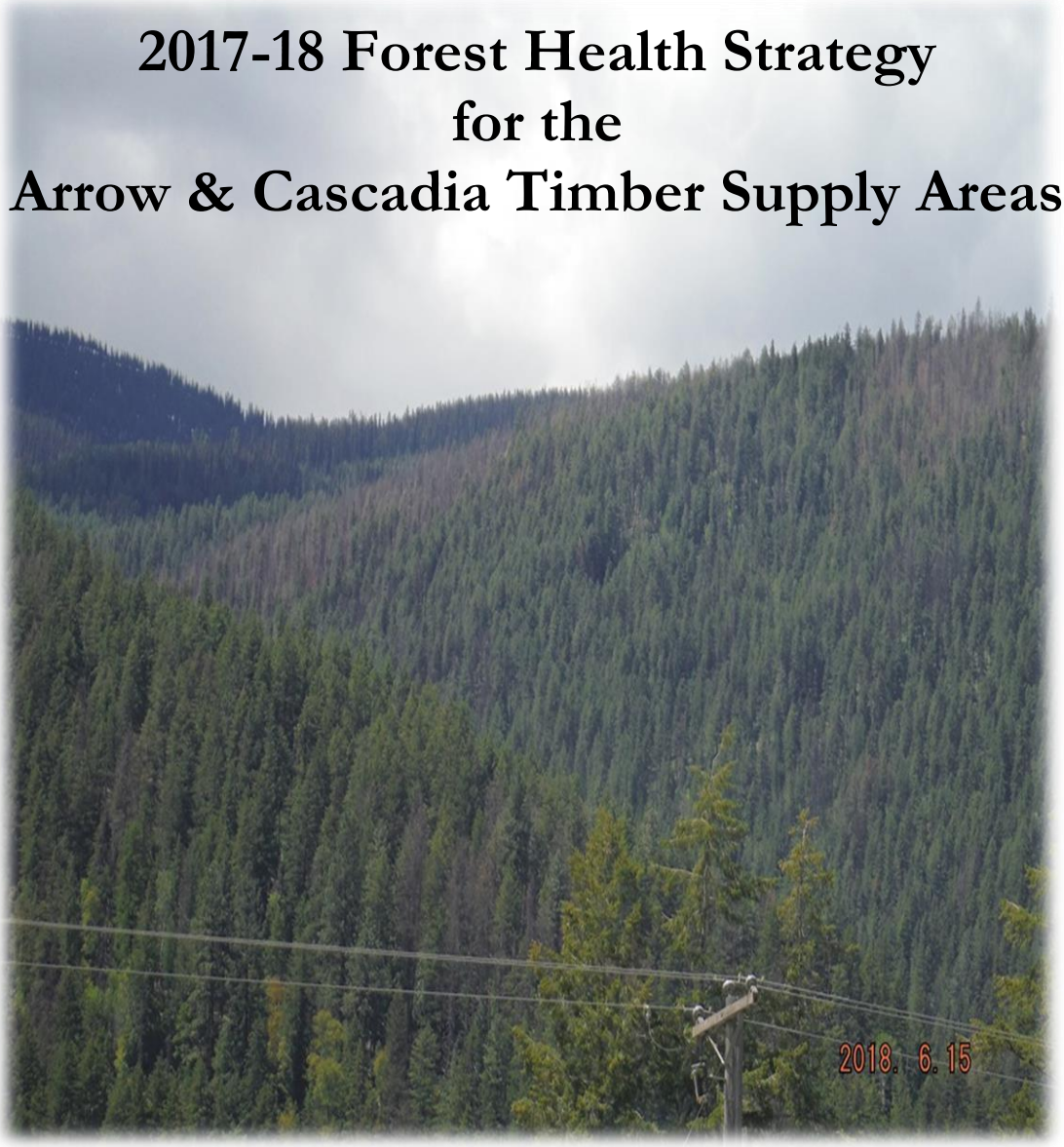
2017-18 Forest Health Strategy
for the
Arrow & Cascadia Timber Supply Areas



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IBD funnel trapping

1. Goal

The goal of this Forest Health Strategy is to serve as a resource for directing forest health management and for communicating hazards or other relevant information on major pests in the Arrow Timber Supply Area (TSA) including Cascadia TSA and other area based tenures with Arrow TSA including TFLs, CFAs and Woodlots. It provides some of the tools necessary to improve sustainability and resiliency of forested ecosystems by identifying strategies and tactics to minimize losses from damaging insects, diseases and abiotic disturbances.

2. Objectives

The overall objective is to minimize timber losses and the hazard and risk from forest health factors by:

- maintaining a detection program for forest health agents over the land base;
- assessing the potential risks and impact of the identified forest health agents on resource values and timber supply;
- identifying prevention and suppression strategies and tactics for major pests;
- implementing ecologically sound, economically feasible and socially acceptable mitigating strategies and tactics to address forest health agents while considering constraints and limitations placed on the land base;
- encouraging and fostering knowledge sharing on forest health agents amongst Arrow TSA forest stakeholders, primarily forest tenure Licencees;
- evaluating management practices for the purposes of adaptive management; and
- Provide strategic direction for management activities.

2.1 Provincial Forest Health Mandate

The goal of the Provincial Forest Health Program is to manage pests to meet forest management objectives. The provincial government's three key strategic forest health objectives are to:

1. **Pest impacts are monitored and assessed**
   The evaluation of pest impacts on forest resource values is supported by forest health monitoring and assessments.
2. **Practices are adapted to accommodate known forest health risks**
   Forest practices are modified to minimize the impacts of forest health factors based on the best available information.
3. **Resources are protected**
   Forest resources are protected from pest damage through appropriately applied direct management actions.

Additional information on the Provincial Forest Health Program can be found at:
https://www.for.gov.bc.ca/hfp/health/index.htm#first

3. Arrow TSA Description

The Arrow Timber Supply Area (TSA) lies in the West Kootenay area in the southeastern part of the province and is part of the Selkirk Resource District. The TSA covers 605,640 hectares (ha). Management units include: Arrow TSA, Cascadia TSA, Tree Farm Licences 23 and 3, Valhalla Provincial Park, Goat Range Provincial Park and Kokanee Glacier Provincial Park. The main communities in the TSA are Trail, Castlegar, Nakusp, and Rossland.

Table 1: Total Volume (m^3) by Species Composition for Arrow TSA & Cascadia TSA(Arrow portion only), over 60 yrs old as of March 2017. Does not include TFL23, TFL3, Parks or private land.

Species	Leading Species Total Volume m^3 (>= 60 yrs)	Secondary Species Total Volume m^3 (>= 60 yrs)	Third Species Total Volume m^3 (>= 60 yrs)	Fourth Species Total Volume m^3 (>= 60 yrs)	Totals	Species %
Douglas-fir FDI, FD	31,698,997	6,290,003	2,410,938	668,909	**41,068,847**	**23%**
Spruce SE, SX, S	18,528,073	11,138,496	2,558,841	810,917	**33,036,327**	**19%**
Sub-alpine fir BL, B	18,800,427	7,010,059	1,270,867	511,714	**27,593,067**	**16%**
Hemlock HW, Hm, H	15,999,729	4,938,916	1,524,271	427,340	**22,890,255**	**13%**
Western Larch L, LW	10,328,008	6,223,060	2,192,461	1,010,460	**19,753,989**	**11%**
Lodgepole Pine PLI, PL	8,628,481	3,561,558	2,711,306	826,721	**15,728,066**	**9%**
Western Red Cedar CW	3,782,947	3,708,368	1,392,592	513,490	**9,397,397**	**5%**
Trembling Aspen AT	1,005,684	518,703	341,914	289,943	**2,156,244**	**1%**
Paper Birch EP	659,882	402,395	302,540	240073	**1,604,890**	**1%**
Western White Pine PW	100,613	226,512	461,905	388,508	**1,177,539**	**1%**
Cottonwood ACT, AC	408,752	134,827	100,817	82,834	**727,230**	**0%**
Grand fir BG	322,361	127,722	89,330	67,191	**606,604**	**0%**
Ponderosa pine PY	109,087	364,952	81,998	47,305	**603,343**	**0%**
Whitebark pine PA	21,928	130,177	98,702	12497	**263,304**	**0%**
Alpine Larch LA	138	1,738	1,441	1,881	**5,197**	**0%**
Totals	**110,395,109**	**44,777,486**	**15,539,922**	**5,899,783**	**176,612,300**	

The inventory data indicates that many of the stands in the Arrow TSA are approaching age and diameter thresholds which will make them more susceptible to attack from insects such as bark beetles.

The TSA is situated in the Interior Wet Belt, and its forests are among the most productive in the B.C. interior. Major biogeoclimatic zones include the Interior Cedar Hemlock, Engelmann Spruce-Sub-alpine Fir, and Alpine Tundra zones. A few small areas in the Lower Arrow Lakes are classified as Interior Douglas-fir zone. The dominant tree species (10% or greater) are Douglas-fir, Spruce,

Sub-alpine fir, Western Hemlock and Western larch, Spruce. Minor species found in the TSA include Lodgepole pine, Western red cedar, Western white pine, Grand fir, Ponderosa pine, Whitebark pine and Broadleaf species. As a result of fires at the turn of the century, only 16 percent of all stands are over 140 years. The majority of the stands in the TSA are between 60 and 120 years of age.

The following 22 Beetle Management Units (BMUs) are included in the Arrow TSA, See map for locations:

BMU #	BMU Name	BMU #	BMU Name
N501	Sheep	N514	Perry
N502	Rossland	N515	Lemon
N503	Bear	N519	Eagle
N504	Pend Oreille	N520	Whatsan
N505	Stagleap	N521	Woden (partial)
N506	Erie	N522	Caribou
N507	Glade	N523	Hills
N508	Blueberry	N524	Idaho
N509	Dog	N525	Wilson
N511	Cayuse (partial)	N528	Kuskanax
N512	Ladybird	N530	Trout(partial)
N513	Pedro	N531	Fish

TFLs' & Cascadia TSA BMUs	
N510 – Johnston	N518 – Gladstone
N511- Cayuse (partial)	N521-Woden (partial)
N514 - Perry	N526 – Vipond
N516 – Hoder	N527 – Fosthall
N517 – Koch	N529 – Halfway
	N530-Trout (partial)

Table 2: Arrow, Cascadia TSA and TFLs 3 & 23 BMUs

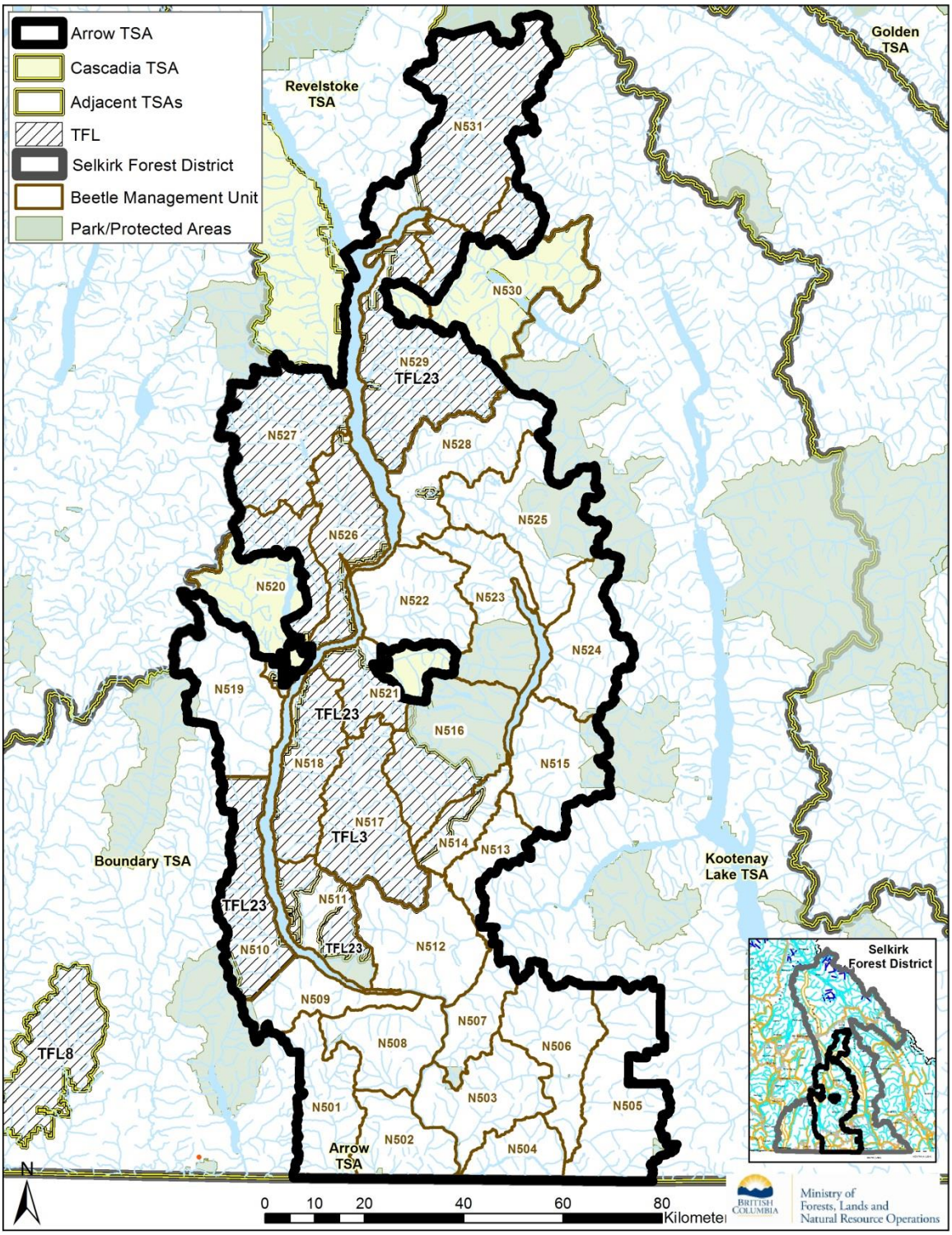
The Arrow TSA is characterized by steep, mountainous terrain in the north, with gentler terrain and wider valleys and trenches in the south. Approximately half of the TSA is productive forest land. A significant portion of the productive forest land area is unavailable for timber harvesting for various reasons, including: operability, environmental sensitivity, unstable soils and steep slopes, non-merchantable forest types. Consequently, approximately 202,000 hectares, or 27 percent, of the Arrow TSA's total land base is considered available for timber harvesting under current management practices. Additional operable land has also been removed as a result of the Caribou GAR order. Ungulate Winter Range, Old Growth Management Areas and Connectivity Corridors are additional resource constraints are placed on the land base. All the above land use values and constraints make management of forest health agents in the Arrow TSA challenging.
Comprehensive descriptions of the Arrow TSA are included in the following documents:

Arrow TSA Website http://www.for.gov.bc.ca/hts/tsa/tsa01/

- Information Report
- Analysis Report
- Rational for Allowable Annual Cut Determination

Kootenay-Boundary Land Use Plan

https://www.for.gov.bc.ca/tasb/slrp/pdf/LRMP/Kootenay%20Boundary%20Land%20Use%20Plan%20Implementation%20Strategy.pdf



Map 1: Arrow TSA showing, TFLs (includes Cascadia TSA) and Parks.

3.1. Previous Forest Health Strategies in the Arrow TSA

The last full forest health strategy was completed in 2016-17. Since 2005, there have been annual updates to BMU strategies based on annual aerial overview mapping, detailed mapping, ground reconnaissance and other local information. No BMU updates have taken place in Arrow for at least the last 7 or more years.

No ground surveys or single tree treatments of mountain pine beetle have been carried out in Arrow TSA for at least 10 or more years and only a limited amount of Douglas-fir beetle ground sampling and some limited Douglas-fir beetle funnel trapping over the last 5 years.

4. TSA Priority Ranking of Forest Health Agents

The priority forest health agents have been ranked following the Provincial Forest Health Strategy (Table 2). Rankings were based on the following factors:

- The collective knowledge of the regional and district forest health specialists, forest managers, licensees and contractors
- Historic recorded occurrence patterns
- Known or suspected impacts to forest resource values, based on the knowledge of local forest professional and regional forest health specialists
- Availability of operational detection and treatment methods
- Costs and benefits of applying detailed detection and treatment activities
- Overall level of knowledge about the hazard and risk zones
- Distribution of pest and current incidence levels

The rankings are somewhat subjective, so an additional approach is to consider what the impact of the forest health factor would be equivalent to in terms of area. This approach provides a useful perspective to the rankings and generally applies as follows:

- Very High: a forest health factor that could result in damage equivalent to the loss of >400 ha per year
- High: loss of 200 – 400 ha per year
- Moderate: loss of 100 – 200 ha per year
- Low: loss of 50 – 100 ha per year
- Very Low: very little or no known damage (<50 ha per year)

Note: some abiotic injuries (i.e., flooding) are not ranked, as the severity can change with each event. Also note that not all forest health factors are ranked, only the more significant pests within the two TSAs. Table 3 covers the major forest health agents which can potentially impact the timber supply.

Table 3: Ranking of Forest Health agents by potential impact on forest management activities in the Arrow TSA

	Very High	High	Moderate	Low
Defoliators		Western Spruce Budworm		Western hemlock looper Aspen Serpentine Leaf Miner
Diseases	Armillaria root disease		White pine blister rust	Dothistroma, Lophodermella, Hard pine rusts (Western gall rust, Stalactiform blister rust & Comandra blister rust)

Insects	**Douglas-fir beetle, Spruce beetle Mountain pine beetle, Western balsam bark beetle**			Spruce weevil
Mammals		Bear & other animals		
Abiotic Factors	**Fire**	Windthrow	Drought	

5. Description of the Priority Forest Health agent status

Table 4 provides an overview of the activity status of some of the priority forest health agents which were reported during the 2016 and 2017 provincial overview surveys. Note that spot tree counts have been incorporated into the severe category of damage based on a fraction of a hectare per spot. Forest Health agents listed as priority 1's should be the focus of Forest Licencees with any significant areas of this in their Licence or operating areas.

Table 4: Selected Summary of 2016 & 2017 Arrow TSA significant Forest Health damaging agents

Forest health agents	2017 Affected Area (ha)	2016 Affected Area (ha)	Trend	Current Impact on Timber Supply	TSA Priority
Douglas-fir beetle	**1552**	**1412**	**Slight Increase**	**Very High**	**1**
Mountain pine beetle	**623**	**1904**	Significant Decrease	**High**	**1**
Spruce bark beetle	**397**	173	Significant Increase	Moderate	**2**
Western balsam bark beetle	**2945**	**13,459**	Significant Decrease	Very High	**2**
Fire & Post Fire	**2667**	229	**Significant Increase**	**Very High**	**1**
Larch needle blight / cast	622	ND	Significant Increase	Nil	n/a
Lophodermella Needle Cast	ND	328	Significant Decrease	Low	3
Dothistroma Needle Blight	124	303	Significant Decrease	Low	3
Unknown Disease	1624	0	Significant Increase	Low	n/a
Aspen Serpentine Leaf Miner	11,194	14,756	Slight Decrease	Low	n/a
Birch Leaf Miner	ND	294	Significant Decrease	Very Low	n/a
Animal damage(Bear)	172	144	Slight Increase	Low	3

Windthrow	ND	8	No change	Very Low	2
Balsam Wooly Adelgid	ND	ND	No change	Nil	n/a
Flooding	19	37	Slight Decrease	Very Low	n/a

5.1. Mountain Pine beetle IBM(*Dendroctonus ponderosae*)

The area of current mountain pine beetle infestation has decreased by 67% from 2016. Slightly more than half of the area affected was surveyed as moderate and severe severity which is up from 2016 when most of area was trace and light severity. Mountain pine beetle has been active in the Arrow TSA since 2002 and activity has been generally declining since 2006 likely due to much of the concentrated Pli stands having been already attacked and/or harvested. Areas of known significant attack in 2017 include the Hills, Trout, Eagle and Barnes BMUs however most of the attack is generally scattered throughout the TSA and TFLs.

Over the past decade Arrow TSA licencees and adjacent TFL holders had aggressively responded to the beetle population with targeted harvesting and have significantly reduced the area of susceptible pine on operable terrain. **Continued harvest of susceptible stands** and any identified polygons of attack to reduce non recoverable losses is the recommended strategy. Table 4 below shows recent harvest of IBM polygons is minimal to date and response appears to be lagging by about 2 to 3 years to harvest. As of 2015 just over 30% of the THLB Pli volume was estimated to have been killed by IBM in Arrow.

Table 4: Mountain Pine Beetle attacked area 2015–2017 compared to area harvested and planned to be harvested.

	2015-17 IBM AOS Polygon % Harvest Area			
Year	Total AOS Polygon Area -ha	Harvested as of Winter 2017-18	Planned Harvest as of Winter 2017-18	**Total Current and Future Harvest %**
2015	1485.5	4.6%	3.1%	**7.7%**
2016	1854.6	0.0%	0.4%	**0.4%**
2017	590.8	0.0%	0.0%	**0.0%**

Future Trends

A Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak (BCMPB) estimates that less pine will be killed than originally thought but the impact on Arrow TSA has still been significant. Model projections are available by TSA. http://www.for.gov.bc.ca/hre/bcmpb/

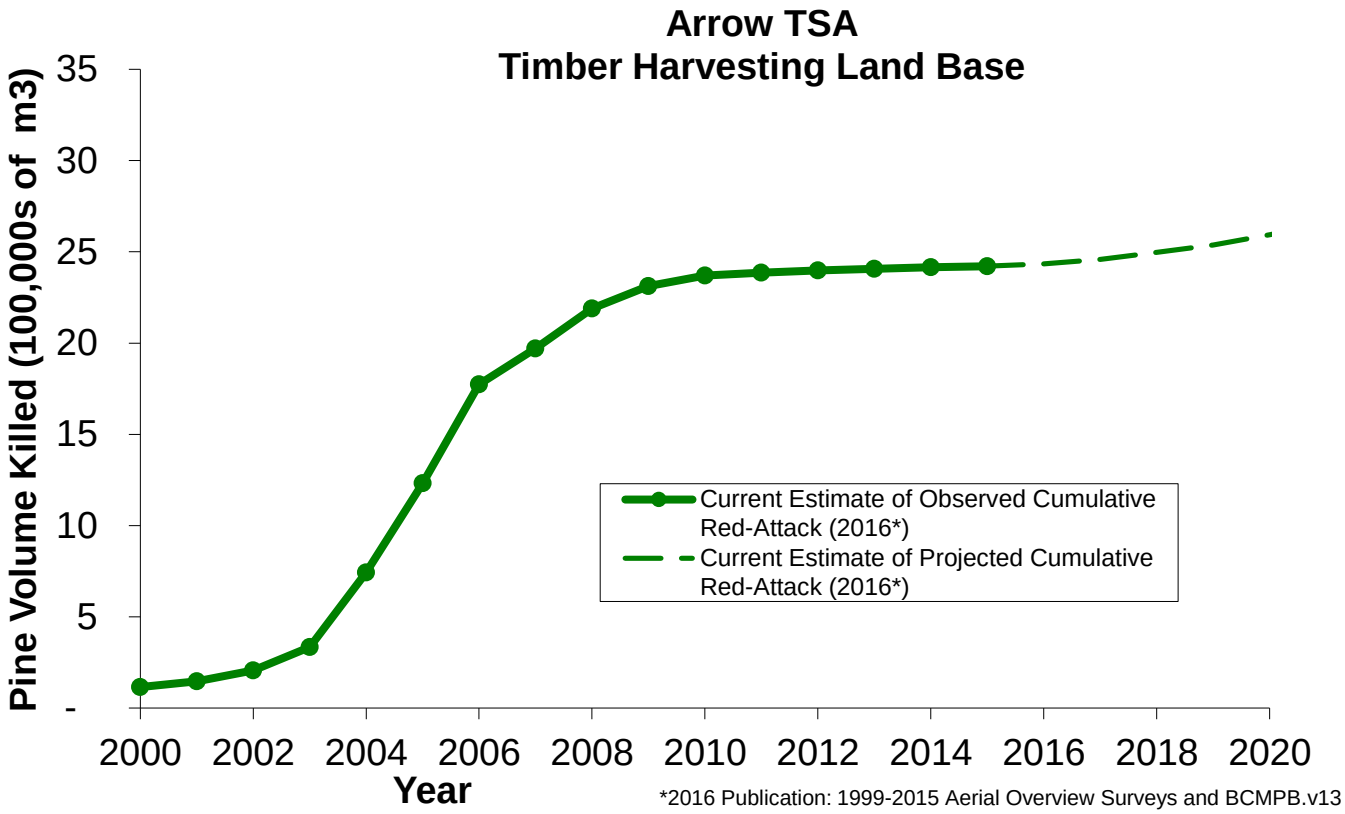


Figure 1: Arrow TSA THLB Pli volume loss in 100,000's of m3 and future projections

5.2. Douglas-fir beetle IBD(*Dendroctonus pseudotsugae)*

The Douglas-fir beetle population increased slightly from last year by approximately ten percent. Most of the polygon's area total was in the trace, low and moderate attack severity classes, very small amount in severe. Areas of known significant attack in 2017 include the Slocan Junction to Passmore, Galena Bay south to Arrow Park, Edgewood/South Whatshan/Fauquier, North Whatshan and Bulldog. There are 142,885 ha of susceptible (>20 rating) forest types to Douglas-fir beetle in the Arrow TSA based on a 2014 BMU analysis and Douglas-fir is one of the dominant tree species in this TSA. In addition, inventory data indicates many of the stands in the Arrow TSA are approaching age and diameter threshold which will make them more susceptible to attack from bark beetles. The Douglas-fir beetle has the potential to significantly impact the Arrow TSA. Therefore, the management of Douglas-fir beetle and Douglas-fir leading stands remain a priority for the Arrow TSA. **Trap tree and/ or funnel trap programs and monitoring post harvest slash and monitoring blowdown in recently harvested blocks and removing or burning any slash are recommended beneficial practices to minimize future losses.** Additional good practice includes harvesting fired damaged trees and adjacent stressed trees to reduce IBD population increases. This may be even more important for small tenure holders – Woodlots primarily and Community Forests.

Forest Licencee plans and harvest of IBD attacked areas from 2015-2017 is shown in Table 5. Only a small amount of area has been planned for harvest and no areas have been harvested to date. Response is currently too minimal and slow to effectively reduce IBD populations through harvesting actions. **Licencee response in suppression BMUs should be targeting harvest of at least 70% of the previous year's attack within 1 to 2 years.**

Table 5: Douglas-fir beetle attacked area 2015-2017 compared to area harvested and planned to be harvested.

	2015-17 IBD AOS Polygon % Harvest Area			
Year	Total AOS Polygon Area - ha	Harvested as of Winter 2017-18	Planned Harvest as of Winter 2017-18	**Total Current and Future Harvest %**
2015	259.8	0.0%	0.0%	**0.0%**
2016	1361.3	0.0%	3.1%	**3.1%**
2017	1511	0.0%	1.4%	**1.4%**

5.3. Spruce bark beetle IBS(*Dendroctonus rufipennis*)

Spruce beetle has more than doubled from 173 hectares in 2016 to 397 ha in 2017 and most of the area has been assessed as light, moderate and severe attack, with a minor amount in trace and no very severe. There are 86,200 ha of susceptible (>20 rating) forest types to Spruce beetle in the Arrow TSA based on a 2014 BMU analysis. **Spruce blowdown when identified is a high priority for treatment / harvest**. The Bark Beetle Guidebook will guide treatments. Link is as follows: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm

Forest Licencee plans and harvest of IBS attacked areas from 2015-2017 is shown in Table 6 Only a very small amount of area has been harvested to date and no areas planned for future harvest. Most of the 2017 polygon area is located in Provincial parks, or inoperable/ OGMA areas. Rapid harvest response to any IBS outbreaks on operable THLB area is critical to reduce losses and IBS populations. **Licencee response in suppression BMUs should be targeting harvest of at least 70% of the previous year's attack within 1 to 2 years.**

Table 6: Spruce Beetle attacked area 2015 – 2017 compared to area harvested and planned to be harvested.

	2015-17 IBS AOS Polygon % Harvest Area			
Year	Total AOS Polygon Area -ha	Harvested as of Winter 2017-18	Planned Harvest as of Winter 2017-18	**Total Current and Future Harvest %**
2015	0	0.0%	0.0%	**0.0%**
2016	167.4	1.1%	0.0%	**1.1%**
2017	395.2	0.0%	0.0%	**0.0%**

5.4. Windthrow NW

Windthrow is a main concern especially when located in Douglas-fir and spruce dominated stand types. Historically, spruce bark beetle and Douglas-fir beetle outbreaks have been closely associated with windthrow events. Prompt removal of spruce and Douglas-fir windthrow trees are imperative to avoid the buildup of these two bark beetles. The direct impact of windthrow on the TSA in usually minimal however, the indirect impact in the form of bark beetle outbreak, can be serious if not managed in a timely fashion. No windthrow was detected in 2017.

5.5. Amillaria Root Disease DRA(*Armillaria ostoyae*)

Armillaria (DRA) root disease has been identified throughout the Arrow TSA. Recent FREP SDM surveys have been finding DRA as well. Arrow TSA SDM plots DRA incidence ranges from 0% to 3.5% for Layers 1, 2, and 3 throughout the various BECs sampled.

Management of Armillaria in the TSA is recommended to follow the BC Root Disease Management Guide, recently published, and a copy has been placed on the FTP site at the following link:

https://www.for.gov.bc.ca/ftp/DAB/external/!publish/Forest%20Health/

Stocking Standards for Free Growing Stands are contained in each licensee's Forest Stewardship Plan and have been developed to address this disease. Harvested ICH stands of a suitable nature should be considered for stump removal treatments post-harvest to reduce DRA levels. Treatment of stands other than the ICH should be assessed for DRA levels or only after discussions with FLNRO Regional Pathologist. Because deciduous brush thinning can promote spread of Armillaria, such action should be applied carefully. Options might include earlier treatment to maintain conifer crop tree growth vigor when competing deciduous broadleaves have a less extensive root network.

Young plantations with Armillaria tend to suffer a distinct early wave of mortality due to young roots contacting infected stump systems. Mortality usually peaks between 9 and 16 years after planting. Thus, applying free-growing surveys after this time period would provide the most useful information on plantation success. A later FG survey than typical is recommended for areas with known Armillaria, such as ICH sites.

One major licencee reported 702.5 ha of stump removal for 2017, with one other Licencee treating 43.3 ha for a total of 745.8 ha throughout the TSA and TFLs. Few Licencees appear to be conducting stump removal treatments even though a significant portion of Arrow is covered by ICH BEC subzones that are considered highly susceptible to DRA.

A 2016 analysis of information from RESULTS indicated that the average amount of stump removal is less than 35 hectares per year over a 10 plus year timeframe within the Arrow TSA (TFLs and other area based tenures excluded). This number seems far too low given the high % of ICH stands and it is **recommended that all Licencees should be considering stump removal treatments in high risk areas where feasible.**

5.6. Western Balsam bark beetle IBB(*Dryocoetes confuses*)

There are large areas of subalpine fir leading forest stands in the Arrow TSA that are susceptible to western balsam bark beetle. Western balsam bark beetle has been chronically causing mortality over the years. In 2017, 2945 ha had some level of mortality due to the western balsam bark beetle in the Arrow TSA, a significant decrease of about 78% in the area from 2016. Attack levels for 2015 were primarily in the trace severity attack category. Direct control action on that insect is very difficult due to its attack dynamics and the scattered distribution of the stands.

5.7 Fire and Post Fire

Fire damaged area is detected based on previous year's fire season and post fire damage is additional noted mortality in subsequent years. Fire damaged stands should be considered for immediate salvage to reduce future damaging agents such as Douglas-fir bark beetle and to reduce non-recoverable losses. Harvest within a year of damage is recommended for wood quality and reduction of other pests. Fire affected area was up significantly in 2017 from 2016 levels by about tenfold – 2667 ha vs 229 ha.

5.8 Larch needle cast DFM(*Meria laricis*) and blightDFH (*Hypodermella laricis*)

2017 saw a significant increase to 622 ha affected in comparison to 0 ha infected by these two larch foliage diseases in 2016. These diseases infected Western larch of all ages. Defoliation by these diseases may cause minor growth reduction in large trees and young trees may be killed. Area affected varies annually. No significant impact on the TSA is expected at this point and no management is proposed except continuous monitoring of the occurrence. These diseases are reliant on extended cool wet conditions in spring to early summer seasons.

5.9 Hard pine rust: Western gall rust DSG (*Endocronartium harknessii*), Stalactiform blister rust DSS(*Cronartium coleosporioides*), Comandra blister rust DSC(*Cronartium comandra*)

The hard pine rusts are a moderate concern in the Arrow TSA. They are restricted to lodgepole and ponderosa pine. Some low levels have been noted in completed FREP Stand Development Monitoring plots within the Arrow TSA. The loss impact on the TSA is unclear but will impact the future rotation to some degree with timber mortality and quality losses. Free Growing surveys and declarations should be modified to ensure stands are not declared free growing without the stand being old enough or tall enough to more fully express the potential problem with these diseases, especially in ICH sites where Pli is planted or regenerated. Where possible, a mix of species is highly recommended to be planted or regenerated naturally.

5.10 Lophodermella (Pine) Needle Cast -DFL (*Lophodermella concolor*) and Dothistroma Needle Blight – DFS (*Dothistroma septosporum*)

Both Lophodermella and Dothistroma were not detected in previous years. They typically affect young pine stands and can cause serious defoliation typically during moist summer years. Growth reductions and mortality may result after repeated epidemics. Both are often associated with over planting of Lodgepole pine in ICH sites or planting offsite seedlots. Where possible, a mix of species is highly recommended to be planted or regenerated naturally. The impact on the TSA can be significant in local areas, especially on regenerating plantations. Careful consideration should be given to species selection in higher risk areas such as the ICH BEC zone. Licencees may want to give consideration to timing of Free Growing surveys for high percentage Pli plantations in high risk areas to ensure these diseases are detected. One strategy could be to at least do a sample of surveys earlier in the season.

5.11 Various deciduous diseases and pests

There was a decrease in observed deciduous pests and diseases - Aspen leaf miner to 11,194 ha from 14,756 ha & Birch leaf miner to 0 ha from 294 ha. The impact of these pests and diseases on the TSA is not significant. No management is planned. As per Chief Forester direction, deciduous species should not be included in stocking standards. Chronic damage has been impacting deciduous species in the Arrow TSA over the last many years, possibly related to climate change or weather patterns, supports this recommendation.

5.12 Bear-AB and other Animal Damage

Bear damage appears to have increased slightly to 172 ha in 2017 from 144 ha in 2016. Damage was also noted in the FREP SDM surveys, primarily on Lodgepole pine but also on other species. Most mortality appears to be on younger single trees but to be detected on the AOS it would be significant damage within an opening or strata. Potential solutions to managing animal damage and in particular

bear damage might include high species diversity at time of planting, less Pli, and perhaps higher establishment density as well.

5.13 Western Spruce Budworm IDW (*Choristoneura occidentalis)*

The population of IDW was not detected after three years in a row of noted attack. Detection, prediction and treatment of defoliators remain the responsibility of the Kootenay Boundary Regional staff. More specific information on the defoliator program can be obtained from them and in the Defoliator Management Guidebook (1995). Forest tenure holders should give thought to appropriate silviculture systems to manage for this pest where other management constraints allow. This would include limiting the amount of single tree selection harvesting or heavy retention systems which attempt to regenerate a younger layer under an established canopy. Future managment may include a spray program by the Province if the outbreak is significant enough and funds available.

5.14 Western Hemlock Looper ID(*Lambdina fiscellaria lugubrosa)*

In 2017 no evidence of looper attack was found in the aerial overview survey for the fourth year in a row. The current management strategy is to monitor and if necessary consider spraying with Btk. Monitoring is through the aerial overview survey and ground sampling carried out at the Regional level. While not significant at this time, an outbreak would impact short term timber supply of host species. The preferred host of the looper is western hemlock followed by interior spruce, Douglas-fir and western red cedar and it is found primarily in mature and over mature hemlock and hemlock-cedar stands.

5.15 White Pine Blister Rust DSB(*Cronatium ribicola*)

White Pine blister rust is an introduced pathogen which has caused extensive mortality of western white pine and whitebark pine within the Arrow TSA. On the neighbouring Kootenay Lake TSA, it is the #1 insect/disease factor in stands younger than 40 years (SDM). Arrow SDM sample found 35.5% of Layers 1, 2, 3 Pw being dead or unacceptable. The availability of disease-resistant white pine makes it possible to ensure this valuable timber species is restored. Disease resistant white pine should be promoted as a reforestation species on appropriate sites. Based on successfully yielding approximately 65% survivorship of white pine, a similar rust-resistance effort should continue to be supported for whitebark pine which is occasionally harvested, federally endangered, and especially valuable for wildlife. Forest Licencees are encouraged to consider planting rust resistant Pw seedlots.

5.16 Whitebark Pine Decline

Whitebark pine (*P. albicaulis*) often occurs within harvest units at elevations above 1600 meters. About half of all whitebark pine in the Arrow region is dead or dying. The causes are primarily white pine blister rust and mountain pine beetle. To a lesser extent, the exclusion of fire has favoured its less fire-hardy competitors. As a result, this tree species was placed on the federal endangered species list in 2012. Whitebark pine is valuable to grizzly bears and many other wildlife species for its very large seeds.

The cutting or damaging of whitebark pine should be strictly avoided. Whitebark pine stands, especially those with many cone-bearing trees and in good health, are good candidates for wildlife tree reserves, Old Growth Management Areas, and Wildlife Habitat Areas for grizzly bears. In

harvest areas, the thinning of competing trees can promote whitebark pine survivorship by reducing competition and providing seed regeneration habitat.

5.17 Birch Decline

Paper Birch (*Betula papyrifera*) decline has been widespread throughout the Southern Interior region of the province. Characterized by crown die-back, most mature birch appear susceptible. The spatial distribution patterns and actual causation remain poorly understood. A variety of agents have been observed including bronze birch borer (*Agrilus anxius*), non-native birch leaf miners (*Fenusa pussila* and *Profenusa thomsoni*) and Armillaria. Climatic perturbations may be a pre-disposing factor.

The decline of birch can accelerate the impacts of Armillaria within mixed conifer-broadleaf stands. A particularly important aspect of forest health relates to birch's resistance and tolerance of armillaria root disease. In fact, the roots of deciduous trees often provide a barrier to disease spread, thus protecting neighbouring conifers such as Douglas-fir and lodgepole pine from infection. When birch are harvested, or killed by other causes, the Armillaria fungus is able to quickly spread along dead birch roots and transfer to conifers. Overall, the incidence accelerates. Thus, careful consideration should be given before in regards to thinning birch and other deciduous brush. Early treatments may be an option to reduce DRA issues before root spread on deciduous becomes too large.

5.18 Hot Droughts

The frequency and intensity of drought combined with higher summer temperatures appears to be increasing in the southern interior of BC. As a result, trees become stressed, especially young regeneration and overstocked (high density) mature stands. A total of 0 ha were mapped as drought in 2017. Although 2017 experienced a record high hot drought, mortality may not become evident until 2018. Impacted trees often don't die until a year or two post hot drought. The hot droughts of 2003 and 2007 are implicated in the timing of deaths of Armillaria infected regeneration on the Knappen Creek Stump Removal Trial. In a report to the Chief Forester, Axelson and Ebata (2015) predict the following impacts:

- Bark beetles of various species populations will increase.
- Plantation pests such as spruce weevil or lodgepole pine terminal weevil will increase.
- Defoliator activity could increase. Decline syndromes already being experienced in aspen and birch, they will continue or will become accelerated.
- Root diseases impacts will accelerate.

6 Management objectives for priority forest health agents

6.1 Integrated Forest Health Management objectives

The following principle for management objective commonly known as "Integrated Forest Health Management" will be followed for all the priority forest health agents in the Arrow TSA:

1. Know the landbase and resource management objectives;
2. Manage from an ecological perspective;
3. Don't make the situation worse;
4. Practice adaptive management.

The Integrated Forest Health Management is a system that, in the context of specific resource management objectives and knowledge of the associated environment and the biology of the forest health agent and host species, applies all suitable techniques and methods to maintain forest health agent populations at levels below those causing unacceptable damage or mitigates such damage.

6.2 Management objectives for bark beetles (IBM, IBD and IBS)

The following are the management objectives to be implemented for the three main bark beetles in the Arrow TSA: mountain pine beetles, Douglas-fir beetle and spruce bark beetle. Any reference to "bark beetles" in the following management objective refers to the three bark beetles listed above.

1. **Sanitation and salvage harvesting of beetle killed areas where economically feasible, especially moderate or higher severity IBM, IBD and IBS attacked polygons and larger Light attack polygons identified by the Aerial Overview Survey or other surveys. Limit the amount of unsalvageable losses due to bark beetles. Target harvesting a minimum of 80% of the area to maintain the suppression strategy for IBD and IBS and 50% of the IBM attacked stands to maintain the current holding action suppression strategy within 12 months of the AOS flight.**
2. Prioritize the forest management to higher hazard forest stands by harvesting or reducing the susceptibility of stands to bark beetles.
3. Limit the amount of non-recoverable losses due to bark beetles;

Definitions:
Sanitation harvesting: harvesting operations specifically designed to maximize the extraction of currently infested or infected stands in order to reduce the damage caused by forest pests and to prevent their spread, e.g. bark beetles.

Salvage Harvesting: harvesting operations primarily designed to recover timber damaged or degraded by fire, an old insect attack, wind, or disease before the potential wood products become un-merchantable. Control of forest health factors such as bark beetles is incidental and is not the primary objective of salvage logging.

6.3 Harvesting Treatments

Harvesting is to be considered the preferred treatment for all infestations where it is operationally feasible. Treatment may include a single harvest regime or combination of harvest regimes ranging from large cut blocks, to single tree selection or small patch where appropriate.

The treatment goal is to remove as much, if not all of the current attack prior to the next beetle flight period. Within the Suppression Zone action plans must contemplate harvest before the next flight period. If this is not achievable, or the likelihood of pre-flight harvest is low, then these areas should be tabled as opportunities for other Licencees by at least April 1st of the following year.

Direct single tree treatments are not to be considered an alternative for harvest where the recovery of otherwise lost timber values and sanitation of beetles, i.e. removal of trees with brood can be attained. Where resources are insufficient to address the removal of all infestations prior to the next beetle flight, consideration must be given to minimizing block sizes and/or harvesting only those portions of the block that are infested this should be considered a short-term strategy until resources permit the removal of logical openings.

It is imperative the operational planning requirements are scheduled accordingly and where necessary to meet tight time frames. If necessary, expedited approvals should be requested and are appropriate where infestations are identified post-flight and where harvest is planned to take place prior to the next beetle flight.

Licencees should consider a small-scale sanitation program as required to meet overall objectives. Sanitation is defined as the removal of infested material prior to beetle flight. Sanitation is to be

used, where necessary, to balance resource allocations to optimize the effectiveness of harvesting and single tree treatment strategies and maximize the recovery of otherwise lost timber values.

Sanitation should also be considered where landscape level disturbances and impacts dictate a light footprint approach and where a minimum of one truck load (40 m^3) of operable timber can be recovered, within reasonable skid distance (400 metres) of established logging truck access; the objective is to remove all infested trees prior to the next beetle flight. Only under exceptional circumstances where the methods cannot be applied should these sites be baited and held over flight.

If it is determined that harvesting prior to the next beetle flight is impossible, then consideration should be given to expanding the harvest area to include the area baited, as well as sufficient susceptible host.

6.4 Hauling and Milling Guidelines

The following guidelines should be considered when areas surrounding the mill site are in or near urban areas, or in areas not yet affected by bark beetles.

In recognition of the potential for bark beetles to fly from milling facilities into adjacent areas the following guidelines apply during the period of July 1 to September 15 for mountain pine beetle and April 1 through August 31 for Douglas-fir beetle and May 15 through July 15 for spruce beetle:

- Manage -spring break up inventories of infested timber for priority processing prior to the above-noted period;
- Keep mill inventories and deliveries of bark beetle infested wood at a minimal operational level to meet business needs;
- Mill profile requirements permitting, prioritize processing beetle- infested sources over uninfested sources.
- Establish funnel traps (especially for IBD) in and around log yards, log decks and log booms to assist in monitoring bark beetle flight and to serve as a control measure. Traps should be monitored at least weekly and contents destroyed.

In recognition of the potential for bark beetles to fly from infested cut blocks (standing trees or decks) to adjacent timber, the following guidelines apply:

- In Salvage BMU's, no special considerations
- In Suppression and Holding BMU's:
  - For infested cut blocks that are not harvested/hauled prior to beetle flight, consider baiting in an attempt to minimize spread. Licensees should, where practical, plan operations that avoid leaving decks of infested timber on site.
  - Communication of business needs/expectation for awareness between licensee and DSE prior to spring break-up/next beetle flight is required.

In recognition of the potential for bark beetles to fly from trucks during transport the following guidelines apply:

- Inform truck drivers when they are hauling green attack loads and that the beetle flight period extends from July 1 to Sept. 15 for mountain pine beetle and April 1 through August 31 for Douglas-fir beetle and May 15 through July 15 for spruce beetle:

- Inform truck drivers that extended delays along the way can result in bark beetles flying from the load into the adjacent forest land base.
- When practical, hauling of beetle infested logs should be as direct as possible from the cutting area to the mill.

6.5 Pheromone Placement

Pheromone placement is to occur in **infested stands only**, where beetle control activities cannot be implemented until after the next flight and in mop up operations around harvested and treated infestations. In the case of larger blocks with isolated concentrations of attack, only the infested portions of the block should be baited.

The use of pheromone baits must always be followed by actions to remove or eradicate the concentrated beetle populations. All pheromone placement plans should be shared at operational beetle planning meetings, including scheduling follow-up treatments and responsibilities.

Pheromone placement can be implemented throughout the spectrum of treatment strategies including fall and burn. Pheromones should not be placed in operable areas where population levels are extremely high and increasing, or in inoperable areas where population levels are endemic and declining.

The responsibility to carry out follow-up treatments to remove or eradicate concentrated beetle populations resulting from baiting lies solely with the placement agency (Section 41 of the Forest Planning and Practices Regulation (FPPR)). Follow-up actions must be carried out prior to the subsequent beetle flight unless specifically exempted by the District Manager (Section 91 of the FPPR).

Licensees, excluding TSL holders not operating under a cutting permit authority, should consider pheromone bait placement in unharvested portions of beetle infested blocks prior to biological beetle flight times where due to unforeseen circumstance the Licensee will not be able to complete harvest prior to the beetle flight.

All pheromone placement activities must be carried out in a manner which allows for future identification and location of baited trees. Baited trees must be marked conspicuously in the field using flagging, and the placement agency must be identified at each bait site. Maps identifying all baited areas should be provided to the District by September 15th each year. Detailed guidance and protocols on the use of pheromones is provided in "Strategies and Tactics for Managing the Mountain Pine Beetle", developed for the B.C. Forest Service by Lorraine Maclauchlan and J. E. Brooks (*http://www.for.gov.bc.ca/ftp/HFP/external/!publish/MPB_booklet/*).

6.6 Roles and Responsibilities

Detailed bark beetle surveys are carried out to determine the nature and extent of bark beetle infestations within the area of the plan. Specific areas requiring surveys are identified from aerial overview maps and previously known infestations.

If significant risks to forest resources are identified from surveys, actions to reduce risks are identified and reported within bark beetle survey reports and shared with the appropriate licencee. The responsibility to carry out these actions or measures is the responsibility of the licencee.

1. Responsibilities are assigned in this matrix according to funding source. Although there are allowances for some activities under the appraisal system, the responsibilities assigned include the implementation and funding of these activities.
2. In the event that a Forest Licencee must carry out activities within the operating area of another Forest Licencee, the responsibility for bark beetle management activities post-harvest are to be negotiated in advance.
3. Where special management areas have been identified such as areas of interest for the Protected Areas Strategy, the responsibilities identified in this matrix may be amended to address specific management guidelines for these areas.

DSE Forest Health Responsibility Matrix

DISTRICT RESPONSIBILITIES	REGIONAL RESPONSIBILITIES
Prepare an annual Arrow TSA Forest Health Strategy when time and funding permits	Conduct annual aerial overview surveys and provide digital data to districts to produce overview maps and to distribute to DSE clients
Info sharing at TSA Steering Committee meetings and directly to Forest Licencees and other clients	Produce and distribute the Provincial annual forest health overview surveys
Conduct detailed aerial and ground surveys within the Arrow TSA where deemed appropriate	Conduct aerial treatments for defoliators (ex. spruce budworm Bt spraying)
	Conduct defoliator monitoring
Produce maps from the aerial surveys and provide ground survey information and maps to Licensees and clients	Provide overwinter mortality estimates of bark beetles

Within Selkirk Resource District (DSE), Forest Licensees have a responsibility to track, monitor and treat forest health factors. The following table covers the responsibilities for Licensees and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

ACTIVITY	***FLNRORD***	***LICENCEES***
Monitor and evaluate forest health activities (Utilize the best current information to detect and manage forest health factors)	***X***	
Conduct treatment of defoliator outbreaks (FLNRORD regional responsibility)	***X***	
Develop annual reports of bark beetle activities for the Province	***X***	
Conduct bark beetle treatments when required by the Forest Health Strategy	***X***	***X***
Maintain and share records of collected survey information	***X***	

Conduct ground surveys when required to verify incidence and severity of forest health pests	***X***	***X***
Conduct aerial overview forest health surveys and report on results (FLNRORD region)	***X***	
Conduct detailed aerial surveys focusing on suppression beetle management units	***X***	
Submission of survey and treatment data to FLNRORD		***X***

7 Provincial Ranking and BMU Strategy for IBM and IBD

Ranking for the two bark beetles with the highest potential impact on the TSA will be covered in this section: Mountain pine beetle and Douglas-fir beetle. The two ranking tables below follow the methodology outlined in the Provincial Bark Beetle Strategy and also include the bark beetle Strategy for each BMU.

7.1 Mountain pine beetle BMU ranking table

BMU #	BMU Name	# green attack	Susceptibility	Provincial Ranking	BMU Strategy
501	Sheep	Unknown	High	1	Hold
502	Rossland	Unknown	High	1	Hold
503	Bear	Unknown	High	2	Hold
504	Pend Oreille	Unknown	Low	3	Hold
505	Stagleap	Unknown	High	4	Hold
506	Erie	Unknown	High	1	Hold
507	Glade	Unknown	High	4	Hold
508	Blueberry	Unknown	High	4	Hold
509	Dog	Unknown	High	4	Hold
511	Cayuse	Unknown	High	1	Hold
512	Ladybird	Unknown	High	4	Hold
513	Pedro	Unknown	High	1	Salvage
514	Perry	Unknown	High	1	Salvage
515	Lemon	Unknown	High	1	Hold
516	HoderTFL3	Unknown	Not Available		Hold
517	KochTFL3	Unknown	Not Available		Hold
518	GladstoneTFL23	Unknown	Not Available		Hold
519	Eagle	Unknown	High	1	Hold
520	Whatsan	Unknown	Low	8	Hold
521	Woden	Unknown	High	1	Salvage
522	Caribou	Unknown	High	1	Hold
523	Hills	Unknown	High	3	Hold
524	Idaho	Unknown	High	3	Hold
525	Wilson	Unknown	Low	8	Hold
526	VipondTFL23	Unknown	Not Available		Hold
527	FosthallTFL23	Unknown	Not Available		Hold
528	Kuskanax	Unknown	High	3	Hold
529	HalfwayTFL23	Unknown	Not Available		Hold
530	Trout	Unknown	Low	8	Hold
531	Fish	Unknown	Low	8	Hold

7.2 Douglas-fir beetle BMU ranking table

BMU #	BMU Name	# green attack	Susceptibility	Provincial Ranking	BMU Strategy
501	Sheep	Unknown	High	1	Suppression
502	Rossland	Unknown	High	3	Suppression
503	Bear	Unknown	High	3	Suppression
504	Pend Oreille	Unknown	High	3	Suppression
505	Stagleap	Unknown	High	3	Suppression
506	Erie	Unknown	High	3	Suppression
507	Glade	Unknown	High	3	Suppression
508	Blueberry	Unknown	High	3	Suppression
509	Dog	Unknown	High	3	Suppression
510	JohnstonTFL23	Unknown	Not Available		Suppression
511	Cayuse	Unknown	High	3	Suppression
512	Ladybird	Unknown	High	1	Suppression
513	Pedro	Unknown	High	3	Suppression
514	Perry	Unknown	High	3	Suppression
515	Lemon	Unknown	High	3	Suppression
516	HoderTFL3	Unknown	Not Available		Suppression
517	KochTFL3	Unknown	Not Available		Suppression
518	GladstoneTFL23	Unknown	Not Available		Suppression
519	Eagle	Unknown	High	3	Suppression
520	Whatsan	Unknown	Low	8	Suppression
521	Woden	Unknown	Low	8	Suppression
522	Caribou	Unknown	High	3	Suppression
523	Hills	Unknown	High	3	Suppression
524	Idaho	Unknown	High	3	Suppression
525	Wilson	Unknown	High	3	Suppression
526	VipondTFL23	Unknown	Not Available		Suppression
527	FosthallTFL23	Unknown	Not Available		Suppression
528	Kuskanax	Unknown	High	3	Suppression
529	HalfwayTFL23	Unknown	Not Available		Suppression
530	Trout	Unknown	Low	8	Suppression
531	Fish	Unknown	Low	8	Suppression

8 Recommended activities to manage IBM, IBD and IBS

8.1 Mountain pine beetle

8.1.1 Harvesting

Harvesting is the most efficient short-term method of managing IBM populations with the intent to prevent timber loss. Timber harvesting in infested (1st priority) and red/grey attack (2nd priority) and un-infested stands (3rd priority) with high hazard and/ or infestation is critical to reducing non-recoverable losses. Failure to address these losses will impact future timber supply determinations negatively. In order to reduce mid-term timber supply impacts harvesting should be targeted at infested stands with significant hazard where feasible.

8.1.2 Pheromone Use

None planned at this time.

8.1.3 Single tree treatment and other treatments

No planned single tree treatments at this time.

8.1.4 Detailed Flight and Ground Surveys

None planned at this time.

With no suppression BMUs, no active management by the District has been occurring or is planned including detailed surveys, pheromone use or single tree treatments. Licencees should be targeting any moderate or higher severity attacked areas for harvest within 12 months or less from date of detection.

8.2 Douglas-fir beetle

8.2.1 Harvesting

The overall strategy for Douglas-fir beetle (IBD) management is that of suppression/monitor through the use of one or a combination of the following:

1. Trap trees;
2. Antiaggregation pheromones (MCH);
3. Traps trees and (MCH); and
4. Clean harvesting practices.

Timber harvesting in infested (1st priority) and red/grey attack (2nd priority) and un-infested stands (3rd priority) with high hazard and stress factors such as nearby windthrow, fire damage for example and/ or infestation is critical to meeting suppression strategy objectives and reducing non-recoverable losses. A combination of sanitation and salvage harvesting for Douglas-fir beetle suppression should be carried out in areas of current-attack in order to reduce the existing population and inhibit the infestation expansion. Failure to address these losses continues to impact future timber supply determinations negatively.

Trap trees are highly recommended as an effective tool to reduce overall beetle population levels in any IBD areas or Douglas-fir stands and complete a post-harvest mop-up where necessary. Baited funnel traps and MCH anti-aggregant may be used where conditions are appropriate.

8.2.2 Pheromone Use

Pheromone use is planned for use with IBD funnel trapping projects only at this time under Land Based Investment Funding works through Selkirk Resource District and is covered by the Southern Interior Region Pest Management Plan. At this time, DSE plans to deploy about 14funnel trap sites in 4 areas in southern Arrow for IBD which is similar to 2017 activities. Additional Funnel trapping is planned by a few Forest Licencees as well for 2017.
http://www.for.gov.bc.ca/rsi/ForestHealth/PDF/PMP_2013-2017_FH_Southern_Interior_Feb_19_2013.pdf.

8.2.3 Single tree treatment and other treatments

No planned single tree treatments at this time.

8.2.4 Detailed Flight and Ground Surveys

The current plan for 2018-19 is to complete a heli detail survey, budget allowing, of selected higher incident and risk areas in Arrow TSA (excludes TFL and CFA areas). A limited number of ground

surveys may also be completed. Detailed mapping flights were completed for Douglas-fir bark beetle in portions of the TSA in 2017.

8.3 Spruce beetle

8.2.1 Harvesting

The overall strategy for Spruce beetle (IBS) management is that of suppression/monitor through the use of one or a combination of the following:

1. Trap trees;
2. Clean harvesting practices.

Timber harvesting in infested (1st priority) and red/grey attack (2nd priority) and un-infested stands (3rd priority) with high hazard and/ or infestation is critical to meeting suppression strategy objectives and reducing non-recoverable losses. A combination of sanitation and salvage harvesting for Spruce beetle suppression should be carried out in areas of current-attack in order to reduce the existing population and inhibit the infestation expansion. Failure to address these losses continues to impact future timber supply determinations negatively.

Trap trees are highly recommended as an effective tool to reduce overall beetle population levels in any IBS areas or Spruce stands and complete a post-harvest mop-up where necessary.

8.3.2 Pheromone Use

No planned use of pheromones is planned at this time for IBS management.

8.3.3 Single tree treatment and other treatments

No planned single tree treatments at this time.

8.3.4 Detailed Flight and Ground Surveys

The current plan for 2018-19 is to complete a heli detail survey of known higher incident areas, budget allowing, in Arrow TSA (excludes TFL and CFA areas). No Ground surveys currently planned. No detailed mapping occurred in 2017.

9 Priority Activities in BMUs

The following projects are planned:

- Ongoing detailed monitoring (primarily detailed flights) in higher priority areas.
- Ongoing discussions with Licencees regarding active IBM, IBD and IBS populations in their operating areas and targeting these areas for immediate harvest.
- Ongoing Funnel Trapping for IBD in selected areas
- Public meetings as requested for IBD

10 2018-19 Fiscal Year Tactical Plan

The tactical plan will be to continue to monitor forest health agents through the overview survey and IBD / IBS detailed survey in selected areas of suppression units. Selkirk District is currently implementing a small funnel trap program for IBD in southern Arrow in 4 areas. Additional opportunities for funnel trapping will be considered on an annual basis based on current attack levels, funding and site feasibility.

Forest Licencees have been encouraged to consider their own funnel trapping programs and trap tree programs for IBD. The focus will continue on TSA Licencees meetings to address IBM, IBD & IBS

impacted areas through harvesting to reduce non-recoverable losses and attempt to limit the spread of the various bark beetles. No planned single tree treatments at this time.

11 Stocking Standards

Forest health concerns can be a factor in species selection and other aspects of stocking standards. Significant concerns relating to Pli in the ICH in particular rusts, bear damage and other damaging agents exist for this species especially when stands are declared at such a young age due to the fast growing nature of this species. Evidence for this includes FREP SDM surveys within Arrow TSA as well as other SDM surveys in adjacent TSAs and continued research by Alex Woods and David Coates. New BEC and corresponding stocking standards have addressed some of the Pli in ICH concerns.

Licencees and prescribing foresters need to be cognizant of climate change and how this can impact future timber supply through stocking recommendations and forest health issues that may have greater, lesser or different impacts in the future as a result of climate change.

An additional consideration to professionals completing Free Growing (FG) declarations is the age at which plantations are allowed to undergo FG evaluation. The average FG declaration age is 9 years in the South Area. However, Armillaria root disease, the primary agent of mortality in a substantial number of plantations, does not typically spread until 12-16 years. Thus, FG evaluations prior to 16 years of age risk underestimating stand mortality. Several other Pli damaging and mortality agents often express themselves at an older age then 9 years and are an added risk factor for future timber supply with early FG declarations.

12 Non-Recoverable Losses (fire, wind, pests, total current AAC comparisons)

The table below represents the estimated forest volume killed by selected Forest Health Factor and not harvested in the Timber Harvesting Land Base(TSA only, excludes TFL3&23), as well as the amount of that killed volume that has been either harvested by the year 2017. Over the 19 years reported in this table the volume lost represents just over 14% of the AAC for that time period or the equivalent of approximately 3 years of cut in the 19 years. The killed volume harvested percentages show significant drops in recent years, notably 2011 to present, compared to the 1999 to 2008 time frame. IBD losses are now estimated to be larger than IBM losses for the last two years.

Table 7: 1999-2017 THLB volume killed by selected Forest Health factors and not harvested and total killed volume harvested

THLB Volume (m3) killed and not harvested as of 2017							Volume Harvested	
	Forest Health Factors							
Year	IBM	IBD	IBB	IBS	Fire	Totals	m3	% of total Killed
1999	28,059	127	4,735	0	0	**32,921**	22,171	40%
2000	27,664	7,309	1,984	0	0	**36,957**	16,881	31%
2001	16,134	3,742	775	0	0	**20,651**	9,732	32%
2002	27,620	1,265	0	0	0	**28,885**	12,820	31%
2003	47,056	792	8,052	0	0	**55,913**	29,299	34%
2004	193,550	0	4,210	0	0	**197,760**	64,512	25%
2005	253,648	522	4,831	0	5,267	**264,268**	72,507	22%
2006	279,082	511	9,122	0	1,492	**290,207**	79,628	22%

THLB Volume (m3) killed and not harvested as of 2017							Volume Harvested	
	Forest Health Factors							
2007	104,356	41	5,213	0	110,007	**219,617**	49,528	18%
2008	121,695	121	1,932	0	20,808	**144,556**	39,926	22%
2009	64,720	383	2,591	0	15,412	**83,106**	13,524	14%
2010	29,141	0	2,078	0	77	**31,296**	5,120	14%
2011	12,546	665	274	0	0	**13,485**	1,733	11%
2012	7,146	1,080	366	0	540	**9,132**	1,101	11%
2013	5,021	2,871	769	0	5,434	**14,095**	1,171	8%
2014	4,266	3,288	983	0	3,866	**12,403**	1,058	8%
2015	4,154	1,147	933	0	6,535	**12,769**	1,140	8%
2016	4,026	4,786	2,645	0	958	**12,415**	760	6%
2017	6,646	9,934	665	164	7,964	**25,373**	516	2%
Totals	**1,236,530**	**38,584**	**52,158**	**164**	**178,360**	**1,505,809**	**423,127**	**22%**

The historical Arrow TSA AAC from 1999 to present is listed in Table 8.

Table 8: Historical Arrow TSA AAC

Arrow TSA Historical AAC	
Year	Volume m3
1999-2001	619,000
2002-2007	550,000
2008-2011	584,000
2012-2015	535,700
2016-2017	505,853
2018+	500,000

13 Information Links

Report: 2017 Overview of Forest Health in the Southern Interior Region
http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/summary-reports

The above report is based on spatial data found at the location below for 2016 Annual Overview Survey.

Provincial Forest Health Strategy 2013-2017
http://www.for.gov.bc.ca/hfp/health/Strategy/Forest%20Health%20Strategy.pdf

Provincial Bark Beetle Management Technical Implementation Guidelines (formerly Bark Beetle strategy
https://www.for.gov.bc.ca/hfp/health/fhdata/bbstrategy.htm

Spatial Data: Bark Beetle Hazard Ratings
https://www.for.gov.bc.ca/rsi/foresthealth/hazard_rating.htm

2017 and earlier Annual Overview Surveys. (fixed wing based aerial mapping of all visible forest pests).
http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/

2017 and earlier Detailed Mapping (Helicopter based aerial mapping of Beetle Management Units with a Douglas-fir beetle strategy of suppression.) Available upon request from District Forest Health Staff