Extension Note

BC Journal of Ecosystems and Management

Arrow IFPA Series: Note 5 of 8

Criterion 1: Biological richness

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Abstract

This extension note is the fifth in a series of eight that describes a set of tools and processes developed to support sustainable forest management planning and its pilot application in the Arrow Timber Supply Area (TSA). It summarizes the criterion and indicators used to set thresholds and evaluate potential impacts on biological diversity for the sustainable forest management (SFM) pilot basecase analysis for Lemon Landscape Unit. Initial thresholds were developed for some indicators, and measures for others, to assess the SFM basecase harvest scenario. Although this did not represent a comprehensive evaluation, preliminary results indicate that under the SFM basecase scenario, habitat attributes (e.g., snags) associated with late seral stands were met primarily in the non-harvested land base, and may be unsustainable for biodiversity objectives. Retention strategies in the harvested land base are therefore important, but could not be assessed for their potential contribution to late seral attributes because of the lack of available models.

This extension note provides both an example of how criteria and indicators can be applied to evaluate SFM scenarios, using indicators to set targets and thresholds, and a framework for evaluation. Some indicators, based on dynamic habitat elements (e.g., snags, downed wood, and understorey vegetation), require models to project these elements across a range of stand types and stand treatments. If these models are to act as effective tools, further development and refinement is required to ensure that they are calibrated and verified with field data. Our understanding of habitat thresholds also needs improvement to better define risks and appropriate management responses.

KEYWORDS: *biodiversity indicators, habitat elements, habitat modelling, sustainable forest managment.*

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Wells, R., D. Haag, I. Houde, B. Seely, and F.L. Bunnell. 2006. Arrow IFPA Series: Note 5 of 8. Criterion 1: Biological richness. *BC Journal of Ecosystems and Management* 7(1):76–84. URL: ***http://www.forrex.org/publications/jem/ISS34/vol7_no1_art5.pdf***

Introduction

Protection of biodiversity increasingly resonates with public concerns and has become a focus for forest managers in British Columbia, particularly since Canada became a signatory to the Convention on Biological Diversity (United Nations 1992). Results from surveys of Arrow Timber Supply Area (TSA) residents and from workshops involving stakeholders of the Lemon Landscape Unit (see Figure 1, Extension Note 1; see sidebar) suggest that biodiversity is an important issue locally (Extension Note 3).

In this note, we provide a summary of our work to date, which is detailed in Wells *et al.* 2002. We discuss an approach to evaluate harvest scenarios for biodiversity impacts that uses one criterion and three indicators; we also demonstrate the use of indicators, within a decision-support context, for the SFM pilot basecase analysis in the Lemon Landscape Unit.

The intent of this criterion is to maintain productive, well-distributed populations of native species in a defined management area.

Criterion and Indicators

Finding a definition of biological diversity that is useful to managers has proven elusive as biodiversity potentially encompasses genes, species, ecosystems, and ecological processes and their variability. More simply, biodiversity is an attribute of life, the differences among living entities (Bunnell 1997, 1998a). Although the term "biodiversity" represents a complex cluster of concepts, managers often are under pressure to manage for the "thing."

Given the inherent complexity of biodiversity, species richness can be used as a credible interim surrogate for a criterion intended to maintain biological diversity (e.g., Bunnell 1998b; Bunnell *et al.* 2003). The intent of this criterion is to maintain productive, well-distributed populations of native species in a defined management area. Species richness meets the standards for SFM criteria: it is a goal that may be tested in a cost-effective and scientifically credible manner with the application of three indicators designed to assess success in achieving the goal.

The criterion and following three indicators for maintaining biological richness were based on those developed by the Weyerhaeuser Adaptive Management Working Group and implemented on Weyerhaeuser's

The IFPA Sustainability Project

The Arrow Innovative Forestry Practices Agreement (IFPA) was established as a co-operative effort between the five licensees* in the Arrow Timber Supply Area (see Figure 1, Extension Note 1) and the B.C. Ministry of Forests' Nelson Forest Region. The Sustainability Project was an important initiative of the Arrow IFPA that partnered forest practitioners and academic researchers to develop a comprehensive approach to planning and implementing sustainable forest management.

The result of this work has been the Sustainable Forest Management Framework, which is now being used by Canfor* to guide certification and sustainable forest management planning in their British Columbia operations. For further background, refer to: *http://www.sfmportal.com*

Disclaimer

The ideas presented in this extension note form part of a project (outlined in a series of eight notes) that was initiated to develop a system for evaluating management options under a criteria and indicators framework. These ideas do not represent real management options for the Lemon Landscape Unit, or the Arrow TSA, although they could form the basis of such options.

* The Arrow Forest Licensee Group was comprised of Slocan Forest Products, Kalesnikoff Lumber, Atco Lumber, Riverside Forest Products, and Bell Pole. In 2004, Slocan Forest Products Ltd. was acquired by Canadian Forest Products Ltd.

British Columbia coastal tenure (see Bunnell *et al.* 2003 for detailed descriptions and rationales for the indicators). Below, we provide a brief summary. A description of how the indicators were applied in the SFM basecase follows.

Criterion 1: Biological Richness and its Associated Values are Sustained Within the Arrow Timber Supply Area

Indicator 1

Ecologically distinct ecosystem types are represented in an unmanaged state in the Arrow TSA to sustain lesser-known species and ecological functions.

Indicator 1 is intended to ensure that little-known species and functions are sustained. It covers species that may not be assessed by Indicators 2 and 3, and provides unmanaged "benchmarks." Representation is determined by assessing the amount and proportion of area in the non-harvested land base for all ecosystem types within a management unit.

Indicator 2

The amount, distribution, and heterogeneity of habitat elements and landscape structure important to sustain biological richness is maintained in the Arrow TSA.

Indicator 2 is intended to complement Indicator 1 by focussing on the maintenance of important habitat elements and landscape structures in the harvested land base. The focus of this indicator is on habitat elements that are manipulated by forest management and that are associated with a large portion of vertebrates. Key sub-indicators for terrestrial vertebrates have been identified and include dead and dying trees, downed wood, riparian habitat, hardwoods, shrubs, and structural stages (Bunnell *et al.* 1999).

Indicator 3

Productive populations of selected species or species guilds are well distributed throughout the range of their habitat in the Arrow TSA.

Particular species or guilds are proposed to monitor the effects of forest practices on species populations across the current range of their distribution within the TSA. Species selected for monitoring are used to evaluate whether staying within initial thresholds for Indicators 1 and 2 will sustain well-distributed populations of species. In addition to maintaining habitat through Indicators 1 and 2, specific habitat requirements may be managed to maintain productive populations of species of special management concern.

Applying the Concept: The Sustainable Forest Management Pilot Basecase Analysis

The goal of the SFM pilot basecase analysis for the Lemon Landscape Unit was to evaluate initial thresholds developed for multiple indicators (see Extension Note 4). We developed measures and selected some initial thresholds for the three Criterion 1 indicators. Many of these initial thresholds were applied here as an example of the approach. They are not intended to represent real management options at this stage. Our analyses also reflect natural disturbance projections in the non-harvesting land base (NHLB) that were based on rates set out in the Forest Practices Code (FPC) *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment 1995a) (Extension Note 4).

Indicator 1

For Indicator 1, we evaluated the representation of ecosystem types in the Lemon NHLB and developed thresholds for under-represented types. Ecosystem types were defined according to the "fine" site series groupings described by Huggard (2000) for the Arrow TSA. Of the 15 fine site series clusters that occurred in the Arrow TSA, nine occurred in the Lemon Landscape Unit. For these nine clusters, we developed the following four selection standards to identify under-represented clusters and to set initial thresholds:

1. Uncommon at the TSA level (< 5% by area)
2. Relatively low proportion of area in the Arrow TSA NHLB (< 35%)
3. Disproportionately high area in the Lemon Landscape Unit (> 4% of TSA)
4. High responsibility (significant portion of the provincial distribution found in the Arrow TSA)

Of the nine ecosystem types in the landscape unit, two met all selection standards (i.e., subhygric Engelmann Spruce–Subalpine Fir [ESSF] biogeoclimatic zone, ESSF wc4 01), and one met all but standard 3 (subhygric Interior Cedar–Hemlock [ICH]) (Table 1, Figure 1). Because the subhygric ESSF is very rare (0.4% of the TSA), we set an initial threshold of 100% representation; an initial threshold of 50% representation was set for the other two clusters. Additional areas were selected and reserved to meet these initial thresholds (Table 1; see Wells *et al.* 2002 and Huggard 2000 for further details).

TABLE 1. Ecosystem types in the Lemon Landscape Unit showing area reserved to meet initial thresholds for representation (*italics* = under-represented types)

Ecosystem type	% TSA	% TSA in non-harvesting land base	% TSA in landscape unit	Area in landscape unit (ha)	Additional area reserved (ha)
Subhygric ESSF	*0.4*	*25.0*	*9.1*	*222*	*151*
ESSFwc–site series 01	*2.8*	*32.1*	*6.9*	*1251*	*400*
Subhygric ICH	*2.8*	*33.6*	*1.3*	*242*	*22*
Mesic ICHmw/dw	50.3	33.7	2.8	8943	
ICHmw2–site series 03	8.8	37.8	4.3	2448	
Mesic–xeric ESSFwc1	11.1	40.3	5.8	4105	
Xeric ICH mw/wk	2.4	50.4	2.8	427	
ICHdw–site series 02	1.1	60.0	3.5	255	
Drier ESSFwc4	18.5	61.2	7.0	8241	

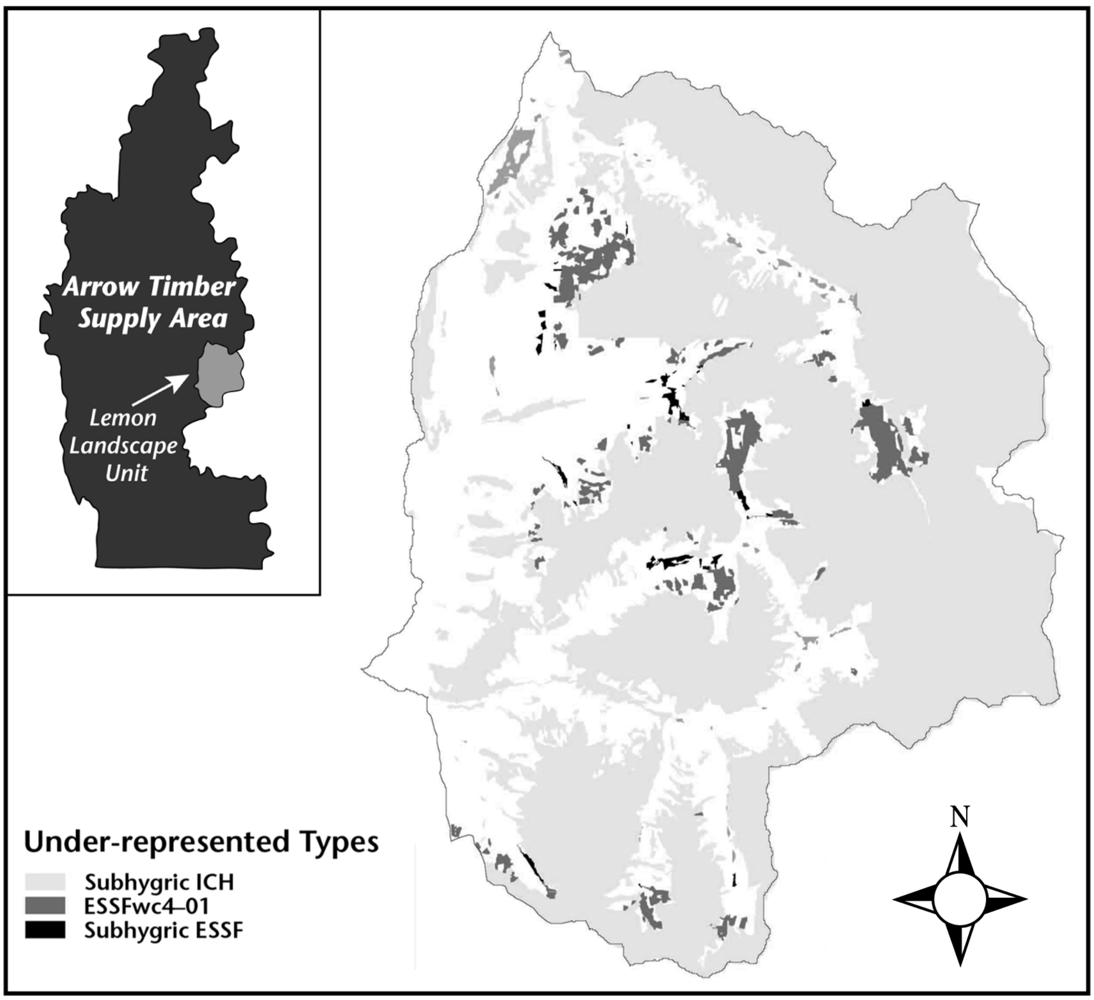

FIGURE 1. Under-represented ecosystem types in the Lemon Landscape Unit timber harvesting land base.

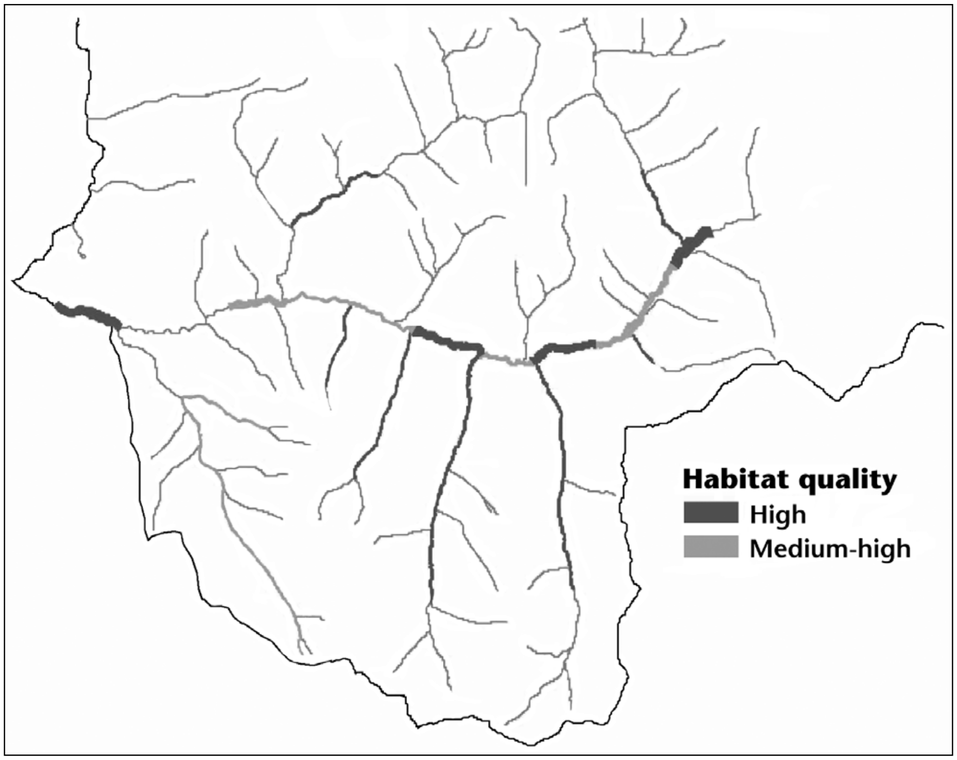

FIGURE 2. High and medium–high riparian habitat along Lemon Creek. Buffer widths represent average riparian widths.

Indicator 2

For Indicator 2, we considered six important habitat elements (Bunnell *et al.* (1999) that were proposed as sub-indicators for the Arrow TSA by Bunnell and Houde (2000): dead and dying trees, downed wood, riparian habitat, hardwoods, shrubs, and seral stages. We chose not to evaluate downed wood because of the complexity of tracking it in a modelling environment. Instead, we set old seral thresholds and developed measures for late seral snags, both of which can be considered as surrogate indicators of downed wood. We also did not evaluate hard-woods because forest cover inventory suggested that hardwoods were not prevalent in the Lemon Landscape Unit, although abundant in other areas of the TSA. Given their importance as a habitat attribute, hard-woods should nonetheless remain a management priority for the landscape unit, but likely are best managed at the stand level. We undertook analyses of four measures used to represent Indicator 2:

1. Riparian habitat
2. Seral stages
3. Late seral snags
4. Shrubs

Riparian Habitat

Riparian habitat was treated as a landscape element for the SFM pilot basecase analysis. Because forest cover and other spatial databases had little to no riparian information, riparian habitat was classified using air photos. We excluded S4 and S6 streams (B.C. Ministry of Forests and B.C. Ministry of Environment 1995b) because air photos and existing spatial data were not sufficient to identify small streams.

Structural components used to define riparian reaches included riparian width, slope, presence of deciduous cover, large trees, multi-layered canopy, and horizontal patchiness (canopy openings). These structural components were then used to classify riparian habitat into different habitat quality categories; buffer widths were assigned according to estimated riparian width (50–200 m). For example, Figure 2 shows stream reaches along Lemon Creek that were classified as "high" quality (all components present) and "medium–high" quality (all but one component present).

Initial no-harvest thresholds were set for all FPC-based riparian reserves and for buffers assigned as high and medium–high quality riparian habitat. These reserves were generally larger that FPC reserves, ranging from 50 to 200 m in width.

Seral Stages

As a starting point for evaluation, initial thresholds for late seral were based on the FPC guidelines for high biodiversity emphasis landscape units (B.C. Ministry of Forests and B.C. Ministry of Environment 1999). These thresholds were further refined through iterations of the SFM pilot basecase analysis (Extension Note 4). We defined seral stages as early, immature, mature, and late seral, according to those given in the FPC *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment 1995a). Partially cut stands were not assigned a seral stage.

We used the SIMFOR model (see Wells and Moy 2002 for a description of SIMFOR) to evaluate seral stage distributions from the SFM basecase. Although we found that all seral stages were maintained over the entire forested landscape under the SFM basecase (Figure 3a), very little late seral occurred in the timber harvesting land base (THLB) after 100 years (approximately one rotation; Figure 3b). Work by Huggard demonstrating lower levels of late seral attributes such as snags in the NHLB compared to the THLB (Huggard 2001) suggests that a strategy which is overly dependent on the NHLB needs further evaluation. Wildlife tree patch and other stand-level retention strategies could be evaluated for their contribution to retaining structure in the THLB.

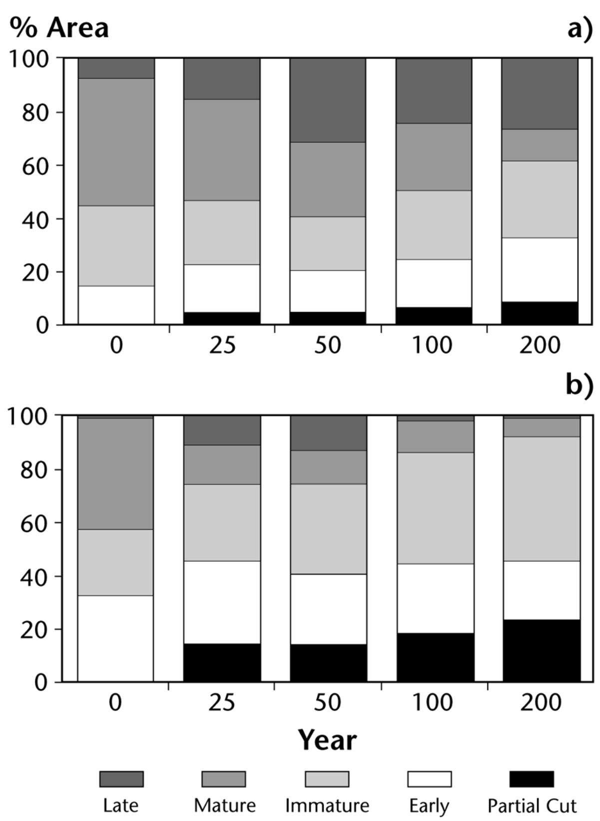

FIGURE 3. Seral stage distributions in: (a) the whole landscape; and (b) the timber-harvesting land base.

Late Seral Snags

We chose to focus on snags in older stands for the SFM pilot basecase analysis. We did not evaluate early seral snags, such as those found after wildfire or in some retention strategies (i.e., partial cutting regimes), for two reasons:

1. we lacked data on snag levels associated with specific retention treatments and different natural disturbance regimes; and
2. we believed that an evaluation of late seral snags in the NHLB should occur first to provide context for potential thresholds in the THLB.

The density of snags (stem per hectare) greater than 30 cm DBH and 0–25% decayed was projected using the FORECAST model (see Kimmins *et al.* 1999 for a description of FORECAST), and modelled at the landscape level using SIMFOR. Projections were made for both managed and unmanaged stands. These projections were preliminary; validation of models against local data would be necessary before further application of the snag models in the study area. We assumed that all snags within 50 m of each cutblock would be removed, according to current safety regulations (Workers' Compensation Board 2005). We did not set initial snag thresholds, but simply evaluated the changes in snag density resulting from the SFM basecase scenario. Snag densities were reported by harvest class (THLB, NHLB) and by fine site series cluster (Wells *et al.* 2002).

Over time, snag density was substantially reduced in the THLB under our scenario assumptions, while snag levels in the NHLB remained relatively constant under the natural disturbance assumptions (Figure 4a, b). When snag densities were evaluated for each site series cluster found in the Lemon Landscape Unit, results similar to those described above were found for common (mesic and submesic) ecosystem types. Conversely, relatively uncommon (subhygric and xeric) ecosystem types often lacked snags for portions of the scenario projection under the NHLB natural disturbance assumptions. These latter types could be a focus of further evaluations of stand-level retention strategies.

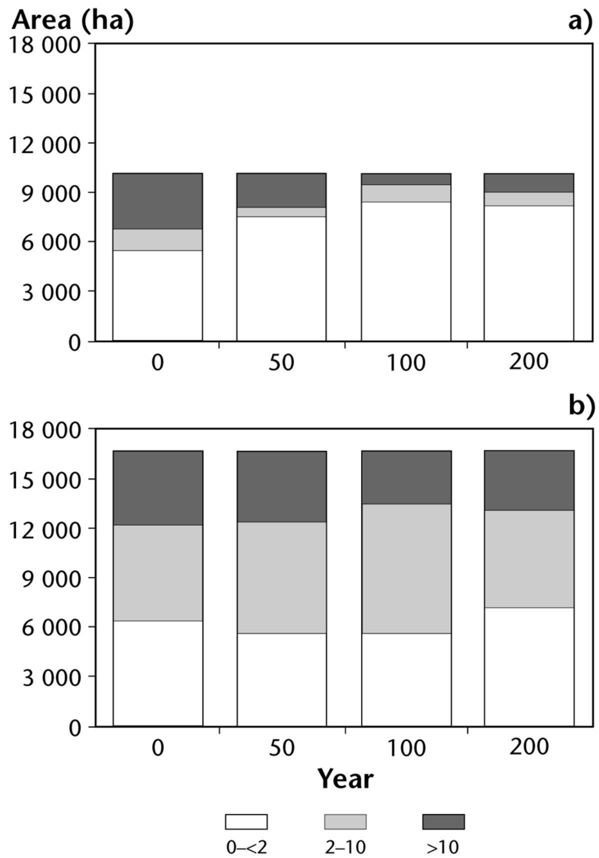

FIGURE 4. Snag-density classes (stems per hectare; > 30 cm DBH) in the Lemon Landscape Unit: (a) timber-harvesting land base; and (b) non-harvesting land base under the SFM basecase scenario. The results for the THLB include removal of snags within 50 m of harvest edges.

We also found that snag removal from mature forests along cutblock edges (50 m) could have significant effects on snag density in the THLB. The snag removal assumptions we modelled resulted in a 14–28% reduction of forested area that otherwise would have snag densities greater than 10 per hectare (Wells *et al.* 2002).

Understorey Vegetation

We identified three different classes of understorey vegetation: riparian, under-canopy, and early seral–upland. Riparian reserves were assumed sufficient to maintain the riparian understorey component; similarly, late seral patches were considered adequate to maintain the understorey component. We modelled early seral–upland understorey vegetation using FORECAST projections (with fireweed as a proxy for shrubs) for managed and unmanaged stands. We did not set thresholds for early seral–upland shrubs, but tracked the sub-indicator by management class (NHLB and THLB) and by fine site series cluster (Wells *et al.* 2000).

Results are not shown here (see Wells *et al.* 2002), but were consistent with seral stage results (Figure 3). These results show that overall area with abundant early seral understorey vegetation was increasing under the SFM basecase. This implies that early seral understorey vegetation is sustainable under the SFM basecase; however, further work should evaluate shrub and forb species and consider current stand-tending practices designed to promote the establishment of the conifer layer.

Indicator 3

For Indicator 3, focal species can be selected as indicators to test habitat thresholds (Indicators 1 and 2) or because they are species that have been identified as having special management concern. The selection of indicator species for the Arrow TSA is discussed further by Houde and Paczek (2002).

Indicator Species

Indicator 3 is intended to monitor the effectiveness of management objectives developed for Indicators 1 and 2. Many owls are secondary cavity users, depending on cavities excavated by other species and on the availability of large snags for nesting. For the Lemon Landscape Unit, we selected the boreal owl (*Aegolius funereus*), found in higher-elevation forests, and the northern saw-whet owl (*Aegolius acadicus*), found in upland stands at lower elevations. These species were selected to test the effectiveness of stand-level management applied for snags and late seral (Indicator 2), and representative ecosystems in the NHLB (Indicator 1). Habitat models based on biogeoclimatic ecosystem classification variant, snag density, and stand age (northern saw-whet owl), or snag density, stand age, and stand type (boreal owl) were developed from owl survey data collected in the Lemon Landscape Unit (Houde *et al.* 2001). Projections of owl habitat indicated substantial reductions in the area of higher-quality habitat over time under the SFM basecase for the northern saw-whet owl, although little change in habitat quality and quantity was observed for the boreal owl (see Wells *et al.* 2002 for details). These results suggest that management for one late seral attribute (snags) may be inadequate to sustain some species in the landscape unit unless better retention of snags occurs in the THLB than that provided in the basecase scenario.

Indicator 3 is also intended to set management objectives for specific species of management concern.

Based on results from the multi-criteria analysis process (Extension Note 3), and interviews with local stakeholders and agencies, bull trout (*Salvelinus confluentus*; a blue-listed fish species) and mule deer (*Odocoileus hemionus*) were identified as species of special management concern in the Lemon Landscape Unit. Based on a review of literature and local interviews, we developed and applied habitat objectives for these species in the landscape unit for the basecase analysis. For bull trout, these included 20-m buffers on non-fish-bearing upstream reaches of Lemon Creek, which were intended to reduce water temperature and siltation in spawning areas (Wells *et al.* 2002). For mule deer, we applied a no-harvest constraint on important winter range (based on local data) found in the Lemon Creek drainage (Wells *et al.* 2002). Bull trout buffers and mule deer no-harvest zones were applied as constraints in the harvest scenarios evaluated in Extension Note 4.

Future Directions

We have outlined and illustrated an approach to evaluate management plans for maintaining species richness in forested landscapes. This approach demonstrates that a criteria and indicators framework can be used to develop management thresholds and ways to track indicators, as shown by the SFM pilot basecase analysis. The scope of this project was not intended to be comprehensive. A full evaluation would require assessment at larger scales (i.e., the Arrow TSA level) and linkages to monitoring programs to address uncertainties about the appropriate thresholds and targets intended to sustain species (Bunnell and Dunsworth 2004). We suggest the following priorities to further develop approaches for evaluating biodiversity indicators in SFM planning scenarios:

1. **Further evaluate management strategies for maintaining late seral attributes.**

   Though this was an example and not a comprehensive evaluation, our results indicate that, under the SFM basecase scenario, habitat attributes associated with late seral stands (e.g., snags) were met primarily in the non-harvested land base, and declined substantially in the timber harvesting land base. These results suggest that retention strategies in the harvested land base are important, and a priority for further evaluation.

2. **Continue to develop management thresholds.**

   More work is required to develop sound standards for setting management thresholds for representation (Indicator 1), habitat elements and landscape structures (Indicator 2), and species of management concern (Indicator 3). The synthesis work of Bunnell *et al.* (1999) provides some direction on initial thresholds for some habitat elements. The general paucity of knowledge regarding species requirements for specific habitat elements (such as those used to estimate initial management thresholds for the basecase analysis) underlines the need for modelling to be complemented with field-based monitoring programs (e.g., Kremsater *et al.* 2003). Results from modelling exercises such as ours can help determine the focus of such monitoring programs.

> *This approach demonstrates that a criteria and indicators framework can be used to develop management thresholds and ways to track indicators.*

3. **Continue to develop models.**

   If we wish to use indicators that are based on habitat elements (e.g., snags, downed wood, and understorey vegetation), we require models that project habitat elements across a range of stand types and stand treatments. For example, we were unable to model snag recruitment in the partial-cut treatments in our scenarios because no data were available to calibrate models. We need to further develop and refine these models, and to ensure that they are calibrated and verified with field data, if they are to act as effective tools for evaluating management scenarios for the biological richness criterion.

4. **Improve inventory for indicators.**

   Inventory investments should reflect data requirements related to habitat indicators (e.g., current forest inventories were inadequate to classify riparian habitat).

Acknowledgements

Publication of this series of extension notes has been supported by Atco Lumber, Bell Pole, Kalesnikoff Lumber, Riverside Forest Products, and Slocan Forest Products, the Ministry of Forests' small business program, and the University of British Columbia, as well as by the British Columbia Ministry of Forests and Range through the Forest Investment Account, Forest Science Program.

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ARTICLE RECEIVED: **July 15, 2005**

ARTICLE ACCEPTED: **January 31, 2006**

Test Your Knowledge . . .

Arrow IFPA Series: Note 5 of 8 – Criterion 1: Biological richness

How well can you recall some of the main messages in the preceding extension note?
Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. Which indicator is intended to sustain little-known species and functions?

2. What are six habitat elements important for sustaining species in forested landscapes?

3. What management activity resulted in up to a 28% reduction of area of stands with high snag density under the management assumptions modelled?

ANSWERS

1. Indicator 1.

2. Dead and dying trees, downed wood, riparian habitat, hardwoods, shrubs, and seral stages.

3. Snag removal in mature forests adjacent to cutblock edges.