase the density of large ponderosa pine trees and snags working?
   f) Are WHAs providing important habitat attributes that are less available in the managed landbase?
   g) Are juvenile and intermediate ponderosa pine trees available to supply future white-headed woodpecker habitat?

4.3.4 *Conifer seed*

1) Is white-headed woodpecker winter foraging habitat being maintained in white-headed woodpecker WHAs? Questions focus on ponderosa pine seed production in WHAs.
   a) What is the annual abundance of conifer seed production in WHAs?
   b) What is the frequency of conifer seed production between years?
   c) What stand attributes are most relevant to conifer seed production?
   d) What is the relationship between the size of ponderosa pine trees and seed production in British Columbia?
   e) How much more conifer seed is being produced in WHA's compared to unmanaged ponderosa pine stands?
   f) Are management actions that are designed to improve conifer seed production in WHAs working?

5 INDICATORS AT 3 SCALES

A diverse set of ecological parameters might be relevant to the development of a monitoring program for white-headed woodpeckers. Following Lint *et al*. (1999) and

Noon *et al*. (1999), potential ecological stressors were identified and grouped into extrinsic (human-induced), intrinsic (natural), and habitat loss disturbance types. These groups formed the foundation for a conceptual model designed to show links between ecological stressors, habitat, white-headed woodpeckers, indicators, and the decision-making processes (Appendix 1, Figures A1 and A2). Conceptual models are an efficient and comprehensive method for identifying indicators in monitoring programs (Noon *et al*. 1999).

Many of the indicators listed in the conceptual model, while considered ideal for evaluating WHA effectiveness, cannot be readily or efficiently measured in British Columbia. As a result, a core set of indicators was selected to evaluate WHA effectiveness. While selecting indicators we considered several primary criteria: the indicators should be linked to the state of the population, we should be able to measure the indicators precisely and accurately, and indicators should be simple and cost-effective to measure (Mulder *et al*. 1999). Using these criteria, a subset of environmental parameters was selected that can be used as indicators in a white-headed woodpecker monitoring program.

Indicators were selected from 3 spatial scales: landscape-scale (10 km radius surrounding the WHA), home range scale (1 km radius surrounding the WHA), and within-WHA scale. At the landscape-scale, the indicators focus on population-level habitat suitability. Patterns of mature ponderosa pine distribution and abundance can affect white-headed woodpecker dispersal success, population size, and actual population persistence. The intermediate scale (1 km radius surrounding the WHA or 314 ha) is being considered to evaluate the context of each WHA within its surrounding habitat. For example, is probable that a 30-50 ha WHA with good white-headed woodpecker habitat will not be used if it is surrounded by inhospitable habitat. Finally, the within-WHA scale focuses on changes to habitat that effect individual pairs of woodpeckers such as nesting and foraging site attributes. Indicators have been identified that could be used to evaluate the effectiveness of white-headed woodpecker WHAs at each of these scales.

We selected 7 indicators at the landscape scale, 5 indicators at the home range scale, and 5 indicators at the WHA scale (Table 1). These indicators have a direct relevance to white-headed woodpecker WHA effectiveness monitoring and can be measured in a cost effective manner. In addition, we show the approximate time intervals for re-sampling each indicator. A description of the indicators and rationale for their selection is provided in the following section.

Table 1. Indicators and indicator re-sampling time intervals for a white-headed woodpecker effectiveness monitoring program in southern British Columbia. Indicators are listed by spatial scale.

Scale	Indicator	Description	Frequency measured	Data sources	References
Landscape					
Amount of habitat-10km	Non-forest	Area that is non-forested (*e.g*. agriculture, vineyard, urban)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Young ponderosa pine forest	Area of young forest (<60 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Mature* ponderosa pine forest	Area of mature forest (60-100 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Old ponderosa pine forest	Area of old forest (>100 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Non-ponderosa pine forest	Area of non-ponderosa pine forest (<25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
Fire risk-10km	Fire hazard rating	Average fire hazard rating for the area surrounding the WHA	10 years or after an advance in information	British Columbia fire hazard ratings	
Connectivity indices-10km	Number of patches	Number, area, and distribution of mature/old ponderosa pine patches >10 ha in size within a 10 km radius	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	
	Average nearest neighbor distance	Average nearest neighbor distance between mature/old ponderosa pine patches >10 ha in size within a 10 km radius	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	
Home range					
Amount of habitat-1km	Non-forest	Area that is non-forested (*e.g*., agriculture, vineyard, urban)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Young ponderosa pine forest	Area of young forest (<60 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Mature ponderosa pine forest	Area of mature forest (60-100 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998

	Old ponderosa pine forest	Area of old forest (>100 years; >25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
	Non-ponderosa pine forest	Area of non-ponderosa pine forest (<25% ponderosa pine)	10 years or after an advance in GIS info.	GIS map data layers, orthophotos	Warman *et al*. 1998
<u>WHA scale</u>					
Bird sampling	WHWO pres./absence	Presence/absence of WHWO measured using call playbacks	annually in late March/April for the first 3 years and every 3 years thereafter	Field	RISC woodpeckers 1999
	Indicator species – relative abundance	Indicator bird species of mature/old ponderosa pine forests surveyed using point counts in the winter and during the breeding season, *e.g*., pygmy nuthatch, Clark's nutcracker	annually in late February or breeding season for the first 3 years and every 3 years thereafter	Field	RISC songbirds 1999, RISC woodpeckers 1999, Reynolds *et al*. 1980
Structural habitat sampling	Tree density	Density (#/ha) of all trees ≥7.5cm DBH and large trees ≥40cm DBH in WHAs and managed landbase	10 years or after a major disturbance	Field	NFR 2003
	Snag density	Density (#/ha) of all snags ≥7.5cm DBH and large trees ≥40cm DBH in WHAs and managed landbase	10 years or after a major disturbance	Field	NFR 2003
Stand productivity	Conifer seed production	Annual conifer seed production measured at 3 spatial scales: trees per stand, cones per tree, seeds per cone	annually, in the fall for the first 3 years and every 3 years thereafter	Field	Krannitz and Duralia 2004

[*] "Mature" refers to individual trees in a stand that have reached reproductive maturity.

6 RATIONALE FOR INDICATORS

6.1 Key Life History Requirements

We briefly describe several key aspects of white-headed woodpecker ecology in British Columbia that are relevant to the selection and development of indicators at all 3 spatial scales. We then describe the indicators in more detail and provide rationale for their selection at each spatial scale.

6.1.1 *Landscape-scale requirements*

Nothing is currently known about landscape-level habitat requirements and spatial population dynamics of white-headed woodpeckers. Landscape patterns such as amount and spatial configuration of suitable habitat can influence the abundance, distribution, and dynamics of vertebrate species in addition to local-scale habitat suitability (McGarigal and McComb 1995, Crozier and Niemi 2003). The most severe effects on white-headed woodpecker habitat result from activities such as logging, fire suppression, catastrophic fires, development, and cattle grazing. Habitat loss has been implicated as a cause for recent declines in white-headed woodpeckers in British Columbia (Cannings 1995, Krannitz 2004). Until sufficient young and mature ponderosa pine habitat is restored to suitable old-growth conditions, it is likely that their future status in this province will largely depend on the abundance and dispersal ability of white-headed woodpeckers from Washington State. For this reason an overall monitoring program for white-headed woodpeckers in British Columbia should simultaneously consider the population trends in northern Washington State.

6.1.2 *Home range-scale requirements*

No information exists on white-headed woodpecker home range size in British Columbia. In Central Oregon, estimated home range sizes range from 104 ha in continuous old-growth forests to 321 ha in fragmented sites (Garrett *et al*. 1996). White-headed woodpecker home range size is likely determined by the availability of foraging habitat which is typically mature/old ponderosa pine forests. Given the fragmented distribution of mature/old ponderosa pine forest in British Columbia, large home ranges will almost certainly be necessary to meet foraging requirements. Therefore, area of mature ponderosa pine habitat surrounding each WHA will be an important parameter in a white-headed woodpecker effectiveness monitoring program.

6.1.3 *Stand-level requirements*

Mature ponderosa pine stands in British Columbia provide at least 2 key life history requirements for white-headed woodpeckers: nesting habitat and foraging habitat. In British Columbia, these habitat attributes do not appear to be sufficiently common to support white-headed woodpeckers until forested stands contain living and dead ponderosa pine trees >50 cm DBH (Krannitz 2004, IWMS 2004) which take 100 or more years to develop (Warman *et al*. 1998).

Unlike many woodpecker species, white-headed woodpeckers will nest low to the ground (Garrett *et al*. 1996, Frenzel 2002). Nest sites can be found at <1 m in height and average nest height is often less than 3 m (Garrett *et al*. 1996, Frenzel 2003). Working in Oregon, Frenzel (2003) found 8 white-headed woodpecker nests in the stumps of harvested trees and 62% of all the nests were in silvicultural treatments including clearcuts. However, Frenzel (2003) also found that annual nesting success was 60% higher in unharvested stands with >30 large trees (>53 cm DBH) per ha than in harvested stands with <30 large trees per ha. Frenzel (2003) suggests that higher rates of nest predation in harvested stands are responsible for the majority of nest failures in his study.

It is clear that large diameter, well-decayed (wildlife tree class 5-6) ponderosa pine snags and stumps are preferred nesting sites for white-headed woodpeckers (IWMS 2004). White-headed woodpeckers have nested in snags as small as 14.7 cm DBH (Frenzel 2002). However, snags >60 cm DBH are preferred (Raphael and White 1984, Garrett *et al*. 1996, Frenzel 2002). Dead and dying pines are typically not available as nesting sites until stands are mature because conifers are not as susceptible to decay agents until they are much older (and also much bigger; Bunnell *et al*. 1999). Management targets for snags in white-headed woodpecker habitat include retaining: 4.5 snags > 58cm DBH per ha (Garrett *et al*. 1996), and 5 snags >25cm DBH per ha (Krannitz 2004). These generally agree with results from Bunnell *et al*. (1999) who demonstrated that density of all cavity nesting birds declines sharply when the density of large snags (>30cm DBH) is lower than 4 stems per ha.

White-headed woodpeckers depend on large diameter ponderosa pine for food throughout the year. During the breeding season, they feed by gleaning and flaking invertebrates from the bark or needle clusters of ponderosa pine. Ponderosa pine with deeply furrowed or plated bark (*e.g.*, >60cm DBH) have the highest abundance of ants, spiders, and scale insects and, therefore, are preferred foraging substrates (Garrett *et al*. 1996, Frenzel 2002). During the fall and winter, white-headed woodpeckers continue to feed on insects but increasingly depend on ponderosa pine seed for survival; during the winter, conifer seed is likely a limiting resource (Cannings 1995, Garrett *et al*. 1996). The availability of ponderosa pine seed is low in young stands but is expected to increase as the average stand-level DBH of dominant ponderosa pine increases reaching a plateau at approximately 80 cm DBH (Krannitz and Durilia 2004). High quality white-headed woodpecker foraging habitat in British Columbia is likely monotypic, old-growth ponderosa pine stands with an open understory, 30 to 60 large live trees per ha, and >6 large snags per ha.

See Garrett *et al*. (1996) for a comprehensive review of white-headed woodpecker ecology and see IWMS (2004) and Krannitz (2004) for a review of management concerns in British Columbia.

6.2 Landscape Scale – Indicators

We selected several landscape-scale metrics to evaluate the effectiveness of white-headed woodpecker WHAs including measures of the amount of suitable habitat as well as connectivity indices. These indicators are (Table 1): area of non-forest; area of young, mature, and old ponderosa pine forest; area of forest other than ponderosa pine; number of ponderosa pine patches >10 ha in size; and mean distance to other mature and old ponderosa pine patches. Rationale for these indicator selections follows.

Ponderosa pine is characterized by open, park-like stands, interspersed with grassland communities (Lloyd *et al*. 1990) resulting in a naturally fragmented landscape. However, fragmentation effects due to human disturbance are significant in southern British Columbia and are of concern to white-headed woodpeckers (Krannitz 2004). The ability of white-headed woodpecker WHAs to achieve their goals will, in part, depend on the amount and distribution of suitable ponderosa pine habitat surrounding the WHA. A species' ability to persist in a landscape is affected by processes such as dispersal and connectivity between populations (Wiens *et al*. 1993, Fahrig and Merriam 1994); if WHAs are isolated from other suitable habitat patches, successful immigration and emigration may not occur. For the white-headed woodpecker, this last point is particularly important given that it will likely have to periodically recolonize parts of southern British Columbia.

Therefore, the landscape context of a WHA is likely important in determining the effectiveness of white-headed woodpecker WHAs. The amount of suitable habitat (mature/old-growth ponderosa pine forest) in a 10 km radius surrounding WHAs was selected as one landscape-level indicator of effectiveness monitoring. Species' abundance, distribution, and population dynamics can all be strongly influenced by the amount of suitable habitat in a landscape (McGarigal and McComb 1995, Fahrig 2001, Fahrig 2002, Schmiegelow and Monkkonen 2002). There is no information to-date on white-headed woodpecker spatial population dynamics or the amount of habitat required to maintain viable populations. However, white-headed woodpeckers do individually respond to increased fragmentation by increasing home range sizes to meet resource requirements (Garrett *et al*. 1996). WHAs with higher amounts of suitable habitat in the landscape surrounding them are expected to be colonized first and have a more consistent presence of white-headed woodpeckers.

How a species responds to forest fragmentation depends not only on whether the biological needs and requirements of species are met in some portion of the landscape but also on the species' ability to move within the landscape and detect suitable habitat patches (Ruggiero *et al*. 1988, Wiens *et al*. 1993). This is important even for relatively mobile species such as birds (Desrochers and Hannon 1997, Belisle and Desrochers 2002). Many forest-dwelling birds, including some woodpecker species are less likely to cross openings as the opening size increases (Desrochers and Hannon 1997, Belisle and Desrochers 2002, Robichaud *et al*. 2002). There are a number of costs to individuals associated with travelling in open areas including increased predation risk, and increased time and energy spent traveling rather than foraging or resting (Hinsley 2000, Belisle and Desrochers 2002). Movement constraints affect dispersal success and habitat selection such that even highly suitable habitat may remain unoccupied as habitat isolation increases (Belisle and Desrochers 2002, Robichaud *et al*. 2002). For white-headed woodpeckers there is evidence that they are capable of moving long distances through forested landscapes to forage (Garrett et al 1996). However, it is unknown if their movement is restricted by large openings (*e.g.*, clearcuts, agricultural fields) or immature forest types. Certainly, white-headed woodpecker WHAs can only be effective if they are not isolated in the landscape. Therefore, average nearest neighbor distance and average number of mature/old-growth ponderosa pine patches were two landscape scale metrics selected to provide indices of connectivity of the WHA to the surrounding landscape.

6.3 Home Range Scale – Indicators

One likely effect of extrinsic disturbances on white-headed woodpeckers is habitat dilution (Huggard 1994 in Ehrlich 1996, Ganzhorn *et al.* 1997). Habitat dilution in managed forests occurs when the home range of an animal contains a fixed amount of a resource that decreases in concentration as a result of logging or other disturbances. For example, animals that depend on conifer seeds, such as the white-headed woodpecker, are likely to experience habitat dilution when logging removes mature conifer trees (*e.g.*, Benkman 1993). Thus, home range size must increase to gain access to the same amount of resources. The home range size of white-headed woodpeckers does increase in fragmented habitats compared to continuous forest suggesting they do have to compensate for reduced availability of food resources (Garrett *et al*. 1996).

As was mentioned in a previous section, many white-headed woodpecker WHAs, as they are currently designed, are not large enough to encompass the home range of a breeding pair of white-headed woodpeckers. WHAs will likely be effective only if white-headed woodpeckers are able to use resources from the surrounding area (*e.g.*, Trzcinski *et al*. 1999, Villard *et al*. 1999). Therefore, at the 1km radius scale of evaluation, area of foraging habitat (*i.e.*, mature/old ponderosa pine forest) is the main indicator selected to evaluate the effectiveness of white-headed woodpecker WHAs.

6.4 WHA Scale – White-headed Woodpeckers (Presence/Absence)

Most effectiveness monitoring programs depend on measuring at least one demographic parameter (indicator) directly from the species of interest (*e.g.*, survival, reproduction, dispersal); the parameter most often measured is species abundance. Management actions are then evaluated against changes in this parameter(s). For example, the northern spotted owl (*Strix occidentalis*) effectiveness monitoring plan for the Northwest Forest Plan advocates the use of spotted owl population density, reproductive rate, survival rate, turnover rate, and habitat occupancy as metrics to evaluate forest management (Lint *et al*. 1999). When an effectiveness monitoring program is designed to evaluate management actions using demographic parameters directly, it is important that these metrics are measured with an acceptable degree of accuracy and precision. An inability to measure demographic parameters accurately and precisely will, at best, result in an inefficient monitoring program.

Because of their low abundance in British Columbia, there is currently no cost effective means of directly measuring white-headed woodpecker demographic parameters. Current presence/absence data compared to future presence/absence data could be used as a measure of WHA effectiveness if white-headed woodpeckers increase in response to recovery and management efforts.

6.5 WHA Scale – Surrogate Indicator Species

In the absence of direct white-headed woodpecker population measures, other biological indicators can be used as surrogates. Surrogate indicator species can be an important means of evaluating if white-headed woodpecker WHAs and GWMs are achieving their intended objectives. Pygmy nuthatches, brown creepers, and Clark's nutcrackers may serve as surrogate indicator species (hereafter referred to as indicator species) for white-headed woodpecker habitat. These three species are indicators of stand-level food availability, and landscape and home range-level habitat suitability. Combined, we expect these species to serve as surrogate indicators for white-headed woodpecker habitat. We know of no species that would make a good indicator for white-headed woodpecker nest site availability.

Pygmy nuthatches have been selected as a focal species for ponderosa pine habitat in British Columbia by the Canadian Intermountain Joint Venture (CIJV). The CIJV defines focal species as "organisms that are most vulnerable or have the most stringent ecological needs in a given habitat, and may therefore collectively represent the needs of other species". Pygmy nuthatches show an almost exclusive preference for long-needled pine forests including ponderosa pine (Kingery and Ghalambor 2001). Similar to white-headed woodpeckers, pygmy nuthatches are in their highest abundance in old-growth ponderosa pine stands and depend on pine seeds to meet energy requirements during the winter. Pygmy nuthatches can be used as indicators for white-headed woodpecker habitat for several reasons: they are one of the most abundant bird species in ponderosa pine forests; they are highly vocal and easily detected; they feed largely on ponderosa pine seeds during the winter; they depend on snags for nesting/roosting and foraging; they are year-round residents of ponderosa pine forests in British Columbia; they are sensitive to stand-level disturbances including logging and fire; their home ranges are at a scale appropriate for WHA effectiveness monitoring; and densities appear to be related to the availability of large cone-producing ponderosa pine trees (Kingery and Ghalambor 2001). In addition, pygmy nuthatches are already being used as an indicator species for forest health in the ponderosa pine forests of Idaho, Wyoming, and Colorado (Kingery and Ghalambor 2001).

Clark's nutcracker is a pine seed specialist and is strongly associated with whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) during the summer, and ponderosa pine during the winter (Tomback 1998). Clark's nutcracker will also feed on the seed of Douglas-fir in years of seed crop abundance. Both whitebark and limber pine grow at high elevations in British Columbia (1500 m asl to treeline; Parish *et al*. 1996). During the winter Clark's nutcracker makes altitudinal migrations to wintering habitat (Tomback 1998, Campbell *et al*. 1997); in British Columbia wintering habitat is likely ponderosa pine and Douglas-fir dominated forests. Clark's nutcrackers are appropriate indicators for white-headed woodpecker habitat because they depend on ponderosa pine seed for overwinter survival, can be locally abundant, and are easily detected using point count surveys.

Brown creepers are a small, non-migratory, insectivorous species associated with old-growth conifer forests. They primarily feed on insects, larvae, spiders, and ants by gleaning them from the bark of conifer trees (Hejl *et al*. 2002). The abundance of brown creepers has been positively correlated with large conifer trees with deeply furrowed bark. Again, this correlation is related to the abundance of spiders and arthropods found on old-growth trees (Hejl *et al*. 2002). Working in the Okanagan of British Columbia, Herbers *et al*. (in prep.) found densities of 1 brown creeper per 5 ha in 90-150 year old Douglas-fir dominated stands. This density will likely increase in older conifer stands. Brown creepers can make good indicators for white-headed woodpecker habitat because: they feed by gleaning insects from the bark of conifer trees; they are positively correlated with old-growth stand attributes; their abundance is high enough to consistently measure; they are year-round residents to ponderosa pine forests; they are sensitive to stand-level disturbances; and their home ranges are at a scale appropriate for WHA effectiveness monitoring.

Data collected on these three species will allow white-headed woodpecker WHAs to be assessed using direct demographic estimates from bird species that depend on resources important to white-headed woodpeckers. Information on these indicator species can provide a strong monitoring tool for assessing white-headed woodpecker WHA effectiveness. That is, it will be more certain that WHAs are providing locally and regionally important white-headed woodpecker habitat if the relative abundance of these indicator species is highest and not declining over time in WHAs. These data will be particularly relevant if efforts to directly monitor white-headed woodpeckers in British Columbia continue to be difficult due to low densities.

6.6 WHA Scale – Monitoring Habitat Attributes

White-headed woodpeckers in British Columbia are strongly associated with large living and dead ponderosa pine trees. Their dependence on these forest attributes for nesting and foraging is nearly exclusive. Tracking changes in the abundance of these attributes will be an important tool for assessing WHA effectiveness and for choosing management actions that will improve white-headed woodpecker habitat in WHAs. If appropriate monitoring intervals are used (*e.g.*, 7-10 year intervals), these data will be particularly relevant for tracking the effects of WHA management options on the long-term availability of white-headed woodpecker habitat.

6.7 WHA Scale – Conifer Seed Production

The availability of ponderosa pine seed is clearly an important aspect of white-headed woodpecker ecology. Stand-level changes to seed production will have a direct effect on the ability of white-headed woodpeckers to survive and reproduce in and around WHAs. There are 3 parameters in annual ponderosa pine seed production that are relevant at the scale of white-headed woodpecker WHAs: 1) the number of trees in a stand that produce cones (and thus seeds), 2) the number of cones that a tree produces when it does produce cones, and 3) the number of viable seeds that are produced per cone.

The total number of trees in a WHA that produce conifer cones is an important variable for seed-eating species. There is little quantitative information available to describe this variable. Krannitz and Duralia (2004) generally suggest that ponderosa pine cone production increases with decreasing stand density. Similarly, Bilan (1960) found that 100% of "released" loblolly pine (*Pinus taeda*) in North Carolina produced seed compared to only 80% of "unreleased" trees and Herbers (2001) reports that a higher proportion of Douglas-fir trees produced cones in partially harvested stands compared to unharvested stands. It is likely that diffuse, open canopy ponderosa pine stands have a higher proportion of cone-producing trees than dense, closed canopy stands.

The second variable important for seed-dependent wildlife is the number of cones produced per tree under different stand densities. Foresters have long realized the benefits of "releasing" individual conifer trees on seed production (Bilan 1960). "Open grown" trees can produce between 2 and 12 times more conifer cones compared to trees growing in dense stand conditions (Issac 1943, Bilan 1960, Owens and Blake 1985, Karlsson 2000). The seed-producing ability of a conifer stand is likely related more to the total surface area exposed to direct sunlight rather than to the total number of trees in that stand. For species that depend on conifer seed, the quality of the habitat (assuming seed is the most important resource) will likely decline when individual ponderosa pine trees are densely packed and vigorously competing for access to direct sunlight (Krannitz and Durilia 2004).

Finally, conifer trees appear to produce fewer seeds per cone as stand density increases (Owens and Blake 1985, Krannitz and Durilia 2004). For example, the production of sound conifer seed per cone in loblolly pine was as much as 67% lower in high density stands (Bilan 1960). Tree and stand characteristics determining the number of seeds per cone remain largely unknown but can have important implications for stand-level management in white-headed woodpecker WHAs. Monitoring seed production directly is important because there is such high variation and uncertainty. Understanding the relationship between trees, stands, and seed production will greatly improve our ability to manage for white-headed woodpeckers and other seed-dependent species.

Understanding how ponderosa pine seed production is affected by variables such as stand density, stand age, and tree size will greatly improve the management of white-headed woodpecker WHAs. Specifically, this information will enable managers to implement stand-level management actions designed to enhance white-headed woodpecker habitat in an efficient and cost-effective manner.

7 SAMPLING DESIGN

The methods described in this report are designed to sample WHAs that have reasonably uniform forest cover and are structurally mature. When a single WHA has 2 or more widely different forest cover types (*e.g.*, age class 5 vs. 8 or dense vs. open areas within an age class) the sampling protocol would benefit from within-stand stratification.

7.1 Management Systems

Although this report largely details single WHA stand-level monitoring designs, these methods can be similarly applied to larger scale management programs. Dividing WHAs into "management systems" could be an effective means of implementing several management options and would result in a reduction in the monitoring effort needed to determine overall WHA effectiveness.

There are many benefits to imposing a larger stratified study design on the entire network of white-headed woodpecker WHAs. Ideally, all of the WHAs would be randomly stratified into 3 or 4 "management systems". Each system would contain between 12 and 15 WHAs that are managed in the same way. For example, one system could be managed by conducting stand-level improvement cutting that created an average spacing of 6m between dominant and codominant ponderosa pine trees. A second system could be managed by excluding cattle and implementing low intensity fires at 10 year intervals. Finally, a third management system might leave WHAs as they are and let them mature with little human interference. Implementing multiple management systems and designing an effectiveness monitoring program to update the status of those systems is the most certain and efficient method of improving white-headed woodpecker habitat in WHAs. Specifically, it will allow the outcome of several management systems to be compared directly, it will reduce the intensity of information that needs to be collected from individual WHAs (*e.g.*, from 3 to 2 habitat plots per WHA), and it will facilitate the data analysis and decision-making process. Ultimately, the ability to select the most effective way to manage white-headed woodpecker habitat in WHAs will be improved by using a larger systematic study design.

Before selecting and implementing management systems, forestry and wildlife professionals including Pam Krannitz from the Canadian Wildlife Service and Orville Dyer from the BC Ministry of WLAP should be consulted. Any larger design would also benefit from dividing management systems into high and low landscape-level habitat suitability. The degree to which this overall study design could be accomplished will largely depend on the total number of white-headed woodpecker WHAs created and the level of cooperation in the management of WHAs between jurisdictions. A larger stratified design might also include other ponderosa pine dominated WHAs (*e.g.*, Lewis' woodpecker and ponderosa pine WHAs).

7.2 Comparative Sampling

We suggest pairing WHA sampling with sampling in the managed landbase. The "managed landbase" refers to forested stands that are managed primarily for timber values rather than wildlife conservation (*i.e.*, stands that are not being actively managed for old-growth ponderosa pine habitat characteristics). This comparison allows WHAs to be assessed relative to the rest of the ponderosa pine ecotype. The expectation is that indicators will show that WHAs have better white-headed woodpecker habitat. This comparison will make 2 important contributions to the management of white-headed woodpecker WHAs. First, the effect of the WHAs will be filtered out from natural changes in the abundance of indicators. For example, if conifer seed production drastically increased in WHAs, it would be difficult to determine if the cause was because of the management practices in WHAs or because conifer seed production increase naturally in all ponderosa pine stands. Second, the managed stands will act as a benchmark against which WHAs can be assessed. Efforts to quantify WHA "effectiveness" would benefit greatly by having a spatial comparison against which WHAs can be assessed. Ideally, this information would be used to assess if the recovery of white-headed woodpeckers in British Columbia is linked to WHAs or if it is independent of WHAs.

For every WHA that is being monitored there should be one stand in the managed landbase that is monitored in the same way as the WHA. This will allow ecological trends in the WHA to be compared to trends in managed landbase providing an empirical means of assessing the effectiveness of establishing the WHAs. The expectation is that if WHAs are contributing to maintaining and enhancing white-headed woodpecker habitat then the indicators should be able to quantify their contribution. There is probably no need to sample more than 12-15 stands in the managed landbase for spatial comparisons.

Stands in the managed landbase should be controlled for ecosystem type (*i.e.*, biogeoclimatic subvariant and dominant site series), should be approximately the same size as the paired WHA, and should be a minimum of 2 km from the WHA. Managed landbase stands should **not** be controlled for habitat characteristics such as stand age, tree composition, and stand density. They are intended to be an unbiased sample of the managed landbase. The paired stand should be randomly selected from a comprehensive list of suitable stands between 2 and 3 km from the WHA. All of the WHA monitoring details discussed below are applied to stands in the managed landbase as well as the WHA.

8 SAMPLING METHODOLOGY

8.1 Landscape Scale

The landscape-scale is defined by a 10 km radius circle from the centre point of the WHA. Indicators will be estimated from GIS map layers such as forest cover, as well as air photos or orthophotos. At this spatial scale, seven landscape-scale metrics are calculated: area of non-forest, area of forest composed of stands with < 25% ponderosa pine, area of young (0-60 years), mature (60-100 years), and old (>100 years) forest composed of > 25% ponderosa pine, number of mature and old ponderosa pine patches >10 ha in size, and average nearest neighbor distance between mature/old ponderosa pine forest patches >10 ha in size. Age classes of ponderosa pine forest (young, mature, and old) and percent composition of ponderosa pine (>25% ponderosa pine as suitable) were selected based on habitat suitability criteria established by Warman *et al*.

(1998). Finally, WHA's with lower risk of experiencing a stand-replacing fire will likely provide more stable and secure habitat.

8.2 Home Range Scale

The home range-scale is defined by a 1 km radius circle from the centre point of the WHA. At this scale, indicators will be estimated from GIS data layers such as forest cover and orthophotos. At this spatial scale, five indicators of white-headed woodpecker WHA effectiveness should be calculated: area of non-forest, area of forest composed of <25% ponderosa pine, area of young (0-60 years), area of mature (60-100 years) forest composed of >25% ponderosa pine, and area of old (>100 years) forest composed of >25% ponderosa pine. Similar to the landscape-scale analysis, age classes of ponderosa pine forest and percent composition of ponderosa pine in forest were selected based on habitat suitability criteria established by Warman *et al*. (1998).

8.3 WHA Scale – White-headed Woodpeckers (Presence/Absence)

Even if white-headed woodpeckers were abundant in and around WHAs, differences in the scale of woodpecker home ranges and WHAs would confound any attempt to estimate relative abundance. One breeding pair of white-headed woodpeckers likely requires a home range that is 2-5 times greater than the size of most WHAs. In fact, the white-headed woodpecker recovery strategy (Krannitz 2004) suggests that a single breeding pair in British Columbia would require 200-300 ha of mature ponderosa pine habitat for survival and reproduction. Clearly, the best case scenario is that a single pair of white-headed woodpeckers would be living in and around each WHA. As a result, any efforts to sample for white-headed woodpeckers in WHAs should only focus on collecting presence/absence data using call playback surveys described in RISC Inventory Methods for Woodpeckers (RISC woodpeckers 1999). The layout of playback stations in each WHA should follow the point count layout described below for sampling surrogate indicator bird species.

The call playback portion of the monitoring program should not be resource intensive. One observer can probably sample 2-3 WHAs or managed stands in a single morning, depending on logistics. Playbacks can be conducted from one-half hour after sunrise until early afternoon. Call playback surveys should be conducted once per year per WHA/managed landbase combination during the early portion of the breeding season (late March-April). Call playbacks should be conducted annually for the first 2-4 years after a WHA is established so that there is base-line information on presence/absence. Although it is important to conduct base-line presence/absence data for each WHA, the results will likely yield no white-headed woodpecker responses until populations in British Columbia begin to recover. After a presence/absence base-line is established for each WHA, surveys can be conducted every 3 years for each WHA; there is no need to collect annual presence/absence data. This 3 year sampling schedule might need to be re-evaluated if/when a significant number (*e.g*., 20-30%) of WHAs in the province have been observed to have white-headed woodpeckers present.

8.4 WHA Scale – Surrogate Species

8.4.1 *Surrogate indicator species surveys – point counts*

Ideally, WHA indicator species sampling would occur 2 times during the year: once in January/February to collect winter abundance data when resources are predicted to be most limiting for non-migratory birds, and once in late April/May to collect abundance data during the breeding season. However, costs may prohibit sampling in both seasons. Both have advantages that are worth considering when deciding which season is most appropriate for a long-term monitoring program.

Collecting data on indicator species during the winter would be the most informative survey strategy for assessing white-headed woodpecker habitat in WHAs. In British Columbia, white-headed woodpeckers depend, in part, on ponderosa pine seed for overwinter survival (Bent 1939, Ligon 1973, Garrett *et al*. 1996). Garrett *et al*. (1996) suggest that fluctuations in the production of pine seed may act to regulate white-headed woodpecker populations during the fall and winter. There are at least 2 other species in the south-central British Columbia that depend on ponderosa pine seeds for over winter survival: pygmy nuthatch and Clark's nutcracker. During winter, territorial behaviour in these species largely breaks down thus reducing the effect of intra-specific agonistic interactions on spacing within and between habitat types. As a result, there is a more direct link between bird abundance and local stand and landscape-level forest structure. In other words, the distribution and abundance of pygmy nuthatches and Clark's nutcracker should be related to the availability of forest resources rather than to territorial exclusion behaviour. The abundance of these two species in WHAs during the winter can be used as an index of ponderosa pine seed production and availability, and, thus, of white-headed woodpecker habitat. Similarly, the abundance of brown creepers during the winter will also be informative because they depend on insects living in the bark furrows of large live conifer trees; another important food resource for white-headed woodpeckers.

Collecting data on indicator species during the breeding season has at least 3 benefits. First, point count information will include presence/absence and abundance data on migratory as well as non-migratory bird species. Second, surveys will include presence/absence and abundance information for Lewis's woodpecker, another listed species likely to be found in white-headed woodpecker WHAs. Third, bird detection rates are higher during the breeding season because territorial behaviour make animals more conspicuous. There are drawbacks to collecting indicator species data during the breeding season. For example, information on Clark's nutcracker cannot be collected because this species migrates to high elevation forests in early spring. Also, pygmy nuthatches are notoriously quiet during the spring making them difficult to survey. If fiscal constraints require that only a single season be selected for indicator species monitoring, the decision between seasons may be influenced by monitoring considerations external to white-headed woodpecker indicator species monitoring.

Variable radius point counts (Reynolds *et al*. 1980) should be used to measure the relative abundance and diversity of indicator species in WHAs. This sampling technique is consistent with procedures described in RISC Inventory Methods for Forest and Grassland Songbirds (RISC songbirds 1999) and RISC Inventory Methods for Woodpeckers (RISC woodpeckers 1999). The point count method was selected over the transect method to increase survey precision (Reynolds *et al*. 1980, Rosenstock *et al*. 2002), to enable the data to be efficiently compared and used by other landbird monitoring initiatives (*e.g.*, CIJV 2003, PIF 2003), and to increase sampling consistency between years; between year sampling consistency is a particularly desirable quality for a long-term monitoring program. A minimum of 8 and maximum of 12 point counts should be systematically spaced at 200 m intervals within each WHA. To reduce the sampling bias associated with proximity to other habitat types (*e.g.,* clearcuts or different ecosystems), point count stations should be a minimum of 100 m from WHA boundaries.

The number of point counts that are established within each WHA will depend, in part, on the size and shape of the WHA.

When establishing systematic point counts in WHAs and the managed landbase, an overall layout should be approximated using airphoto or GIS maps and should not be influenced by within stand biogeophysical variation. That is, the unit of interest is the entire WHA or managed stand, so point counts should not be "adjusted" to specifically include/exclude aspects of the stand such as older forest types or rocky outcrops. However, common sense must also be exercised if, for example, a point count is supposed to be established in the middle of an unsafe wetland or steep cliff. In cases where worker safety might be compromised during the establishment of a point count, field personnel should randomly choose a direction for the point count to be moved while remaining conscious that it cannot be within 200 m of another point count or 100 m of the WHA/stand boundary. Because this is anticipated to be a long-term project, the original layout and design is extremely important.

Point count stations do not need to be centered on a tree; however, the closest tree to the station should be well marked using flagging tape and tree paint. A description of the exact location of the point count station should be written on the flagging (*e.g.*, distance and degrees). A universal transverse mercator (UTM) coordinate should be recorded at each point-count station and each tree. To facilitate the accurate estimation of distances, flagging should be placed in at least two cardinal directions at 20 m and 40 m from the center of the point count.

Winter surveys should be conducted from one half-hour after sunrise to one half-hour before sunset. One observer should be able to survey 2 stands (1 WHA and 1 managed landbase pair) in one day. To reduce sampling bias, WHA and managed landbase sampling should be systematically alternated with respect to time of day (*i.e.*, morning and afternoon) through the duration of the study. Sampling should not occur when winds exceed 15 km/hr, when daytime temperatures are below -20° C, or during heavy snowfall.

Breeding bird surveys should follow methods outlined in RISC Inventory Methods for Forest and Grassland Songbirds (RISC songbirds 1999). One observer may be able to survey 2 stands (1 WHA and 1 managed landbase pair) in one morning; however, logistical constraints may limit this to only a single stand per morning. Several important features of breeding bird sampling are: sampling should be conducted from sunrise to four hours after sunrise, WHA and managed landbase sampling should be systematically alternated with respect to time of morning (*i.e.*, first 2 and last two hours after sunrise) for the duration of the study, and field personnel should by systematically alternated between WHA and managed landbase sampling.

The following guidelines apply regardless of whether surveys are conducted in the winter or spring. Each stand should be sampled 1 or 2 times per season (*i.e.*, per breeding season or per winter season). Initially, each stand should be surveyed 2 times per season so that an optimization analysis can be conducted comparing increases in precision to added costs. At the start and end of each stand sampled, observers should record: time, cloud elevation, cloud cover, wind speed, precipitation, and temperature. Point counts should commence one minute after observers arrive at the station for 10 continuous minutes. Data collected for detected birds should include: time of detection (nearest 10 seconds), species, horizontal distance from the point-count station (nearest

5 m), detection method (*e.g.,* visual or auditory), number of birds per flock (primarily a winter variable), and if the animal is within the stand boundary. Treating time of detection and distance at detection as continuous variables will result in greater flexibility with respect to data analysis and comparisons to other studies. If observers are unsure about the distance-at-detection they are asked to make a best guess and put the number in brackets (*e.g.*, [75 m]). The vertical stand boundary should be defined as less than 10 m above tree tops. Birds should only be recorded a single time at every point-count station and only once in every stand when observers were confident the animal had already been enumerated (*e.g.*, pileated woodpecker drumming). Cohesive groups of birds of the same species should be treated as one observation; therefore, distance at detection should only recorded a single time for each species within a group. An example of coding instructions and safety guidelines is given in Appendix 2.

The analysis of distance sampling data is quickly improving (Rosenstock *et al*. 2002, Thomas *et al*. 2002) but remains a controversial subject (Hutto and Young 2002, Ellingson and Lukacs 2003, Hutto and Young 2003). Zero-inflated models should be explored as a tool for analyzing point count data. The program DISTANCE can be used to analyze point count data and is available free of charge online at: http://www.ruwpa.st-and.ac.uk/distance. When analyzing point count data, also refer to RISC fundamentals (1998).

The majority of costs associated with indicator species point count monitoring will come in the first 3-5 years of the program. The first year may be the most labor intensive and most costly if a comprehensive pilot study is conducted. Baseline data should be collected annually for 3-5 years to establish an understanding of variability in bird populations in WHAs and the managed landbase. After baseline information has been established, surveys should be conducted every 2-3 years.

8.4.2 *Surrogate indicator species surveys – presence/absence*

While conducting point count or call playback surveys, observers will detect birds while walking to the first point count or call playback station, moving between stations, and while leaving the forest stand. When a **species** is detected that has not yet been observed during point counts it should be recorded in a separate box on the point count data sheet. The purpose is to compile a list of all the bird species that were detected within the boundaries of the WHA/managed stand. There is no need to record details such as distance-at-detection, number of birds, etc. This cumulative presence/absence list does not need to include animals heard during a point count; point count observations can be filtered into the presence/absence list during data analysis. In effect, point count and presence/absence surveys are two separate monitoring tools. Also, it is **critical** that a bird heard during a point count be recorded even if it was previously recorded in the incidental birds column. For example, if an observer hears a hairy woodpecker while walking toward point count station # 7, the observation should be recorded in the presence/absence box. If the observer then hears the same hairy woodpecker while at point count # 7, the observation must be entered in the point count data. This presence/absence information is primarily a venue to record the presence of rare or unusual sightings such as owls or woodpeckers. A measure of sampling effort can be derived by calculating the total time the observer spent in the stand less the time it took to conduct point counts (*i.e.*, 80-120 minutes).

Collecting this information should add no costs to a WHA effectiveness monitoring program. These data will be collected during the course of white-headed woodpecker call playback and point count surveys.

8.5 WHA Scale – Monitoring Habitat Attributes

We recommend using three $50m^2$ habitat plots per WHA or managed stand. These plots are considerably larger than typical habitat plots because they are designed to capture large well dispersed trees and snags; it is important to measure these parameters accurately. Their nested nature makes the plots cost effective and easy to implement. Two people should be able to finish 6 plots in one day as long as travel time between sites is reasonable.

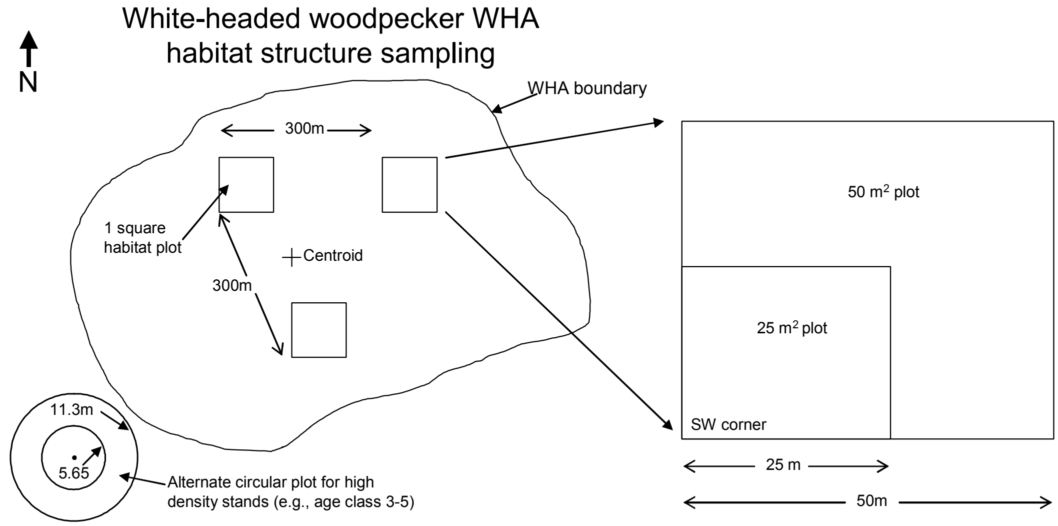
A sample point should be randomly established near the center of the WHA/stand (UTM centroid is effective). From this point, the crew should walk 150m due south. After walking 150m, the nearest tree >20cm DBH should be flagged and blazed. From this "reference tree", a random compass bearing between 280° and 170° is selected. Record all relevant information on the reference tree flagging including the random bearing. The "SW plot corner" is to be located at 15m from the reference tree following the random bearing. A flagged metal pin should mark the SW plot corner and should be obvious because the SW plot corner will have to relocated for future sampling. The reference tree cannot be in the habitat plot. A UTM should be recorded for both the reference tree and the SW plot corner. The SW plot corner of the second and third plots will be located in a 300m triangle from this point and should be established using the same system as plot # 1 (Figure 1). Plot locations should **not** be adjusted to specifically include/exclude aspects of the stand such as older forest types, trees, or rocky outcrops but, rather, should be an unbiased sample of the entire stand. Again, if worker safety will be compromised during the establishment or while conducting the plot, personnel should randomly choose a direction for the plot to be moved. Because this is a long-term monitoring project and plots are intended to be resampled in the future, the original layout and design are extremely important.

Starting in the SW corner, the rest of the $50m^2$ plot can be layed out using a hip-chain and compass (cardinal directions). The boundary of the $50m^2$ plot should be at least 100m from the WHA/stand boundary. A $25m^2$ subplot should be embedded in the southwest corner of the 50 m^2 plot. Flagging should mark the corners of both the $50m^2$ and $25m^2$ plots. The $25m^2$ subplot will be used to measure all trees and snags ≥ 7.5cm DBH and the $50m^2$ plot will be used to measure all trees ≥ 40cm and snags ≥ 7.5cm DBH. Site series for the plot should be taken from the SW corner only and include collecting data relevant for PEM mapping. The following parameters should be measured:

25 m^2 plot = for all live trees ≥7.5cm DBH – species, DBH, wildlife tree class (1 or 2; following Thomas 1979), height, height-to-crown.
for all snags ≥7.5cm DBH – species, DBH, wildlife tree class (3 - 8; following Thomas 1979), height, height-to-crown.
canopy cover taken at the 4 corners of the plot using a spherical densitometer.

50^2 m plot = all live trees ≥40cm DBH – species, DBH, wildlife tree class (1 or 2; following Thomas 1979), height, height to crown.
all snags ≥7.5cm DBH – species, DBH, wildlife tree class (3 - 8; following Thomas 1979), height, height to crown.

Age of the stand should be measured by selecting 2 representative live trees within 20 m of the SW corner. Cores should be taken and counted on site when practical. Pith does not need to be hit and some error is acceptable when estimating stand age. Rings-to-pith (rtp) should be estimated and recorded beside the ring count (*e.g.*, 164 + [7 rtp]). See "Procedure for measuring age on bored trees" in NFR (2003).



25m² plot = all live trees =7.5cm DBH– species, DBH, wildlife tree class (1 or 2; following Thomas 1979), height, height to crown.
all snags =7.5cm DBH– species, DBH, wildlife tree class (3 - 8; following Thomas 1979), height, height to crown.
site-series – taken at SW corner of plot. A PEM card should be filled out to help improve future modeling.
canopy cover – taken at the 4 corners of the plot.
UTM – taken at SW corner of plot.
Approximate age of overstory canopy taken from 2 representative dominant trees within 20 m of SW corner.

50m² plot = all live trees =40cm DBH– species, DBH, wildlife tree class (1 or 2; following Thomas 1979), height, height to crown.
all snags =7.5cm DBH– species, DBH, wildlife tree class (3 - 8; following Thomas 1979), height, height to crown.

Figure 1. Plot layout and design for sampling habitat structure in white-headed woodpecker WHAs.

A random sample of snags and live trees could also be tagged to monitor life history aspects of ponderosa pine stands (*e.g.*, snag creation and persistence). In addition, these plots can be easily adapted to collect information on: the abundance of CWD, understory cover layers, soil depth, shrub and herb dominance by species, lichen and mosses, and % bare soil (see NFR 2003). Finally, we suggest using 3 nested circular plots instead of square plots when sampling structurally immature stands or when density of mature trees is high and large trees are not present in the stand (*e.g.*, age class 3-5; Figure 1). The inner circular plot should be 5.65m in radius and the data collected should be the same as in the 25m^2 plot. The outer circular plot should be 11.3m in radius and the data collected same as the 50m^2 square plot. When using circular plots, all other aspects of the sampling design and data collection remain the same. The basic design and rationale for circular plots can be found in NFR (2003).

8.6 WHA Scale – Conifer Seed Production

Of the all the methods described in this report, the study design for sampling stand-level conifer seed production would benefit the most from a small pilot study. This pilot study should be designed to understand variation at three scales: 1) the number of trees in a stand that produce any cones at all, 2) the number of cones that a tree produces when it does produce cones, and 3) the number of seeds that are produced per cone. Currently, our understanding of these parameters is too poor to have confidence that the methods described for estimating seed abundance are as efficient as they could be. Results from a pilot study could then be analyzed to improve sampling efficiency. A pilot study would only need to be implemented in 3 WHAs and 3 managed stands.

Data collected at these 3 scales can be used to estimate the annual production of conifer cones in a WHA or forested stand. The results can also be used to understand and predict the relationship between ponderosa pine seed production and tree age and stand density. Finally, if stand-level seed production information is collected over multiple years, it will also begin to explain patterns in annual seed production in southern British Columbia.

Ponderosa pine seed production data should be collected using 4 200m long linear transects oriented in a N/S direction. Transects should be systematically spaced throughout the WHA or managed stand at 200 m intervals (Figure 2). The beginning and end of each transect should be at least 100 m from the stand boundary. Conducting these transects is typically more efficient using two observers. One observer should establish the entire transect using hip chain, flagging tape, and a compass. Flagging should be placed at each 20m interval.

Each transect will be composed of a 6m and 50m wide transect. Each transect will be subdivided into 10 20m long sections. The 6m transect (3m on either side of the observer) will be used to sample all living (wildlife tree classes 1 & 2) ponderosa pine trees ≥7.5cm DBH. The 50m transect (25m on either side of the observer) will be used to sample all living ponderosa pine trees greater than 40cm DBH. Data collected on each living tree includes: DBH, wildlife tree class, height, new cones present/absent, and where cones are present the # of new cones. The number of cones should be counted by the observer using binoculars while standing approximately 20 m due east of the tree. When cones cannot be counted from due east, the observer should relocate due west of the tree.

When the transect is finished, 5 trees from the 6m transect and 5 trees from the 50m transect should be randomly selected for conifer cone collection. From each tree, 10 conifer cones should be removed from the east side of the crown and placed in a sealed and labeled bag corresponding to the stand, transect, and tree. Cones should later be dissected to count the number of viable seeds per cone.

The ponderosa pine seed pilot project has purposely been designed to collect more data than is likely necessary to do a good job predicting stand-level seed abundance. The pilot project is designed for an optimization analysis that will select the most cost effective study for all future ponderosa pine seed data collection. This pilot study could also be used to quantify the effect of stand-level ponderosa pine improvement cutting trials on seed production.

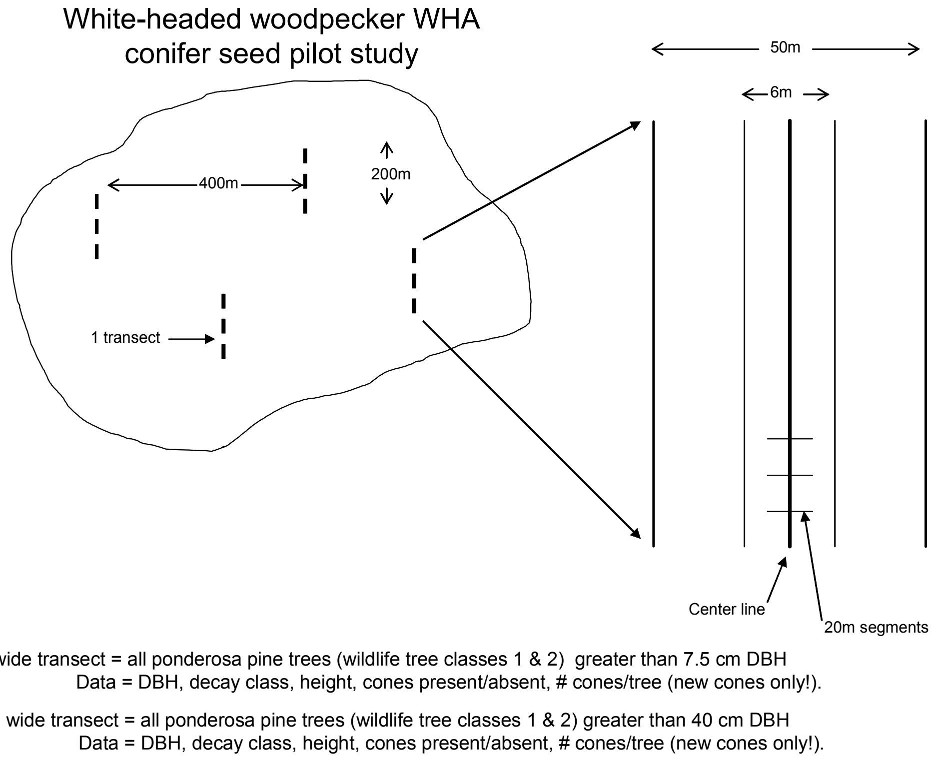


Figure 2. Pilot study transect layout and design for sampling ponderosa pine seed in white-headed woodpecker WHAs.

9 MANAGEMENT FEEDBACK AND DECISION-MAKING

Landscape-level and home range-level analyses can tie into management and decision-making in two primary ways. First, if an objective of the white-headed woodpecker WHAs was linked directly to a landscape/stand-level metric, then these analyses would provide a direct indicator of effectiveness. For example, an objective of WHAs might be to have >20% of the landbase within a 10km radius of each WHA dominated by ponderosa pine >100 years old. In this case, the GIS analyses would directly indicate if a WHA was meeting this criteria, and, therefore, if it was effective. Management actions would need to be taken if the landbase surrounding a WHA had <20% mature ponderosa pine. Second, landscape and stand-level measures can be used to explain variation in the presence/absence of white-headed woodpeckers or the abundance of indicator species at the stand-level. For example, the abundance of pygmy nuthatches might be selected as an indicator for WHA effectiveness; high pygmy nuthatch abundance indicates good white-headed woodpecker habitat. In this case, WHAs that are surrounded by low amounts of mature ponderosa pine habitat are expected to have a fewer pygmy nuthatches than WHAs surrounded by high amounts of mature ponderosa pine habitat. Managers can use this data to make decisions about how forested and non-forested habitat surrounding WHAs could be managed to improve the effectiveness of WHAs.

The use of surrogate indicator species will primarily be used to indicate the availability of important white-headed woodpecker resources in WHAs and the managed landbase. In particular, indicator species are meant to indicate the suitability and productivity of the habitat by measuring the availability of ponderosa pine seeds and bark insects to bird species. These measurements will be accomplished by making comparisons of bird relative abundance between WHAs and the managed landbase and between WHAs with different management systems. They can also be used to determine if the context of WHAs in the landscape affects their use by birds. In the absence of white-headed woodpecker demographic parameters, this data will be the most unambiguous measure of WHA effectiveness. This information can be used to decide which management systems are providing the most suitable white-headed woodpecker habitat in the absence of direct information from white-headed woodpeckers.

Similar to landscape and home range indicators, habitat attributes can be used to directly define and assess objectives or as a means to explain variation in the abundance of indicator species. For example, if an objective of white-headed woodpecker WHAs was to maintain >6 large ponderosa pine snags per ha then "effectiveness" would be directly tied to meeting or exceeding this objective. If this objective were not met, management actions designed to increase snag densities might be considered. Alternately, the abundance of specific habitat attributes could be correlated with the abundance of indicator species. For example, WHAs with a high abundance of large ponderosa pine trees should be expected to have the highest abundance of pygmy nuthatches and Clarks nutcrackers. If this pattern is not observed, it suggests that the WHA management system may not be the most suitable. Managers can use this information to improve the current management system or select a more appropriate one.

Finally, monitoring ponderosa pine seed production will provide a direct measurement of a resource considered limiting to white-headed woodpeckers (Garrett *et al*. 1996). These data can be used to make direct comparisons between management systems and to determine which parameters are most important for enhancing conifer seed production in WHAs. Whether measured directly or indirectly, one of the primary purposes of establishing white-headed woodpecker WHAs is to enhance the production of ponderosa pine seed production in southern British Columbia. Ponderosa pine seed production is influenced by several stand-level attributes that are easily managed for including dominant tree size and density. Implementing a ponderosa pine seed monitoring program will result in direct feedback to the management of WHAs for white-headed woodpecker habitat.

The effectiveness monitoring designs outlined in this report can be used to: determine if WHAs are providing more suitable white-headed woodpecker habitat than the managed landbase, improve the management of environmental parameters important to white-headed woodpeckers, determine what management systems are most effective, and help explain why one management system is better than another (if "management systems" are implemented). They will also increase our ability to develop predictive models that, for example, link seed production to stand level tree age and density. These models will strengthen the ability of managers to determine suitable white-headed woodpecker habitat using remote sensing models alone.

10 PILOT STUDIES, PRODUCTS AND COSTS

Small pilot projects are recommended to evaluate if these methods are providing sufficiently precise data to meet the overall objectives of the WHA effectiveness monitoring program. Pilot projects are strongly recommended to evaluate sampling methodology before beginning long-term monitoring projects (Thompson 2002, Ellingson and Lukacs 2003). Properly designed, they can provide useful, short-term information on the status of white-headed woodpecker WHAs as well as improving the long-term study design so that costs are lowered and precision increased. Pilot projects should focus on implementing a comprehensive effectiveness monitoring program in a smaller number of WHAs (*e.g.*, 6 WHAs and 6 managed landbase comparisons). This approach will keep costs low, allow all the methods to be evaluated and improved before committing to a larger program, provide information on variation between WHAs, and provide useful information on the current status of these WHAs.

A pilot project designed to evaluate the methods discussed in this report would take one year to complete. At the end of one year, a report would be completed that: evaluated and improved the current study designs, collected effectiveness monitoring data on the current status of white-headed woodpeckers in WHAs, established baseline data in WHAs and the managed landbase, suggested future sampling methods and sampling time intervals, and detailed costs associated with a long-term monitoring project. The approximate costs of a pilot project are detailed in Table 2.

Table 2. Approximate 1-year budget for a white-headed woodpecker WHA effectiveness monitoring pilot project. Cost estimates do not factor in any in-kind contributions from industrial or governmental agencies.

Product[1]	**Sampling Design**[2]	**Time of Year**	**Approximate Costs ($)**	**Priority A**[3]	**Priority B**[4]
Landscape analyses	6/6	No time restriction	3000	Medium	Medium
Home range analyses	6/6	No time restriction	3000	Medium	Medium
WHWO presence/absence	6/6	March	7000	Medium	Low
Surrogate species[5]	6/6	February or April/May	18000	Low	High
Habitat attributes	6/6	Late spring-early fall	13000	High	High
Conifer seed production	3/3	Fall	16000	Medium	Low

[1] Includes all aspects of organization, field sampling, data entry, and data analysis. Does not include costs associated with report writing because redundancies and, therefore, report costs will proportionally decline with the total number of products conducted.
[2] Refers to number of replicates (WHAs/managed landbase)
[3] Priorities if WHWO monitoring is the sole focus of the project.
[4] Priorities if monitoring is expanded to focus on the larger ponderosa pine bird community.
[5] Includes sampling each WHA and managed stand 2 times.

11 INFORMATION GAPS, PROBLEMS AND NEEDS

The white-headed woodpecker is a poorly understood species and reasons for their decline in southern British Columbia are unknown. Many wildlife professionals have pointed to habitat loss and management activities such as logging as the primary cause. However, there are many possible explanations for this decline including: habitat loss, interspecific competition, poor stand-level seed production, long times intervals between seed production, a decline in reproductive success in British Columbia, a decline in reproductive rates in Washington state, and a decline in dispersal rates into British Columbia from Washington. Several of these possible explanations are independent of how British Columbia manages ponderosa pine habitat. As a result, it is critical that some level of white-headed woodpecker monitoring occur outside of WHAs.

"The white-headed woodpecker remains one of the most poorly studied woodpeckers in North America" (Garrett et al. 1996). Many of the relationships between white-headed woodpecker demography and their habitat are based on expert opinion. There is little quantitative data describing reproductive success, dispersal, and survival as they relate to forest age and tree species composition. Obviously, this information is critical for managers. Our ability to manage for this species will be greatly improved with every quantitative study that is conducted. However, an increase in the quantitative understanding of white-headed woodpeckers is not likely to come from research in British Columbia because of low densities.

White-headed woodpeckers depend largely on conifer seed for overwinter survival and ponderosa pine is the most important seed source throughout most of its range (Garrett *et al*. 1996). There is little information on which habitat characteristics are most strongly associated with stand-level ponderosa pine seed production. Similarly, the degree to which white-headed woodpeckers can supplement their diet with conifer seed from tree species such as Douglas-fir and spruce remains unknown. This information can have important implications for landscape and stand-level planning.

Niche partitioning between white-headed woodpeckers, wintering Clark's nutcracker and other seed eating birds is not understood. The extent that these species compete for food resources, in particular ponderosa pine seed during the winter, is unknown. If interspecific competition does exist between these species, it may act to limit populations where they are sympatric.

The effect of cattle grazing on white-headed woodpecker habitat is unclear. Grazing and concomitant declines in the frequency of low intensity fires have been implicated as important causes for the reduction of old-growth ponderosa pine habitat in British Columbia (Krannitz 2004). Kingery and Ghalambor (2001) suggest that pine seedling survival is enhanced by cattle grazing because the reduction in grass cover and plant litter results in a lower frequency of low-intensity grass fires. This results in loss of open, old-growth ponderosa pine habitat preferred by white-headed woodpecker. Cattle exclusion trials might be considered for a subset of white-headed woodpecker WHAs. These trials would be intended to remove the effect of grazing on the ecology of ponderosa pine habitat. These trials, however, may be untenable because exclusion trials would likely have to be managed using low intensity ground fires prescribed at 5-15 year intervals. If exclusion trials are possible, it may be appropriate to include Lewis's woodpecker, ponderosa pine, California bighorn sheep, and flammulated owl WHAs in the study design. Cattle exclusion study design and methodology are not discussed in this report.

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APPENDIX 1 - Conceptual Model for Indicators

There are a diverse set of environmental parameters that could be used as indicators in a white-headed woodpecker effectiveness monitoring program. To determine the most relevant and cost effective indicators for evaluating the effectiveness of white-headed woodpecker WHAs, a conceptual model was developed as outlined by Noon *et al*. (1999). Conceptual models are intended to aid in the selection of indicators by outlining links between key ecosystem processes, the structural or compositional attributes characterizing these processes, and the population dynamics of a target species (Lint *et al*. 1999). Using 3 spatial scales, the white-headed woodpecker conceptual model qualitatively outlines the ecosystem processes (disturbances) that affect both white-headed woodpecker demographic parameters and habitat (Figures 1A and 2A). First, intrinsic and extrinsic ecosystem processes relevant to white-headed woodpeckers were identified. Second, the consequences that these ecosystem processes might have on white-headed woodpecker demography and habitat are listed. The third step describes the links between ecosystem processes and indicators that are anticipated to demonstrate measurable responses to these ecosystem processes. Finally, links to management decisions are shown. Thus, the conceptual model links ecosystem disturbances to measurable ecological parameters of white-headed woodpeckers (*i.e.*, indicators). The emphasis of the conceptual model is on the selection of indicators that are of known importance to white-headed woodpeckers, and, therefore, have a direct or indirect link to their demographic parameters. These links allow for possible cause-and-effect relationships between ecosystem disturbances and white-headed woodpeckers to be established; this relationship is necessary to develop a relevant and cost effective means of evaluating and improving WHA management.

White-headed woodpecker indicators were developed at three spatial scales: within-WHA, home range scale (1 km radius surrounding the WHA), and landscape-scale (10 km radius surrounding the WHA). At each scale white-headed woodpecker demographic parameters and habitat parameters were identified. The demographic parameters are clearly the least ambiguous way of examining the effectiveness of white-headed woodpecker WHAs; demographic parameters such as birth rate and survival rate would provide the most direct information about WHA effectiveness. Habitat parameters are usually less expensive to monitor than demographic parameters and are important to managers because habitat is most often the environmental characteristic being managed. Habitat parameters that are directly related to white-headed woodpecker survival, reproduction, and distribution will make the most informative indicators.

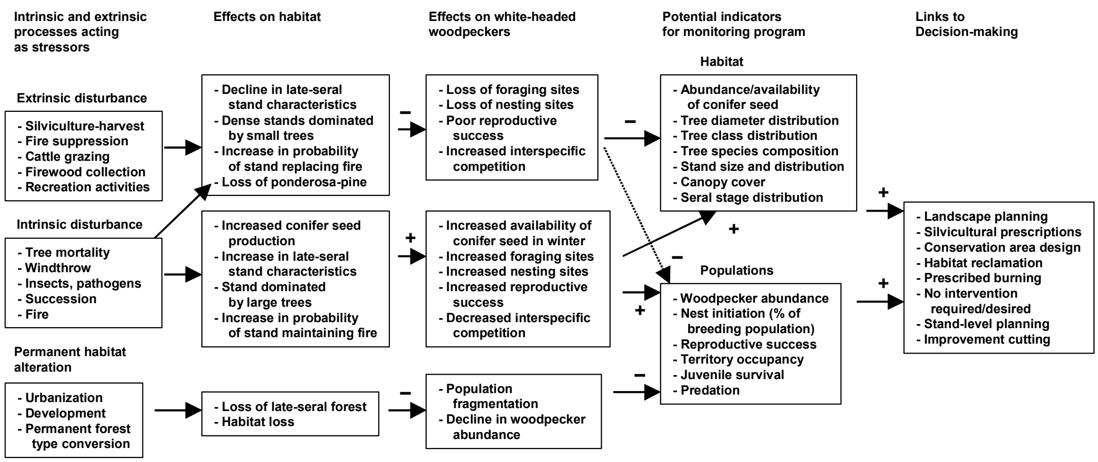

Figure 1A. Home range scale conceptual model.

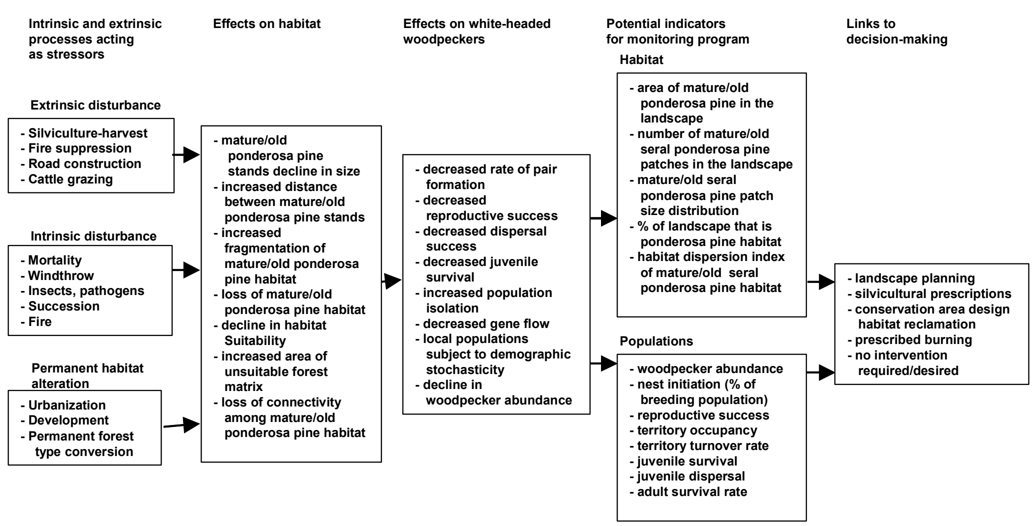

Figure 2A. Landscape scale conceptual model.

APPENDIX 2 - Coding Instructions and Safety Guidelines

Relevant B.C. Bird Codes - Taxonomic Listing

Woodpeckers

LEWO	Lewis's Woodpecker (*Melanerpes lewis*)
RBSA	Red-breasted Sapsucker (*Sphyrapicus ruber*)
DOWO	Downy Woodpecker (*Picoides pubescens*)
HAWO	Hairy Woodpecker (*Picoides villosus*)
WHWO	White-headed woodpecker (*Picoides albolarvatus*)
TTWO	Three-toed Woodpecker (*Picoides tridactylus*)
BBWO	Black-backed Woodpecker (*Picoides arcticus*)
NOFL	Northern Flicker (*Colaptes auratus*)
PIWO	Pileated Woodpecker (*Dryocopus pileatus*)

Chickadees, Bushtit, Nuthatches and Creepers

BCCH	Black-capped Chickadee (*Parus atricapillus*)
MOCH	Mountain Chickadee (*Parus gambeli*)
BOCH	Boreal Chickadee (*Parus hudsonicus*)
CBCH	Chestnut-backed Chickadee (*Parus rufescens*)
RBNU	Red-breasted Nuthatch (*Sitta canadensis*)
WBNU	White-breasted Nuthatch (*Sitta carolinensis*)
PYNU	Pygmy Nuthatch (*Sitta pygmaea*)
BRCR	Brown Creeper (*Certhia americana*)

Etc……………

Daily Equipment List

- Maps
- GPS (using NAD83) and extra batteries
- flagging
- Compass
- Binoculars
- Radio
- Data Forms (includes blank data sheets; data sheet code; species abbreviations)
- Clipboard
- Digital watch(s) and a spare battery
- Thermometer
- Bird field guides
- Several pencils
- Hip chain and extra string
- Extra write in rain paper
- Ear plugs (while riding ATVs/snowmobiles)
- First aid and survival gear
- Headlamp

Point Counts Coding Instructions

General: Criteria for bird surveys will generally follow those outlined by R.I.S.C. (1999-Inventory Methods for Forest and Grassland Songbirds).
Stand ID: Unique WHA/managed landbase code.

Time since last snowfall: for winter surveys record the approximate number of hours since the last significant (*e.g.*, > 2 cm) snowfall. Standardize with your crewmates for each day.
Observer: Initials of person responsible for data collection.
Date: year/month/day (YYYY/MM/DD) on which the data were gathered in the field.
Time Start/End: The time that data collection began and finished (24 hrs).
Ceiling: The height of cloud cover. Record the height at the start and end of the survey. Codes: a/b tt = above/ below tree tops; a/b r = above/below ridges; or h/v h = high/ very high.
Cloud: The extent of cloud cover at the start and end of the survey. Codes: 1 = clear; 2 = scattered clouds (<50%); 3 = scattered clouds (>50%); 4 = unbroken clouds.
Wind: See weather section in RISC Inventory Methods for Forest and Grassland Songbirds (RISC songbirds 1999).
Precip: The type of precipitation at the start and end of the survey. See weather section in RISC Inventory Methods for Forest and Grassland Songbirds (RISC songbirds 1999). For winter surveys the following codes might be used: N = none; F = fog; M = misty drizzle; D = drizzle; LS = light snow; HS = hard snow.
Temp: The temperature at the start and end of the survey (degrees Celsius).
Species: The 4-letter code that uniquely identifies the bird species. If it is not possible to identify the bird to species, record the best taxonomic description possible (in general comments section) and enter in the data sheet UK1, UK2, etc…. The UK stands for unknown species. When foraging flocks are encountered, they will be treated in the same manner as an individual animal. For example, when a flock of 5 chickadees is encountered all of the information will be entered on one line with a single time, single distance at detection, single activity, etc… If a second flock is heard during the same point count, this will be entered separately. Observers will estimate the size of the flock when necessary. Observers will record all birds seen or heard and mark them as in/out of the stand boundaries during each point count. Also, every effort will be made to ensure that each bird (or flock) is recorded only once per point count. When there is uncertainty if the animal has already been recorded, the observation will be entered. Similarly, observers will not record the presence of a bird more than once per stand being sampled (*e.g.*, during the 8-12 point counts) when it is clear that the bird has already been recorded. This is likely to be a greater issue for loud, territorial species such as pileated woodpeckers and owls.
Distance at Detection: Best approximation of horizontal distance (to the nearest 5 m if possible) between the observer and the bird when it is **first** detected.
Activity: Behaviour of the bird when it was first detected. T = territorial defense/sexual display; G = foraging/feeding; Y = flying; O = other.
How Det?: The type of detection. Codes: V = visual; C = call; S = song; A = other auditory cues (*e.g.*, flight, drumming, or foraging).
Structure: Record which structural element was being used when the bird was first observed. Sh = Shrubs; Sn = Snags; LC = Live Conifer; LD = Live Decidious; NA = not applicable – as in the case of birds flying overhead etc…; UK = unknown.
#: Number of birds of the same species that were detected in a single cohesive group. Observers will estimate when necessary.
TB: = Treatment Boundary. Observed birds will be marked with a Y (yes) when they are in the treatment and a N (no) when they are outside of the treatment boundary. The horizontal treatment boundaries will not extend beyond the polygon (or group of polygons) that has been identified by age class, site series cluster, and landbase type. The vertical treatment boundaries will end 10m above the treetops. Species such as ravens that are simply flying overhead will be counted as out of the treatment boundary.

If the point count is disrupted for some reason (*e.g.*, airplane or snowmobile noise). Abandon the point count completely and restart after the interruption has passed. If the interruption is intermittent but chronic making it difficult to get 10 minutes of uninterrupted silence (eg., proximity to highway or logging operations), the observer may break the point count into subsections (*e.g.*, 2 minute intervals) when it is practical to do so. A census period may have to be abandoned completely if the interruptions are too severe.

Presence/absence

Record bird species that were detected outside of the point counts (*i.e.*, while in the stand boundaries walking to the first point count or between point counts). Only birds located within the stand boundary should be recorded. For this information, there is no need to record details such as distance at detection, number, etc…..; simply record the species code. This cumulative presence/absence list does not need to include animals heard during a point count. In effect, these are two separate studies. Also, it is **critical** that a bird heard during a point count be recorded even if it was previously recorded in the incidental birds column. For example, if you hear a hairy woodpecker while walking toward point count station # 7, you can record this information in the Incidental Birds column. If you then hear the same hairy woodpecker while at point count # 7, you must enter the observation again. Overall, this information is primarily a venue to record rare or unusual sightings such as owls or woodpeckers.

General Safety

All field personnel should be required to carry safety equipment, a radio, first aid equipment, and survival gear (eg, matches and extra food) while in the field. It is the responsibility of field personnel to ensure that they are carrying this equipment everyday.

Field personnel should not start or ride ATVs/snowmobiles without proper hearing protection. Besides being a really smart thing to do, wearing hearing protection will add to the accuracy and precision of any bird study. Since there is concern about both accuracy and precision, it is absolutely essential that field crew take precautions with respect to hearing.

An appropriate check-in procedure should be in place for personnel when they are in the field.