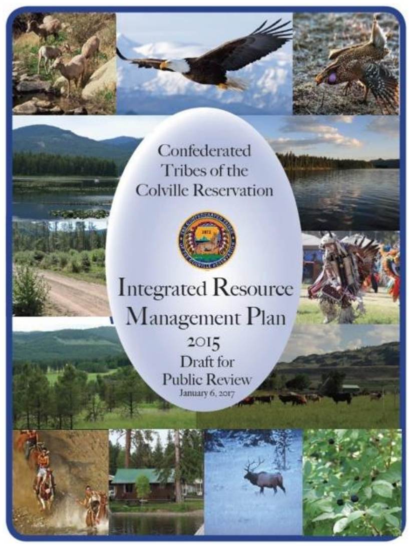
Review of the Confederated Tribes of the Colville Reservation 2015 Draft Integrated Resource Management Plan



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1. Executive Summary

Fundamental to any forest management plan – in this case, relevant portions of the 2015 Integrated Resource Management Plan (IRMP) and, by extension, the Draft Programmatic Environmental Impact Statement (DEIS) for the Colville Reservation Forest (CRF)[1] – is confirmation of owner objectives. Based on 2014 Community Survey results, there was strong support for controlling insect and disease (97%) and strong opposition to any expansion of forest and livestock production (93%); indeed, 10% wanted to eliminate timber harvesting and livestock grazing entirely from the Reservation.[2]

Ironically, this is a case in which the near unanimity of community opinion to both combat insect and disease and resist production increases comes into direct conflict with each other. As Figure 1.1 shows, over the past 35 years, as timber harvest has fallen, mortality – much of it exacerbated by increased insect and disease infestations, has increased.

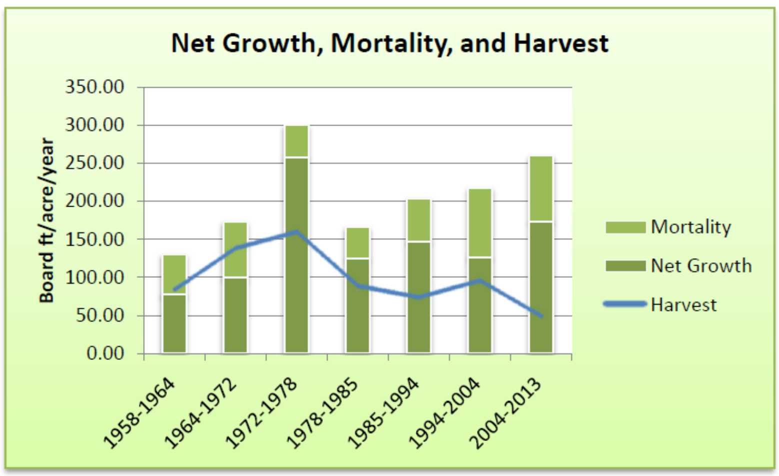

Figure 1.1. Net growth, mortality, and harvest, 1958-2013, on the Colville Reservation Forest.[3]

After reviewing the CRF forest management plan portion of the IRMP, we believe none of the alternatives considered to date, including the preferred alternative, achieve desired results of addressing forest health issues while maintaining an ecologically resilient forest and providing economic benefits to the Colville Reservation. In this critique we will show the present plan was developed under an unnecessarily narrow interpretation of what is considered "sustained yield." As a result we believe the current plan hampers attempts to address the accelerating insect and disease issue on the forest, heightens the risk of catastrophic loss to uncharacteristic wildfire, and reduces the ecological vitality of the CRF. Further, despite citing the objective to move the forest toward a set of desired future conditions (DFC) that are

[1] In addition to the DEIS we also reviewed the 2015 Forest Management Plan (FMP) and the 2015 Forest Inventory Analysis (FIA) report of the 2013 Continuous Forest Inventory (CFI) re-measurement as supporting documents to the DEIS.

[2] DEIS, p. 51.

[3] 2015 FIA Figure 3, p. 10.

intended to bear some agreed resemblance to the historical range of variability, none of the alternatives offered actually report any progress toward meeting DFC objectives.

Simply stated, there is general concurrence the present forest is overstocked relative to historical conditions and, in combination with species drift from historical conditions, the overstocked condition has contributed to the forest health crisis. Despite this, community concern has also expressed the forest is being managed “unsustainably” whenever harvest exceeds net growth. However, if net growth continues to exceed harvest, the overstocking condition will become worse, exacerbating forest health issues and increasing the prospects for catastrophic wildfire events in the CRF. The answer, it seems, is to refocus attention on moving the forest back toward these DFCs rather than restricting management prescriptions to those consistent with a misunderstanding of sustained yield management as non-declining even-flow harvest, net growth exceeding harvest, and ever increasing inventory.

Garnering community support to develop management plans that achieve DFCs has been complicated by an inadequate understanding by the community of existing and changing forest conditions as compared to those DFCs. In this review we identify a variety of deficiencies in the IRMP and DEIS that will need to be rectified before starting the necessary process of developing a plan that addresses the legitimate concerns expressed to date through community input. Those topics are reviewed in brief below:

Annual Allowable Cut and Sustained Yield – Applying non-declining even-flow methodology as the standard of sustained yield management is inappropriate for a forest that has one-third of its acres beyond rotation age, overstocked, beset by significant forest health issues, and faced with an increasing catastrophic wildfire threat. Consequently, none of the alternatives considered adequately address the community issue of improving forest health. We suspect, because of the inappropriate application of the non-declining even-flow methodology, the significant forest age class gap in the current 20- to 60-year-old age class is impeding the treatment of currently aging, overstocked, insect- and disease- afflicted forest stands. New, more flexible alternatives need to be developed, in concert with community education regarding sustained yield management concepts applicable to the forest’s present condition; this needs to occur to provide a suitable forest management plan. If not, selective cutting decisions made 20 to 60 years ago that failed to regenerate stands – and that are recognized as representing a significant contribution to the current forest health crisis – will continue to plague the forest for decades to come.

Desired Future Conditions – While the plan refers to managing the forest toward a set of DFCs, there is no portrayal of how current conditions relate to those DFCs. The most frequent appeal to any gap is an allusion to today’s overstocked forest compared to an open, park-like forest of large ponderosa pine and western larch. Both plant association group classifications (which are largely independent of species stocking) and recorded historical documentation suggest there are other relevant features on the forest landscape beyond the frequently cited open, park-like forest condition; rather, it seems appropriate that one-third of the forest would be managed toward such a self-perpetuating condition while the remaining two-thirds are managed toward a Douglas-fir/grand fir complex. Further, there is no description of forecasted forest conditions compared to DFCs for any of the alternatives. At a minimum projected age classes, projected inventories, and projected species mix should be provided, compared against DFCs, and used as a decision-making metric in the new alternatives plus any of the existing alternatives.

Timber Inventory Estimates – The current IRMP forest management plan is based on measurements of only one-half the CFI plots on the forest. Analysis of those results identified anomalies suggesting the per-acre forest inventory may be substantially higher than currently reported, with a total inventory of 6.3

billion board feet compared to the reported 5.8 billion. Forest inventory is the foundation of good forest management plans; thus, we urge the rest of the CFI plots be re-measured, and the inventory re-analyzed to either confirm the currently reported inventory or provide a more precise revised estimate. The new alternatives should then be analyzed with the revised inventory, along with reexamination of any current alternatives the community desires to continue considering.

Wildfire Threat – Both acres burned and burn severity have been increasing on the Reservation. The upward trend is indicative of the accelerating forest health issues. Overstocked stands lead to increased mortality, providing an abundance of dry fuels that pose heightened risk to live trees, infrastructure, wildlife and domestic animals, and human life. Deteriorating forest health conditions, coupled with the increasing risk of catastrophic fire, underscore the need for significant changes in forest management. Hence the need to develop new alternatives to the five presently considered in the IRMP.

DEIS Economic Impact – The economic impact analysis is beset with a number of flaws we feel muddled clear and decisive communication regarding differences between the Alternatives. We identify issues with the Baseline as presently defined, the Study Region as presently delineated, both the inclusion and inconsistent application of Omak Mill revenues, several calculation methodologies that impact projected revenues and net present value calculations, and inconsistencies with the reported results of the analysis and the Overview table. In several instances the issues resulted in implicit biases against higher timber production alternatives.

Timber-based Revenue – The current IRMP reports revenues two times higher than plausible revenue expectations from the timber management plan. The principal error seems to be that delivered-log prices, rather than stumpage prices, were used to estimate revenues from the timber program. Rather than average timber revenues of $29.3 million per annum a more realistic estimate would be $14.3 million. Of that amount, after deductions for the Colville Tribe Sort Yard, harvest road maintenance costs, and forest development, an average of $10.8 million per year would be paid to the Tribe’s General Fund. Beyond increasing the harvest during the next 15 years, which would have to be considered within the context of one of the recommended new alternatives, revenues could also be increased by being more responsive to market dynamics when selling timber. An analysis of that potential suggested revenue would be greater than the expected value of the IRMP harvest plan 59% of the time.

Miscellaneous Observations – Apart from the specific topics itemized in this review we offer several specific observations regarding the IRMP analysis and the alternatives considered. E.g., the Open Ground Equivalency (OGE) metric is important but its application seems to trump almost all other considerations when applied to ground disturbance stemming from timber harvest. This is done without reference to any economic trade-offs while acknowledging that, in the case of catastrophic wildfire (which is more likely in scenarios with lower timber harvest), OGE exceedance is also virtually assured.

For any alternative in which timber harvest is includes, harvest volumes in the annual allowable cut (AAC) should consist only of “green timber;” salvage volume should be counted as incidental to the AAC.

Consideration of Alternative 3 seems curious since it represents in many ways a return to forest management that deemphasizes regeneration harvest. It is generally understood that such practices in the past contributed to the forest health issues seen today. Until the interpretation of sustained yield management is expanded beyond the current restrictions of non-declining even flow and restrictive minimum rotation ages, higher timber production alternatives such as Alternative 4 will be perfunctorily dismissed as unviable despite providing superior options to address forest health issues. While Alternative 5 is recognized as potentially contributing to heightened forest health problems and catastrophic wildfire risk, the inevitability of those outcomes is addressed in a rather cavalier manner.

Fiduciary Responsibilities – Although the Reservation forest is a valuable capital asset, worth nearly $1 billion, the DEIS provides no benchmark of asset performance. We present a preliminary range of estimates (from 0.44% to 1.07%) for the return on asset value (ROAV), with an average of 0.73% per year. That return is essentially equal to the current average earnings before interest, taxes, depreciation and amortization (EBITDA) among institutional timber assets in the Pacific Northwest. However, owing to differing management objectives the CRF EBITDA returns are not supplemented by appreciation returns as is the case with institutional investors. We propose for consideration several methods by which financial performance can be improved. These suggestions are the starting point for elements that should be included in any plan aimed at maintaining and improving the CRF's financial performance. Moreover, the ROAV should be estimated for each management alternative under consideration, and used as one of the key criteria when selecting from among alternatives. Finally, we recommend adopting metrics aimed at assessing "financial sustainability" as well as ecological sustainability.

New Alternatives – To deal with the CRF's forest-health issues, an alternative definition of sustained yield management must be adopted. The management alternatives considered in the DEIS lack the flexibility, with respect to varying harvest and rotation length over time, that is necessary to successfully address the ongoing forest-health issues in the CRF. The situation of declining forest health that is unfolding at present will continue to spiral out of control until a more holistic perspective of sustained yield management replaces the notions of ever-increasing inventory, non-declining even-flow timber harvest, and net growth in excess of harvest. A fresh approach is required, in which new alternatives are developed that include the possibility of adjusting harvest levels up and down over time, coupled with forest-condition metrics that measure progress toward attaining a desired set of future conditions. We suggest a variety of characteristics that could be included as part of a collection of new alternatives. Also, we demonstrate how an example alternative begins moving the forest toward a healthier condition, without sacrificing its ability to be perpetuated for future generations, and while simultaneously providing additional revenue for the Tribe's General Fund.

2. Deficiencies and Remedial Recommendations

Delphi Advisors was retained to review the 2015 Integrated Resource Management Plan (IRMP), and by extension – since the IRMP derives from it – the associated Draft Programmatic Environmental Impact Statement (DEIS) for the Colville Reservation Forest (CRF).[4] Our review uncovered numerous deficiencies, of which the following list (arranged by corresponding report section) constitutes a representative sample. Remedial recommendations are also provided.

Allowable Cut Calculations and Sustained Yield

Deficiencies:

- Misapprehension of the concept of "sustained yield" management – that the concept of "sustained yield" means standing inventory must never decrease despite the forest being in a decidedly unhealthy and imbalanced condition, and annual harvest must adhere to non-declining even-flow constraints – has led to an inappropriate estimate of annual allowable cut (AAC). Moreover, there is no evaluation of projected forest conditions, either related to age-class distributions or in comparison to attaining desired future conditions (DFC).
- The effect of constant 120-year rotations and extremely unbalanced age classes that would be perpetuated under the preferred alternative results in further extending rotations on timber already well in excess of 120 years of age and in biological decline. This, in turn, is expected to exacerbate insect and disease issues, along with increasing the risk of catastrophic wildfire losses as mortality increases.

Recommendations:

- Develop an alternative plan(s) that more rapidly moves the forest toward a balanced age- and size-class condition. The AAC in the preferred alternative should not be computed under the non-declining even-flow constraint. Rather, the alternative should have the flexibility to adjust harvest levels, rotation lengths, and stand prescriptions over time until the forest is transitioned into a condition where it can perpetuate itself at the desired 120-year rotation lengths while meeting other DFCs.

Desired Future Conditions versus Projected Plan

Deficiencies:

- In the Forest Management Plan (FMP), DFC table columns and rows appear to be mislabeled.
- Forest-acreage proportional breakdowns within the DFC tables often exceed 100%. This may not necessarily be erroneous, since DFCs often report ranges of values; however, if that is the case in the FMP, it should be explained.
- No documentation is provided on how the DFCs were derived.

[4] In addition to the DEIS we also reviewed the 2015 Forest Management Plan and the 2015 FIA report of the 2013 CFI re-measurement as supporting documents to the DEIS.

- There is no objective, quantifiable procedure for classifying forest acres into the various DFC categories. Similarly, the FMP lacks statistics enabling comparison of current forest conditions to the DFCs.
- There are no results provided from the growth and yield projections utilized in each of the alternatives that would allow for a meaningful comparison of how each management alternative meets the DFC goals.

Recommendations:

- Document how the DFCs were derived.
- Provide an objective, quantifiable procedure for classifying forest acres into the various DFC categories.
- Provide the information required to compare current forest condition to the DFCs.
- Provide results from the growth and yield projections utilized in each of the management alternatives enabling a meaningful comparison of how each alternative meets the DFC goals.
- Design and incorporate new forest management prescriptions into the Forest Management Plan that demonstrably facilitate movement of forest acres into desired DFC categories.

Timber Inventory Estimates

Deficiencies:

- The timber inventory used to develop forest management alternatives considered in the IRMP is based on the 2013 continuous forest inventory (CFI) re-measurement that included only about half the number of CFI plots extant on the Reservation.
- There is a significant contradiction between the reported inventory per acre in the 2013 re-measurement versus the calculated inventory when net growth and harvest from the 2013 re-measurement are added to the 2004 inventory.
- There is reason to believe the 2013 inventory is actually higher than the reported 8,784.8 board feet per acres (BF/ac), and could be over 9,500 BF/ac.
- The reported 2013 inventory, which showed almost no increase over the past inventory, could influence community perceptions to favor reducing timber harvest for fear that the forest inventory would otherwise fall.

Recommendations:

- Secure funding to expeditiously complete and incorporate measurements from the CFI plots not measured in 2013, and revise the calculations and analysis related to the forest inventory as warranted.
- Disseminate findings from the revised inventory throughout the community to correct any possible misconceptions regarding current forest conditions and trajectory.
- Use the revised inventory to not only re-compute the currently considered alternatives (which would thus be based on a more solid data footing), but also to formulate additional alternatives that explore meeting DFCs with greater flexibility than is possible under non-declining even-flow constraints.

Wildfire Threat

- Deficiency: Management alternatives presented in the DEIS do not adequately address existing forest health issues, and likely will not significantly decrease the risk of catastrophic wildfire in the future.
- Recommendation: New silvicultural prescriptions should be devised that will prevent development of overstocked, decadent stands susceptible to catastrophic wildfire, and instead generate stand structures and compositions consistent with the DFCs.

DEIS Economic Impact

Deficiencies:

- The baseline conditions defined for the analysis are flawed, hampering clear communication and apprehension of the implications of the economic impacts analyzed. Alternative 1, the status quo alternative, should represent the baseline.
- The Omak mill's value-added contribution is included in the analysis even though it is no longer operating. Even if it were operating, the calculated impacts are not adequately and consistently quantified across the various alternatives.
- The Study Region, defined as Okanogan and Ferry Counties, excludes economic geographies that are relevant to the alternatives examined. This oversight contributes to an inherent bias against commercial timber production in the analysis. By excluding from the analysis mills that logically could (and do presently) receive harvested timber from the Reservation, but are located just outside the two-county Study Region, there is no value-added component included in the analysis for alternatives that generate harvest levels in excess of in-Study Region mill capacity.
- It is unclear from the descriptions in the DEIS whether the timber revenue utilized in the analysis includes all expenditures related to forest management; if not, then that is a deficiency in the analysis. In addition, the calculation methodology used to derive the real escalation rate used in the analysis is incorrect on several counts. Finally, using a single index as a real escalator for the variety of different types of revenue included in the calculation is inappropriate.
- The Overview of Economic Impacts table (DEIS Table 39, p. 262) does not correspond to the reported analysis. In addition, the net present value (NPV) calculations reported in the Output/Production Table (DEIS Table 38, p. 261) are unconventional and may be incorrect; if incorrect, they understate the outputs attributable to each alternative.

Recommendations:

- Baseline conditions should be appropriately defined as Alternative 1 (status quo) to clarify communication and apprehension of the implications associated with the economic impacts analyzed.
- The Omak mill should be dropped from the analysis.
- At a minimum, Stevens County should be added to the study region, along with the value-added manufacturing conversion of Reservation timber included for mills located in that county.
- The calculation methodology used to derive the real escalation rate in the analysis should be corrected to account for the variety of revenue types represented.
- Tables 38 and 39 (DEIS, pp. 251 and 252) should be corrected to correspond with the supporting analysis and exhibit valid NPV estimates.

Timber Revenues and Market Responsiveness

Deficiencies:

- The DEIS projects timber harvest-related revenue of $439.3 million ($29.3 million per year) under the preferred alternative during the 2015-to-2029 planning period. Because delivered-log prices were incorrectly used instead of stumpage prices as the basis for this projection, these revenue estimates are roughly 2.4 times higher than is defensible.
- An independent analysis, which follows the IRMP harvest plan while also incorporating stumpage prices, provides a more realistic estimate of $162.3 million (or $10.8 million/year on average) that could be available for distribution to the Tribe's General Fund.
- Inflexibly following the preferred-alternative's harvest plan regardless of future log-market conditions risks foregoing revenue that could accrue to the Tribe if, instead, harvest levels are allowed to increase when stumpage prices are expected to rise and reduced when log prices are expected to fall.

Recommendations:

- Re-estimate timber-related revenue distributions to the Tribe's General Fund during the planning period – under both the already-considered alternatives and any new alternatives devised after incorporating the updated CFI and other recommendations provided in this report – using stumpage prices instead of delivered-log prices.
- Explore opportunities for heightened revenue by allowing market-based flexibility in the annual harvest schedule. Of 10,000 simulations generated for this review, which incorporated only a modest amount of flexibility during the plan period, nearly 6,000 exceeded the median outcome of a base-case scenario that exactly followed the preferred-alternative harvest schedule.

Miscellaneous Observations

- Open Ground Equivalency (OGE) Thresholds.
    - Deficiency: No information is provided regarding the extent of economic tradeoffs related to remaining within versus exceeding the OGE thresholds specified in this analysis.
    - Recommendation: Provide greater clarity regarding economic tradeoffs of adhering to OGE thresholds.
- Alternatives 1 and 2 (but applicable to any alternatives that is selected to be implemented).
    - Deficiency: Salvaged mortality counts toward the AAC whereas the AAC is based on "green cut."
    - Recommendation: Explicitly recognize that any timber volume harvested as salvage, except in extreme cases (such as the aftermath of the 2015 wildfire season), will be treated as incidental to the AAC.
- Alternative 4
    - Deficiency: The overly narrow definition of what constitutes sustained yield management preempted serious consideration of this higher-timber-production alternative that – in addition to providing for increased timber revenue and employment, also more aggressively addresses forest health conditions.

  - Recommendation: Provide greater flexibility in defining sustained yield management so that higher timber production alternatives beyond non-declining even flow can be assessed as a viable alternative.
- Alternative 5
  - Deficiency: This alternative is counterintuitively described as limiting environmental impacts because there is no timber harvest, despite acknowledging forest health would likely deteriorate amid increasing risk of catastrophic wildfire.
  - Recommendation: The statements made regarding ecological risks associated with this alternative are too benign and need to be strengthened.

Fiduciary Responsibilities

- Deficiency: Although the CRF is a valuable capital asset, worth nearly $1 billion, the DEIS provides no benchmark of asset performance. We estimate the return on asset value to be roughly 0.73% per year, essentially on par with the current average EBITDA return among institutional timber assets in the Pacific Northwest. While this performance is noteworthy, differing management objectives prevent CRF from also realizing the benefits of the larger appreciation return (1.33%), for a total institutional return of 2.08%.
- Recommendation: The necessary data should be collected to tighten the return-on-asset-value estimate mentioned above. Moreover, this value, as well as other "financial sustainability" metrics should be estimated for each management alternative under consideration, and used as one set of key criteria when selecting from among alternatives.

New Alternatives

- Deficiency: The management alternatives considered in the DEIS lack the flexibility, with respect to varying harvest and rotation length over time, that is necessary to successfully address the ongoing forest-health issues in the CRF.
- Recommendation: Define new management alternatives (using our guidelines and provided example as a model), and associated prescriptions that do incorporate the needed flexibility.

3. Allowable Cut Calculations and Sustained Yield

We believe the methodology employed to determine the sustained yield allowable cut is inappropriate given the CRF's current conditions and the stated objectives of the community – namely, to address declining forest health evidenced by heighted and accelerating incidence of insect and disease. We infer this misapplication is due to an interpretation of sustained yield management that overlooks a key ingredient: the condition of the forest compared to a DFC that is consistent with perpetuating the production of goods and services (both tangible and intangible) from the forest consistent with landowner (in this case community) objectives.

We note repeated references throughout the documents that CRF is carrying higher stocking levels than has been seen historically. Here is one example:[5]

> Historically, the forest landscape of the Colville Reservation was much different than it is today. Early descriptions often refer to an open, park-like setting of large Ponderosa pine trees with an understory of productive grasses. Dense stands of smaller trees characterize today's forest. Fire sensitive species such as Douglas fir and subalpine fir are more common, often forming dense understories that compete strongly with the dominant overstory for limited resources. The change in species composition and structure over time has resulted in significant forest health concerns.

Increased levels of tree stocking are among the conditions identified as contributing to the accelerating incidence of insects and disease on CRF. Yet a dominant criterion used for measuring sustained yield in this case is whether the timber inventory – identified as being too high and contributing to the forest health issue – is being maintained or increasing. It would seem that discussions of maintaining inventory levels and determining whether net growth and harvest are in balance are most appropriate **after** the forest has been transitioned to a more "sustainable" condition. This condition would reflect changes in species mix toward a more ecologically resilient species composition, stocking levels across the forest lowered to densities that are more consistent with the historical range of variability, and a distribution of age and size classes that support indefinite production of forest goods and services. The comments that follow address what we contend is a proper interpretation of sustained yield management and highlight the deficiencies of the interpretation as utilized in the IRMP.

The Draft Programmatic Environmental Impact Statement Executive Summary (EXSUM-DEIS) states:[6]

> Continuous Forest Inventory analysis revealed that continuing an Annual Allowable Cut (AAC) level of 77.1 MMBF under Alternative 1 would not be sustainable with a 120-year rotation age. The preferred alternative reduces the rotation age to 80-100 years in order to ensure sustainability over the long term. Although Alternative 3 has a lower AAC (58 MMBF), the forest-wide thinning approach does not provide a predictable recruitment of new age classes and may not be sustainable in the long-term. Alternative 4 would significantly increase the annual harvest to 100 MMBF, well above the level of sustained yield determined for the 2000 and 2015 IRMPs.

[5] Executive Summary-DEIS, p. 23.

[6] Executive Summary-DEIS, p.17.

> The expanded harvest level would not be sustainable in the long run and would likely result in significantly reduced harvest levels in the future.

The fulcrum on which the accuracy of this statement pivots is how the term "sustainable" is defined.[7] If sustainable is defined as a harvest level and rotation that never change, then the statement could be considered true. However, we would argue that such a definition is much narrower than the definition generally recognized by the forestry profession. Further, we believe that the manner in which this definition is applied in the IRMP to the CRF is contributing to the forest's degradation, in both ecological and economic terms, rather than improving it.

First, in the IRMP and various supporting documents, the terms "sustained yield" and "sustainable" and "sustainability" are used interchangeably in the forestry sections. Technically, "sustained yield" and "sustainable" or "sustainability" are related but not synonymous terms. In most instances sustained yield refers to the yield of timber products while sustainability refers to the broader array of forest resources.[8] Even though the terms are used interchangeably throughout the IRMP and related documents, in the forestry sections the terms are predominantly being used to describe sustained yield in the narrower sense of timber production. We follow that convention in our review of the IRMP and related documents.

Sustained yield is commonly understood to mean providing for a continuous supply of timber. The key is what is meant by "continuous." The Forest Management Plan provides the following definition of sustained yield:[9]

> Sustained yield can be defined as the yield that a forest can produce continuously at a given intensity of management. This implies continuous production so planned as to achieve, at the earliest practical time, a balance between increment and cutting. In other words, it is prudent to cut only as much as the forest can grow, and long-term forest planning is needed to determine an appropriate harvest level.

This definition has been implemented in the IRMP by applying the concept of non-declining even flow at a specified rotation length for each specific plant association group (PAG) stratum:[10]

> This analysis utilized BIA software called HARVEST, Timber Harvest Scheduler for Even---aged Structure Forests to model the AAC. HARVEST is a harvest scheduling simulator developed to assist BIA and Tribal foresters with determining the Annual Allowable Cut and harvest schedules for even-aged forests. It is designed to simulate final harvest and subsequent regeneration of an even-aged forest on a generally homogenous site. <u>The model has numerous even-aged scheduling methods.</u> The **Non-Declining Even-Flow** method was used for this analysis to calculate the AAC. Even-flow harvest schedules calculate the maximum volume that can be harvested on a sustained basis over the analysis period (200 years for this project). Non-declining even flow schedules have constant or increasing harvest levels, but never decreasing levels. The HARVEST program will

[7] More in-depth discussion regarding the definition of sustained yield is presented in Appendix A.
[8] Luckert, T.K. and T. Williamson. 2005. Should sustained yield be part of sustainable forest management? *Can. J. For. Res.* 35:356–364. http://www.cfs.nrcan.gc.ca/bookstore_pdfs/26944.pdf
[9] Forest Management Plan, p. 47.
[10] Forest Management Plan, p. 49.

> determine an AAC that ensures the harvestable volume is not exhausted at the end of the analysis period. (bold emphasis in the original, underline emphasis added)

The classic forestry text, *Forest Management: Regulation and Valuation* by K.P. Davis of Yale University,[11] offers the following definition of sustained yield, which integrates existing forest conditions, landowner objectives, production of outputs, and maintenance of the forest on an indefinite basis. In defining the term, he appeals to the Society of American Foresters (SAF) 1958 definition of sustained yield, and then offers further commentary and interpretation on how this definition should be understood and implemented in practice.

The SAF definition Davis refers to states:

> Sustained yield is, "Management of a forest property for continuous production with the aim of achieving, at the earliest practicable time, an approximate balance between net growth and harvest, either by annual or somewhat longer periods."[12]

Note that this definition is very similar to the definition of sustained yield given in the IRMP. Davis then provides commentary on how the definition should be understood and applied in practice:[13]

> Sustained yield management, as the term is most commonly and accurately employed, means continuity of harvest (includes footnote to the SAF definition cited above). Whether reckoned by years or longer periods, the purpose is to obtain a sustained flow of products, ***a flow that may be currently increased or decreased in accordance with the purpose of management and the condition of the forest***, but ***which may be continued indefinitely even though often at variable levels***. (emphasis added)

The key for developing an allowable cut under sustained yield management is developing a harvest and regeneration strategy that will provide **a continuous**, **perpetual**, **but not necessarily invariant**, flow of forest products and services over time that satisfies landowner objectives for the forested property. What the IRMP and the Davis definition have in common is a recognition of the forest being first transformed into a condition where ultimately the more conventional measures of sustained yield can be appropriately applied. **Sustained yield cannot be understood apart from existing forest conditions and land owner objectives**; managing a forest such that net growth and harvest are in balance or net growth exceeds harvest, or that that inventory is maintained or increases over time does not ensure the forest is being managed under sustained yield. Such commonly applied measures of sustainability are only appropriate **after** a forested property has been managed such that the distribution of tree ages and sizes are sufficiently balanced to perpetuate the forest, and the products and services derived from it. **Until the forest has been transformed into that condition the singular focus on net growth and harvest being in balance and inventory being maintained is premature**.

In short, while sustained yield management **could be** accomplished using non-declining even-flow concepts to calculate the AAC, an AAC calculated using non-declining even-flow does not necessarily result

[11] Davis, K.P. 1966. Forest Management: Regulation and Valuation. McGraw-Hill Inc. Second Edition. 519 p.
[12] Ibid. p. 6, footnote 1.
[13] Ibid. p. 6.

in sustained yield management. In fact, we contend that applying non-declining even-flow constraints to the CRF **does not** implement sustained yield management because of the existing forest conditions.

For even-aged forest management to achieve a sustained yield basis, it is necessary to transition the forest to a condition in which the distribution of age classes can perpetuate the forest. The DFC acreage distribution tables[14] in the Forest Management Plan seek to establish some objectives along this line. Given their importance in ostensibly driving the management of the forest, we are curious about the data source for these historical range of variability (HRV) and DFC tables; no citation is offered. Specifying DFCs is a critical aspect of rationalizing forest health (a key community objective) with other management objectives. For example, while forest health is a primary objective, the economic contribution the forest makes and is able to make to the community – both directly in terms of stumpage revenues and indirectly in terms of regional economic activity – is not inconsequential. Similarly, terrestrial wildlife habitat conditions are important, as is site integrity to protect water quality. Thus, the DFCs need to be defined in the context of a multiplicity of management objectives. The discussion of the DFCs and the relevance of the preferred forest management plan to them will be discussed in greater depth in the Desired Future Conditions section of this report.

Although the stated forest management objective is to manage under an even-aged regime (which we concur is appropriate for these ecological types) there is little discussion of existing age class distribution in the IRMP documents. Figure 3.1 summarizes the existing forest age class structure of the CRF, developed from tables in the FIA report.[15]

[14] Forest Management Plan Tables 19 to 25, pp. 73-79.

[15] In this part of the analysis, the focus is on the distribution of forest acres by age class. Our contention is that by managing the forest toward a balanced age class objective, the sustained yield management goals for the forest can be attained while substantially achieving the DFCs. However, the DFCs themselves lack a sufficient discussion of their derivation, and an objective, quantifiable method of assigning acres to DFCs, as discussed more completely in Section 4.

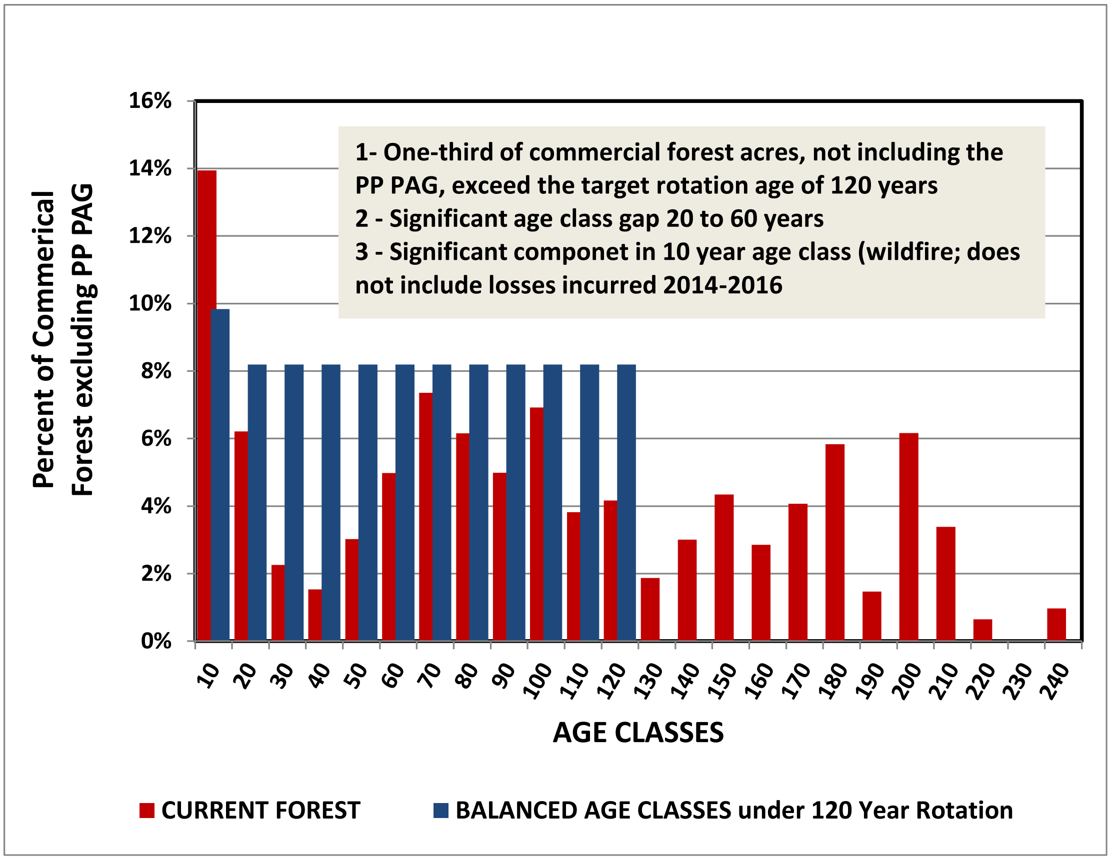

Figure 3.1. Existing forest age class structure of Colville Reservation Forest.

First, note that one-third of the commercial forest base, but not including the 68 thousand acres on the ponderosa pine PAG,[16] exceed the target 120 year rotation age. As will be subsequently discussed, this means one third of the forest is in biological decline – evidenced by slowing growth each year and increased tree mortality.

[16] We believe excluding the ponderosa pine PAG stratum (PP PAG) from regeneration harvest as part of the forest management plan is a shortcoming of the analysis. While the forest plan does include some management of the PP type, it appears it is predominantly via intermediate management (see FMP Table 13, p. 50). There are no managed yield tables for the 68 thousand acre PP PAG stratum reported in the FMP or FIA reports. Regeneration harvests within the PP PAG would allow for stand improvement and insect/disease control as needed.

According to the FIA report, the PP PAG has 211 MMBF on 68 thousand acres, representing about 9% of the ponderosa pine inventory on the commercial forest base. It has 26.6 trees per acre in DBH sizes 8" and larger. We observe this is akin to descriptions of the historical range of variability for the ponderosa pine types found on the Reservation (from FMP, p. 11):

> In 1904 a forester named Franklin Reed described two forest types on the Reservation (Reed 1904): "…a pure, open stand of bull pine (ponderosa) with a ground cover of bunch grass. The stand consist of 10 to 15 trees, 12 inches and over diameter breast high, per acre…"

Second, there is a significant age-class gap in the 20-to-60-year age class. We speculate this age class gap is a major contributor to the IRMP claim of the CRF being unable to "sustain" an AAC of 77.1 million and a rotation age of 100-120 years. For context, the recommended 77.1 MMBF AAC is 67% of current net growth. Conversely, mortality is 74% of the recommended AAC and was 175% of the average annual harvest observed on the CFI plots from 2004 to 2013 (Table 3.1). Ironically, with growth exceeding both harvest and mortality, stocking across the forest will increase; yet it is generally believed the already-high stocking levels are contributing to the forest health problems. Forest health issues are indeed being exacerbated, rather than reduced, due to the age class gap in the 20- to 60-year-old age classes, and the IRMP commitment to view non-declining even-flow – in conjunction with the 120-year rotation – as practicing sustained yield.

Table 3.1. Reservation-wide growth, mortality and harvest.[17]

Commercial Cut Base (660,418 acres, 415 Plots)

	Bd Ft/Per Acre/year	Total Million Board Feet per year
Gross Growth (bdft/acre/yr)	260	171.7
Mortality (bdft/acre/yr)	86.2	56.9
Net Growth (bdft/acre/yr)	173.8	114.8
Harvest Volume (bdft/acre/yr)	49.15	32.5

Third, a share of the accelerating mortality across the forest is due to wildfire losses; this is most readily apparent in the "excess" acreage in the 0- to 10-year-old age class despite the harvest dropping significantly over the past 10 years. Figure 3.2 shows the drop in harvest levels over the past 10 years; note that these data are only through 2013.

While wildfire-related mortality, as well as other mortality, occurs throughout the property, in the case of stand-replacing fire, stand acres are "recycled" to the 0-10 year class. Such losses are a common consequence of tree stands decimated by insect and disease that are more susceptible to stand-replacing conflagration. This age-class acreage distribution is actually worse than portrayed in Figure 3.1, as stand-replacing wildfire losses from the 2014-2016 fire seasons are not reflected in Figure 3.1's numbers.

Further, applying non-declining even flow to a forest in this extremely unbalanced age-class condition produces an outcome that, in addition to being incongruous with forestry yield and science, confounds existing forest health and productivity issues. As a stand develops over time it enters a phase in which there is the rapid accumulation of wood fiber per acre. As the trees in the stand grow past a certain age, the rate of wood fiber accumulation slows. If the accumulated wood fiber at each stand age, plus any wood fiber removed in prior intermediate harvest operations, is divided by the stand age the result is called the Mean Annual Increment (MAI). MAI is a measure of the biological vitality of the forest. The age at which MAI is at a maximum is referred to as biological maturity. The IRMP sets rotation length in the forest plan to equal biological maturity, which is roughly 120 years for these species and ecological types.

[17] FIA report, p. 38.

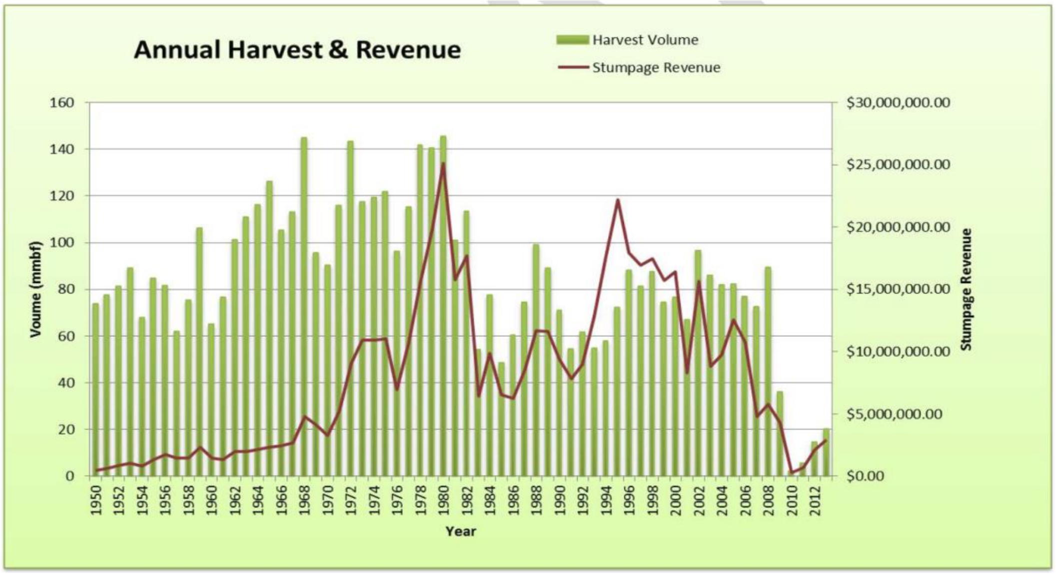

Figure 3.2. Historical (1950-2013) harvest volume and value.[18]

Figure 3.3 shows the trend of forest level MAI per acre under the managed yields included in the FIA report (blue line on the chart). Note how the volume grown per acre per year peaks at age 100, declining only slightly by age 120, the selected rotation age. Had the yield curve been extended to older ages, the average growth over the course of that age would continue to decline. Some of this is due to increased mortality but most of the decline is due, at least initially, to slowing growth as the tree ages.

The implication of this growth curve is that when forests are routinely grown beyond biological maturity, the biological vitality of the forest declines. Likewise, when stands are managed on rotations less than biological maturity, biological vitality declines as well, unless there are additional investments to increase growth potential of the trees (e.g., genetically improved planting stock, fertilization, or herbicides). The analysis depicted in Figure 3.3 shows that when a forest is managed at a 60-year rotation, the biological vitality and hence the sustained yield, will be 48% less (136 bf/ac/year compared to 260 bf/ac/year) than a forest being managed to a 120-year rotation.

[18] FMP Figure 5, p. 66.

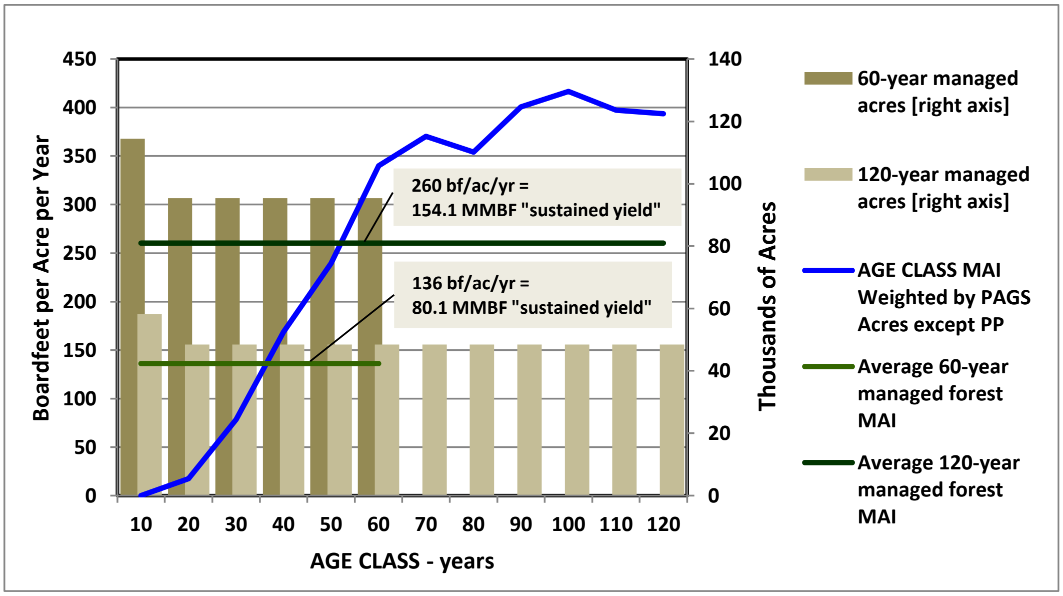

Figure 3.3. Forest-level mean annual increment per acre, by rotation age.

This analysis is not intended to suggest what the AAC should be, only to demonstrate the expected results of operating a forest under a balanced age-class condition at a 60-year rotation compared to a 120-year rotation. All else being equal, reducing the rotation age from biological maturity should reduce the MAI along with sustained-yield AAC.

However, the rotation analysis with non-declining even-flow applied to the current forest results in a very different outcome -- with the 60-year rotation exhibiting **a higher AAC** than the 120-year rotation despite the expectation that the AAC (which is necessarily related to MAI) would be lower for the shorter rotation. The question is why would this be the case for the CRF?

From FIA report, page 26:[19]

Table 13. Sustainable Annual Allowable Cut of regeneration volume in net million board feet per year, calculated with HARVEST using the Non Declining Even Flow method. Assumes 10% reduction for overstory retention requirements outlined in the IRMP.

Plant Association Group	60 Year Rotation	120 Year Rotation
DFWM	18.4	9.7
DFCM	37.8	20.3
DFCD	7.5	4.8
GF	14.4	10.5
SF	15.4	10.8
TOTAL	**93.5**	**56.1**

[19] A table similar to this one occurs in the Forest Management Plan report, p. 50. The table in the Forest Management Plan report includes intermediate harvest volume for the 120 year rotation. However, the key point remains: reducing rotation age below biological maturity resulted in AAC increasing, rather than falling, as would be expected with shorter rotations.

We speculate this occurred for two main reasons. First, the shorter rotation was better able to cope with the large age class gap (20- to 60-year-old timber) by providing more acres beyond rotation age (403 thousand acres of 70- to 240-year-old stands) to fill the gap. In the contrasting case of 120-year rotations, there are currently only 205 thousand acres beyond rotation age (over 120 years of age), so there is less flexibility to fill the age class gap and hence harvest levels must be reduced to bridge it. Second, under the 60-year rotation the existing forest is more quickly transformed to a forest with a balanced set of age classes. The yields on the current forest are substantially below those of the managed forest (Figure 3.4).[20] The 60-year rotation alternative transitions the forest more rapidly to these higher per-acre managed yields, increasing the effective biological vitality of the CRF over the planning horizon.

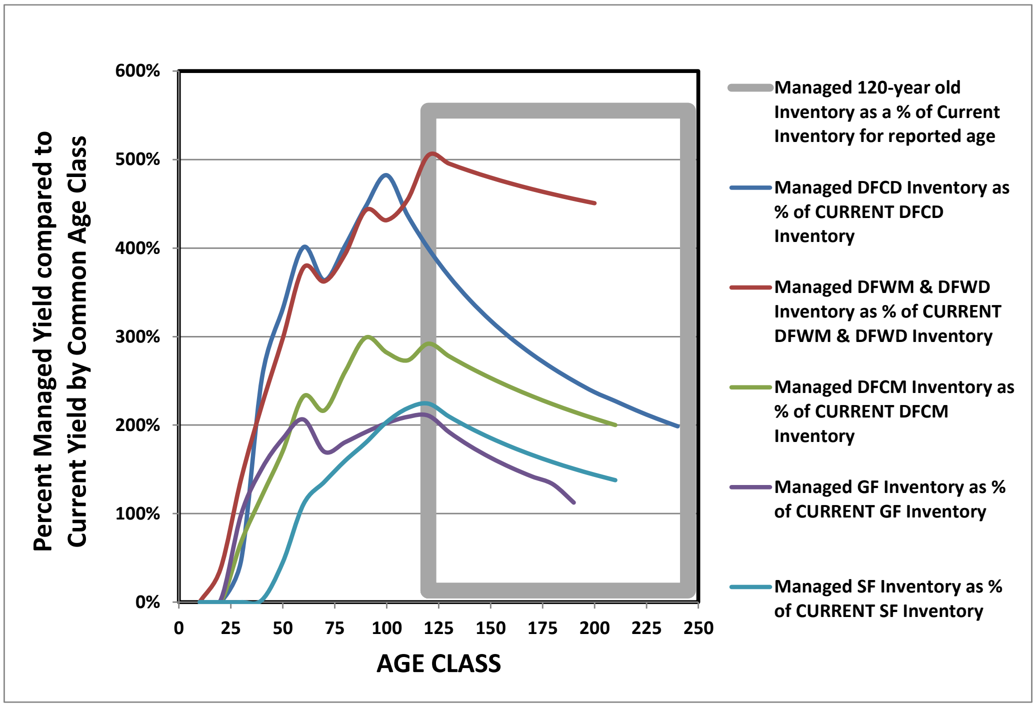

Figure 3.4. Percent managed yield compared to current yield, by common age class.

Transitioning to managed and younger stand-age conditions more quickly should help blunt the impact of accelerating mortality impacts across the forest. The FIA reports 15.35 snags per acre of trees 8 inches DBH and greater. This compares to 61.29 live trees per acre that are 8 inches DBH and larger; i.e., 20% of all standing trees (both dead and alive) 8” DBH and larger are dead.

For a point of comparison we queried the USFS’s Forest Inventory Analysis data base for all private forested plots in NE Washington counties (Chelan, Douglas, Okanogan, Ferry, Stevens, Pend Oreille, Spokane, and Lincoln) outside a rectangle that includes the Colville Reservation (Figure 3.5). In this way we excluded all forest plots the USFS would have in its data base that fell on the CRF. Across those 1.6 million private timberland acres “Outside the Box” (there were 1.0 million private acres according to FIA

[20] There may be a conflict between the stocking levels implied by the managed yields and the objective of moving the forest toward a lower overall level of stocking. This may require considering alternative stand prescriptions that result in reduced stocking levels than what are currently modeled.

"Inside the Box"; this includes CRF timberland, other private timberland on the Colville Reservation, and private timberland outside the Colville Reservation but "Inside the Box") only 9% of all standing and dead trees 8 inches DBH and larger are dead. So, the percentage of standing dead trees 8 inches DBH and larger on the CRF is **more than double** that seen on other private timberland ownerships within the same geography.

We believe a plan that aggravates an already challenging forest-health problem highlights the inadequacy of the non-declining even-flow concept to define "sustained yield" when applied to a forest in this condition. The effect of constant 120-year rotations and extremely unbalanced age classes results in further extending rotations on timber well in excess of 120 years old and in biological decline. This in turn exacerbates insect and disease issues, and increases the risk of catastrophic wildfire losses as mortality increases. Such wildfires threaten human life, infrastructure, water quality, and air quality.

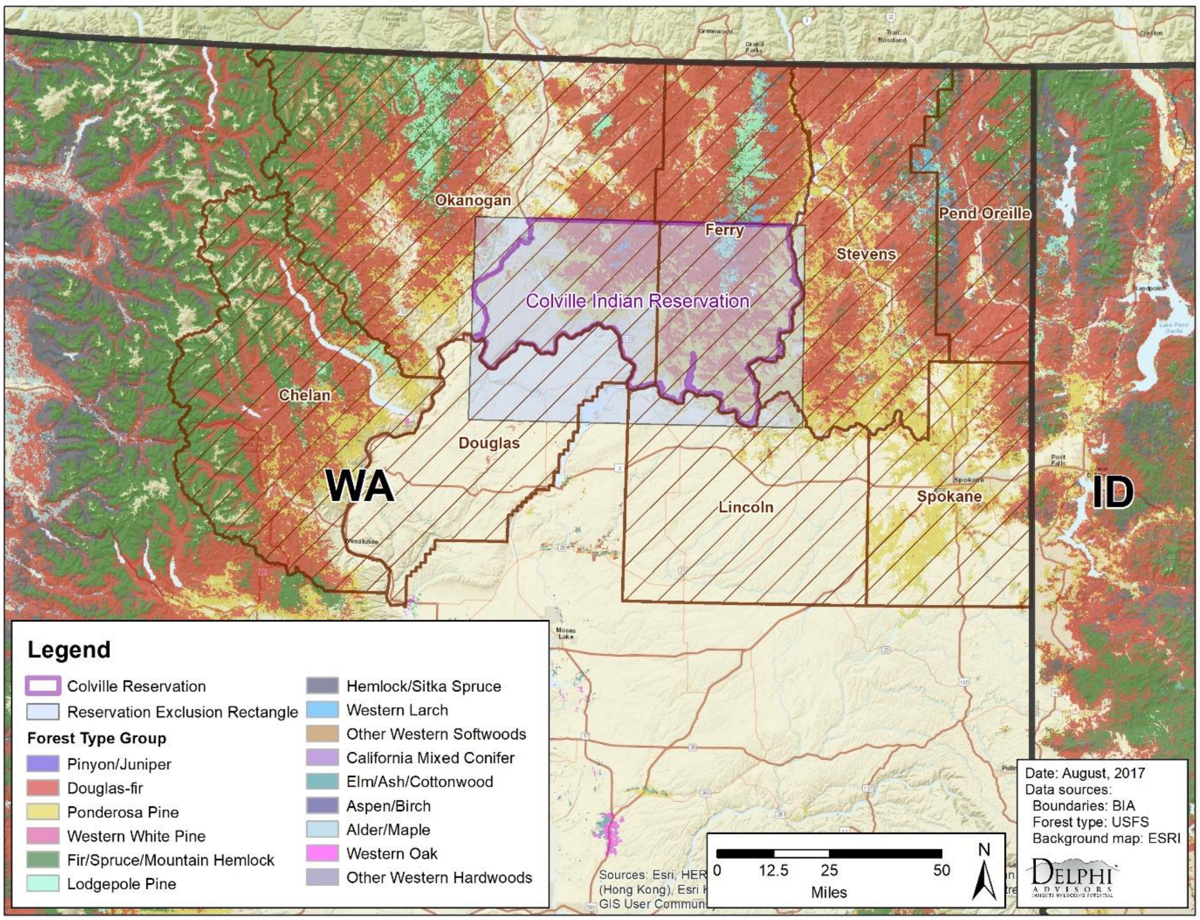

Figure 3.5. Forested acres outside a rectangle bounding the Colville Reservation.

We recommend developing an alternative plan(s) that might move the forest more rapidly toward a balanced age class/size class condition. The AAC in this alternative should not be computed under the non-declining even-flow concept. Rather, the alternative should have the flexibility to adjust harvest levels, rotation lengths, and stand prescriptions over time until the forest is transitioned into a condition where it can perpetuate itself at the desired 120-year rotation lengths and meet other DFCs. We describe such alternatives in greater detail in the Alternative Forest Plan section of this response.

4. Desired Future Conditions versus Projected Plan

The concept of managing for desired future forest conditions has great merit. Simply put, you cannot get to where you want to be, without first outlining what that destination looks like. Accordingly, the Forest Management Plan devotes substantial discussion to the topic of Landscape Level Desired Future Conditions (DFC). The process of generating DFC goals across various forest types is described in the Forest Management Plan (FMP) as follows:[21]

> Desired Future Conditions based on Historic Range of Variability (HRV) were developed by Plant Association Group [PAG] for the 2000 IRMP. These HRV tables can be found in Appendix B and provide a general goal of successional patterns by Plant Association Group that would achieve the DFC. These tables were developed for the 2000 IRMP, and provide guidance to the natural resource program on what the forest should look like to achieve DFC number 7 in the IRMP, "managed landscapes more closely resemble those created by the activities of historic disturbance agents such as fire (natural and aboriginal ignitions), wind, insects, disease and animals". The tables are based on what is considered to be the Historical Range of Variability for the various stand types. Achieving these goals will likely take decades to accomplish, but the tables can help in the development of projects.

An example DFC table from the FMP is replicated in Table 4.1:

Table 4.1. Ponderosa pine historic range of variability and desired future condition.[22]

STRUCT. CLASS	COND.[1]	STRUCTURAL STAGE [2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	1309-6543 (1-5%)					
	DFC	3926-9160 (3-7%)					
2	HRV	1309-13086(1-10%)					
	DFC	7652-17012 (6-13%					
3	HRV	1309-13086(1-10%)					
	DFC	7652-17012 (6-13%					
4	HRV	26172-39258 (20-30%)	6543-19629 (5-15%)				
	DFC	26172-39258 (20-30%)	13086-19629 (10-15%)				
5	HRV	45801-65430 (35-50%)	6543-13086 (5-10%)				
	DFC	32715-49726 (25-38%)	3926-10469 (3-8%)				

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.

[2] Structural Stage: E-S Early Seral; E-M Early Mature; M-S Mid-Seral; M-M Mid-Mature; L-S Late Seral; L-M Late Mature.

When attempting to interpret and apply the DFC tables presented in the Forest Management Plan, numerous problems arise:

- The table labels are confusing, incomplete, and potentially incorrect. As shown in Table 4.1, the rows and columns are labeled as, respectively, "STRUCT. CLASS" and "STRUCTURAL STAGE". This seems an illogical combination, since the two labels are roughly synonymous. In addition, the individual row labels for "STRUCT. CLASS" are simply 1, 2, 3, 4, and 5; with no definition of the individual codes

[21] 2015 FMP, p. 31.

[22] 2015 FMP Table 19, p. 73.

provided. Lastly, the definitions provided for the individual column labels (E-S Early Seral; E-M Early Mature; M-S Mid-Seral; M-M Mid-Mature; L-S Late Seral; L-M Late Mature) do not correspond with any typical successional categories or trends. We believe, based on the layout of Table 9 (p. 44) in the FMP, that the rows of the DFC tables represent stand size class, and the columns represent a combination of seral and structural stage, as detailed below:

Row 1 = Size Class 1 (<1" dbh) (vs "Struct Class 1" in DFC table)
Row 2 = Size Class 2 (1-5" dbh) (vs "Struct Class 2" in DFC table)
Row 3 = Size Class 3 (5-10" dbh) (vs "Struct Class 3" in DFC table)
Row 4 = Size Class 4 (10-20" dbh) (vs "Struct Class 4" in DFC table)
Row 5 = Size Class 5 (>20" dbh) (vs "Struct Class 5" in DFC table)

Column 1 = ES: Early Seral/Single Storied (vs "Early Seral" in DFC tables)
Column 2 = EM: Early Seral/Multi-Storied (vs "Early Mature" in DFC tables)
Column 3 = MS: Mid-Seral/Single Storied (vs "Mid-Seral" in DFC tables)
Column 4 = MM: Mid-Seral/Multi-Storied (vs "Mid-Mature" in DFC tables)
Column 5 = LS: Late Seral/Single Storied (vs "Late Seral" in DFC tables)
Column 6 = LM: Late Seral/Multi-Storied (vs "Late Mature" in DFC tables)

The DFC tables, reformatted and labeled as we believe they should be, are presented in Appendix B.

- We also believe, as will be subsequently discussed, that it is acceptable for the acreage percentages reported in the tables to exceed 100%. If that is the case, then that point should be made within the DEIS. If that is not the case, then the tables are in error, and should be corrected.
- There is no specific documentation provided within the IRMP that quantifies how the DFCs were derived. The lack of such information makes it impossible to evaluate the adequacy and reliability of the DFCs in terms of attaining the stated goal that "managed landscapes more closely resemble those created by the activities of historic disturbance agents such as fire (natural and aboriginal ignitions), wind, insects, disease and animals".
- There is no objective, quantifiable procedure for classifying forest acres into the various DFC categories. For example, what process is used to identify a stand as "single storied" versus "multi-story"? Such classification rules form the basis for evaluating any management option for its ability to meet the DFC goals. Without such rules, no meaningful comparison of alternatives can be made.
- There are no statistics provided in the Forest Management Plan that compare current forest condition to the DFCs. Without such a breakdown, there is no way to know how well the current forest conditions meet the DFC goals, and what management actions may be needed to attain those goals.
- There are no results provided from the growth and yield projections utilized in each of the alternatives that would allow for a meaningful comparison of how each management alternative meets the DFC goals. Specific, quantitative data on projected future forest conditions (e.g., tree size, stocking, species composition, vertical structure, etc.), by PAG, are required in order to evaluate how well each alternative can move the forest toward the DFC goals.

In summary, the DEIS provides no background data to help understand how the DFCs were created; how forest acres can be objectively classified into the DFC size-class and structural stage categories; how the DFCs compare to current forest conditions; and how the proposed alternatives may move acres toward, or away, from the DFC goals. Quite simply, there is currently no objective "measuring stick" with which to evaluate the management alternatives as to their ability to meet the landscape level DFC goals.

In addition, it is important to note that the DFCs represent very broad landscape-level goals. In reviewing the acreage ranges within the DFC tables, two key points should be kept in mind (assuming that the DFC tables were intentionally designed to allow the individual acreage ranges to sum to over 100%):

1) The HRVs (and by association, the DFCs) represent a **range** of acreage values which each structural stage/size-class combination is believed to have historically spanned, prior to intensive human alteration of the landscape. These acreages were historically in a constant flux; environmental conditions which favored the expansion of one structural stage/size-class combination, simultaneously resulted in the decline of another. The HRV (and DFC) ranges represent the maximum/minimum acreage values which each structural stage/size-class combination is thought to have attained over a long period of time.

2) Since the HRV and DFC acreage ranges represent the estimated minimum/maximum acreage representations attained over long-periods of time, under a range of environmental conditions, we cannot expect that the maximum DFC acreage percentages could ever be simultaneously achieved for all, or even a large portion of, the individual structural stage/size-class combinations. And in fact, we often cannot simultaneously attain even the average acreage representation across all structural stage/size-class combinations.

The validity of the above two points can be seen in the DFC tables presented in the DEIS. In Appendix B, calculations were added to the right of the DFC tables, to sum up the average of each acreage range across all seral/structural stage and size-class categories for a given PAG. The results of those calculations are shown below in Table 4.2. As detailed in the table, most of the HRV and DFC acreage percentages sum to more than 100%, and range as high as 157% of total PAG acres. This implies that for five of the seven PAGs on the CRF, it is impossible to simultaneously reach even the average DFC acreage values for the individual seral/structural stage and size-class combinations within the PAG.

Table 4.2. Summary table showing the total of HRV/DFC acreage percentages, summed across all size class and structural stage categories, within a given PAG.

Forest Plan table reference and PAG description	HRV	DFC
Table 19. Ponderosa Pine Historic Range of Variability, and Desired Future Conditions.	99%	99%
Table 20. Douglas-fir Warm Dry Historic Range of Variability, and Desired Future Conditions.	131%	113%
Table 21. Douglas-fir Warm Moist Historic Range of Variability, and Desired Future Conditions.	134%	103%
Table 22. Douglas-fir Cool Dry Historic Range of Variability, and Desired Future Conditions.	134%	103%
Table 23. Douglas-fir Cool Moist Historic Range of Variability, and Desired Future Conditions.	132%	100%
Table 24. Grand Fir Historic Range of Variability, and Desired Future Conditions.	146%	112%
Table 25. Subalpine Fir Historic Range of Variability, and Desired Future Conditions.	157%	108%

The DFCs must therefore be regarded as very broad goals. The range of acreage percentages provided for each seral/structural stage and size-class combination provides flexibility in simultaneously meeting acreage goals for the other categories, and also for meeting other socioeconomic needs from the forest. Any time the minimum DFC acreage goal for a given structural stage/size-class combination is achieved, (or conversely, the maximum acreage goal for over-represented categories), that DFC goal should be considered as being fully met since this allows flexibility in meeting the other DFC goals, as well as socioeconomic needs from the forest not reflected in the DFC approach.

However, we cannot currently ascertain the degree to which the CRF forest meets the DFC goals. No such information is provided within the DEIS, nor is there any set of rules for classifying forest acres into the various DFC categories, which would allow the reader to compute the degree to which DFC goals are currently being met. Both of these evaluation metrics should be included in the DEIS. In addition, the DEIS should also apply the DFC classification rules to the results of the growth and yield predictions used in each of the forest management alternatives; doing so would provide a means of ascertaining how the various alternatives move the forest toward or away from the DFC goals.

Such rules should not only be provided in the DEIS, in detail, but the field procedures for collecting stand inventory data should include on-the-ground estimates of current DFC class, against which to test the accuracy of any DFC classification rules. This field observation should be done for both the current CFI system, and for any stand-based inventory system developed.

Lastly, as is pointed out at several points within this document, there is a strong need for forest management prescriptions that are specifically designed to create the type of size-class and seral/structural stage combinations laid out in the DFCs.

The Forest Management Plan describes historical forest conditions as follows:[23]

> In 1904 a forester named Franklin Reed described two forest types on the Reservation (Reed 1904):
>
> "...a pure, open stand of bull pine (ponderosa) with a ground cover of bunch grass. The stand consist [sic] of 10 to 15 trees, 12 inches and over diameter breast-high, per acre..."
>
> He describes this pine type as occurring on predominantly southern exposures up to 3,500 feet in elevation. The second type, which he called mixed-forest, occurred above 3,500 feet elevation, on all north exposures below that, and in the bottom of deep, narrow, sheltered valleys, such as the San Poil River and Hall and Barnabee Creeks. He describes this mixed stand as:
>
> "...a dense stand of red fir (Douglas-fir) and larch with a varying intermixture of yellow ponderosa and lodgepole pine. The stand is often so dense as to prevent the growth of grass, but where it is open enough the ground cover is usually pinegrass. The proportion of timber under 12 inches in diameter breast high is so high that the yield per acre is not heavy..."

And from the IRMP:[24]

> Much of the Reservation forest was at one time described as having open and park like stands of ponderosa pine and western larch with grass growing in the understory. Fires burned frequently through these stands, influencing and shaping the species composition, structure and density of the forest stands. With the initiation of practices such as fire suppression, timber harvest and grazing, the open park like forest began to change to a multi-layered canopy Douglas-fir and grand fir dominated forest.

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[23] 2015 FMP, p. 11.
[24] IRMP, p. 78.

Many of the Reservation's forest stands that were once composed of ponderosa pine and western larch are now primarily composed of Douglas-fir and/or grand fir. These stands tend to be denser than the historic stands and have a multi-layered structure. Many of the large ponderosa trees are gone and the shift in species composition, structure and density makes these stands more susceptible to attack by insects and disease.

It is worthwhile to note several points from the above descriptions:

1) The open ponderosa pine type was described as having only 10-15 trees per acre, 12 inches dbh and larger. That equates to only 21 square feet of basal area per acre, assuming there were 15 trees/acre, 16 inches dbh in size. That is, obviously, a very low level of stocking compared with current forest conditions, as shown Figure 4.1:

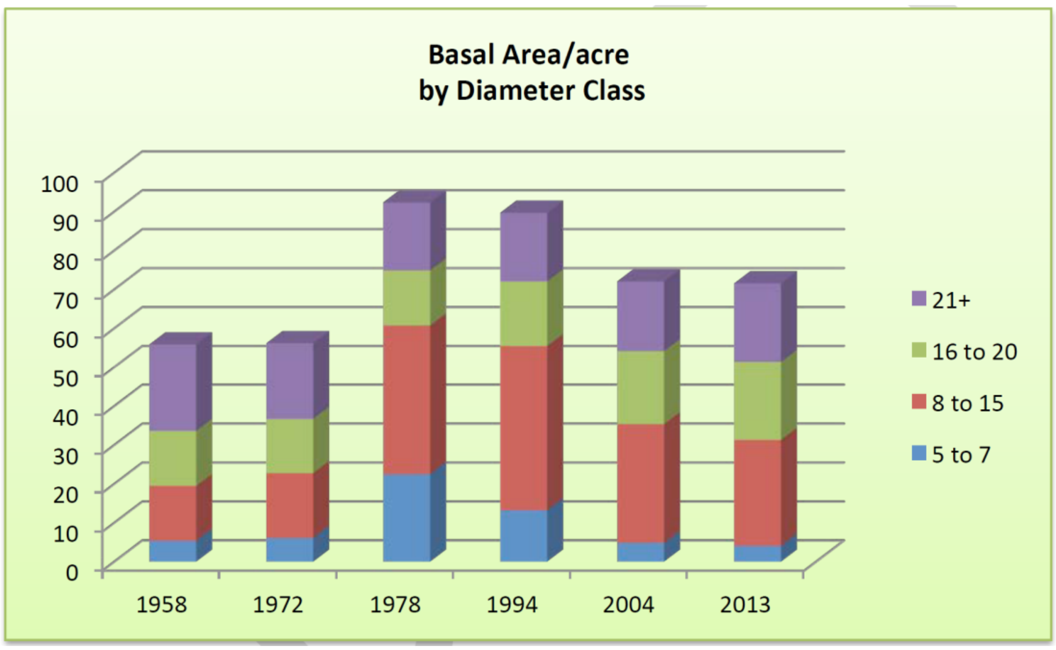

Figure 4.1. Basal area per acre trends (5 inch trees and greater).[25]

2) The open ponderosa pine type was described as occurring on low-elevation, southern exposures. Such sites would likely have been more commonly encountered by both Native Americans and European immigrants, which may help explain why this stand type figures so prominently in the recollections of tribal elders. Tabulating forest acres by elevation and aspect class, using FIA data, indicates that roughly one-third of the Reservation forest lands might be considered to fit the description of "predominantly southern exposures up to 3,500 feet in elevation." It is reasonable to assume that a portion of these sites (low elevation southern exposures) would be relatively hot, dry environments with slow tree growth; putting them outside the productive forest base currently used for timber production. This should be recognized when computing forest acres contributing to the DFC goals. The DFC goals should not only recognize the contributions from lands whose productivity level puts

[25] 2015 FMP Figure 2, p. 17.

them outside the "productive forest" base, but also those acres that are administratively withdrawn from the productive forest land base. These withdrawn acres, primarily riparian management zones, total roughly 31,000 acres, as per Table 1 in the FIA report.

3) The mixed-forest type described by Reed (Douglas-fir, larch, ponderosa pine, and lodgepole pine) was densely stocked with no significant component of large trees. Using the same FIA acreage analysis described above in point 2, this Douglas-fir mixed forest type would be assumed to comprise roughly two-thirds of the Reservation forest lands.

   Reed described this forest type as being dominated by dense, small diameter stands. This would imply that managing for long-rotation, very-large-diameter stands of this type, as a DFC goal, would not be consistent with historical forest conditions. While historical conditions may have been dense, small diameter stands, current fire and disease risks could easily argue for lower stand stockings.

In light of the above points, it seems imperative that new forest management prescriptions be designed and incorporated into the Forest Management Plan that would be specifically aimed at facilitating movement of forest acres into desired DFC categories. Simply adjusting the rotation length of current prescriptions will not have the desired effect. For the ponderosa pine open-park stand types, the use of all-aged stand prescriptions may be needed on a portion of the forest lands. These prescriptions would have significantly lower stand densities than current conditions, and would logically be applied to low elevation, southern exposure sites – including (and perhaps even targeting) those not currently recognized as part of the productive forest land base. There have been numerous studies aimed at developing such prescriptions; most of them involving repeated stand entries to mimic the effect of high frequency, low-intensity fires. An example project of this type, applied in Oregon, is described by Fitzgerald.[26]

And lastly, one must recognize that DFC goals are long-term objectives, to be strived for in conjunction with other forest amenities. Movement towards the goals will take decades, and must be balanced against other needs such as economic returns, social needs, wildlife habitat, watershed protection, and current fire and disease risks.

[26] Fitzgerald, S. Using uneven-aged management as a restoration strategy in ponderosa and dry mixed conifer forests. Corvallis, OR: Oregon State University.

5. Timber Inventory Estimates

Despite indications that the most recent (2013) continuous forest inventory (CFI) was done accurately, we suggest that – based on comparisons to other sample results and comparisons to the 2004 inventory – there is reason to believe the 2013 inventory is actually higher than the 8,784.8 BF/ac reported (Figure 5.1); the analysis that follows suggests the inventory could be over 9,500 BF/ac.

We hasten to add that even if the inventory is higher, as described below, than what is reported, we anticipate the AAC calculations will not be dramatically affected. That is because, based on the description of how the AAC was derived, it appears the higher forest inventory estimates were implicitly utilized when the AAC was computed. Nevertheless, the inventory forms the foundation of the AAC determination and thus should be as unassailable as possible.

But setting aside the mechanics of the AAC issues for the moment, if it is true the inventory is actually higher than reported – and since a key driver behind the forest health crisis on the CRF is too much stocking – realizing forest stocking is even higher than previously thought is not good news. Further, if this is true, our view is the more-likely impact of an understatement of the inventory per acre is the potential it has to influence public perceptions of forest inventory trends, and long-term sustainability of harvest levels.

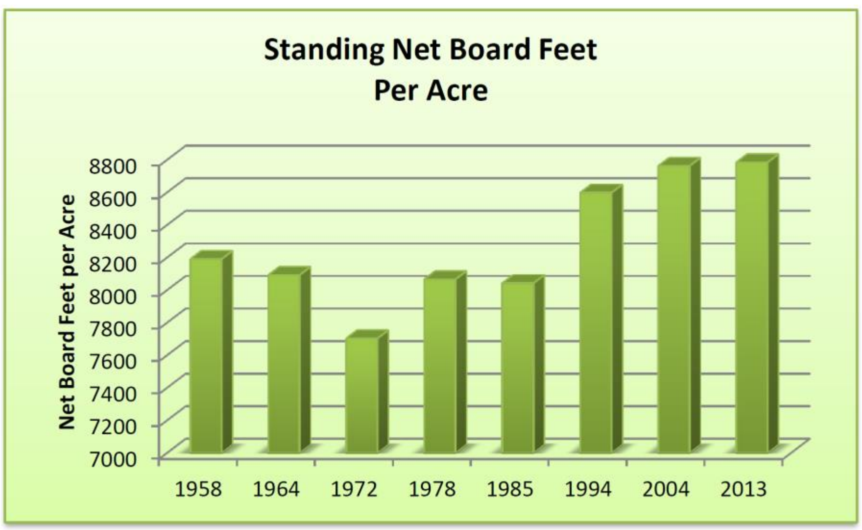

Figure 5.1. Board foot volume per acre over time based upon repeated CFI re-measurements.[27]

Figure 5.1 (reproduced from, and referred to in several places throughout IRMP-related documents) indicates the 2013 inventory barely increased relative to the 2004 inventory. As discussed in the Annual Allowable Cut and Sustained Yield section of this report, a widely-held notion is that a forest managed under sustained yield principles will never experience an inventory decrease. As we show in that section, exclusively non-declining forest inventory as part of sustained forest management is true only in cases of

[27] FIA report Figure 7, p. 13; also FMP, p. 18.

the forest having been first transformed into a more balanced condition so that it can be perpetuated indefinitely – and the CRF has not yet been transformed to such a condition.

Figure 5.1 – combined with community knowledge that the actual harvest over the past 10-odd years was less than the intended 77.1 MMBF allowable cut, and potentially with the incorrect perception that inventory reduction is the mark of "unsustainable forest management" – could lead the community at large to be reticent to maintain the annual allowable cut at 77.1 MMBF. Taken alone, this potential discrepancy in forest inventory is likely not definitive in shaping community perspectives (which are a critical component in supporting the forest management plan included in the IRMP). However, the inventory discrepancy, if inventory is indeed higher than reported, could inadvertently buttress other inaccurate community views on the management, conditions, and trajectory of the CRF that in aggregate present impediments to implementing necessary change if forest health issues are to be addressed.

Our recommendation, relative to the IRMP and in regard to the questions raised here by the inventory, is to secure funding to expeditiously complete/incorporate measurements from the 2013 CFI plots that were not measured, and revisit the calculations and analysis related to the forest inventory, making revisions as required. The findings of the revised inventory need to be shared throughout the community to correct any possible misconceptions regarding current forest conditions and trajectory. Further, the revised inventory should be used to not only re-compute the currently considered alternatives, providing updated calculations based on a more solid data footing, but also to include additional alternatives that explore meeting DFCs with greater flexibility than non-declining even flow. The broad parameters of such alternatives are discussed in the New Alternatives section of this report.

The following presents a summary of the analysis that led to our conclusion it is reasonable to assume the inventory is higher than reported; a more detailed analysis is contained in Appendix C.

The timber inventory used to develop forest management alternatives considered in the IRMP is based on the CFI. The FIA report, which summarizes the timber inventory, describes the latest measurement used in the analysis as follows:[28]

> Starting in the summer of 2013, 445 CFI plots on the Colville Reservation were measured. This was the 8th measurement for these permanent plots. There were 826 plots measured in 2004 [the last re-measurement], but only 445 were measured this period due to budget constraints…There is funding in place to complete the rest of the 826 plots in the summer of 2015. Instead of waiting to complete a CFI Report with the full dataset, this document is being written to aid the Tribe in revising its Integrated Resource Management Plan, which is due to be complete by the end of 2015. The following report will analyze the data, outline basic forest statistics, calculate an Annual Allowable Cut (AAC), and show some forest trends over time. It will end with a discussion of silvicultural issues and long term harvest planning.

Thus, the inventory on which the current plan is based relies on a data set with roughly half the number of plots as the 2004 data set. Assuming the plots re-measured in 2013 proportionally cover the range of forest types and conditions on the forest, the estimate provided should still be statistically accurate (the term accuracy here being used in the formal statistical sense, meaning an unbiased estimate of the inventory) – although the standard error around the estimate (that is to say, the possibility that the actual

[28] FIA report, p. 6.

on-the-ground inventory differs from the CFI estimate) will likely be greater than desired. A map of plot coverage from the FIA report (see Appendix C, Figure C.1) suggests coverage extended across the range of forest conditions, so – at least based on the geographic distribution across the CRF – it is reasonable to expect the inventory estimate is unbiased.

The FIA report highlights a variety of forest measurements, not just the inventory. Other important measurements include gross growth, mortality, net growth, and harvest recorded on CFI plots across the commercial forest base that occurred between the 2004 and 2013 re-measurements. Those results are reported in Table 5.1.

Table 5.1. Growth, mortality and harvest for the 2013 CFI data.[29]

	Bd Ft/Per Acre/year	Total Million Board Feet/year
Gross Growth	260	171.7
Mortality	86.2	56.9
Net Growth	**173.8**	***114.8***
Harvest Volume	49.15	32.5

These "change" results, taken in combination with the reported 2004 and 2013 per-acre inventory present a reconciliation dilemma, however. Figure 5.2 depicts the dilemma, which can be stated as follows: Is the 2013 inventory 8,584.8 BF/ac, as reported (i.e., 153.9 BF/ac higher than the 2004 inventory) or 9,752.8 BF/ac (i.e., 1,121.9 BF/ac higher than the 2004 inventory), as the measurements of change would indicate?

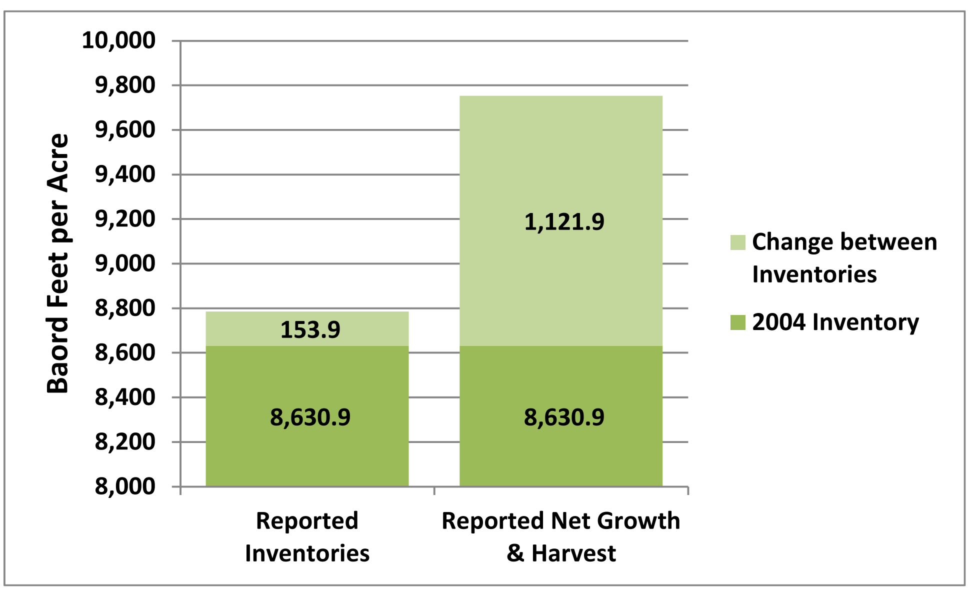

Figure 5.2. The 2013 inventory dilemma.

[29] FIA report Table 2, p. 9.

There is other important data included in the 2013 inventory that may shed light on this dilemma: inventory estimates by individual commercial timber stratum. Using the strata data and the change data, several different estimates of the forest inventory were developed to compare against the reported, single forest-wide volume-per-acre estimate. The different estimates of the timber inventory are summarized below in Table 5.2; how they were calculated is detailed in Appendix C. Based on these alternative estimates – derived from change measurements, the Reservation-wide estimate and its associated standard error, an inventory derived from per-acre strata estimates and GIS (this is the methodology used by BIA-forestry to calculate the AAC), and the recognition the 2013 inventory only re-measured about half of the CFI plots – we conclude it is reasonable to expect when all CFI plots are re-measured and re-analyzed, the inventory will be nearer to 9,500 BF/ac than the reported 8,784.8 BF/ac.

Table 5.2. Comparison of reported and calculated 2013 inventory data and estimates.

	REPORTED			CALCULATED		
	Per Acre	GIS	Forest-wide	Per Acre	GIS	Forest-wide
	BF/ACRE	ACRES	MMBF	BF/ACRE	ACRES	MMBF
2004 Inventory	8,630.9	660,418	5,700.0			
Components of Change	PER YEAR for Components of Change			Between 2004 & 2013 Inventories*		
Annual Gross Growth	260.0	660,418	171.7	2,340.0	660,418	1,545.4
Annual Mortality	86.2	660,418	56.9	775.8	660,418	512.4
Net Annual Growth	173.8	660,418	114.8	1,564.2	660,418	1,033.0
CFI Harvest	49.2	660,418	32.5	442.4	660,418	292.1
Net Change	124.7	660,418	82.3	1,121.9	660,418	740.9
2013 Inventories	8,784.8	660,418	5,801.6			
Lower 95% Confidence**				9,766.2	660,418	6,449.8
Higher 95% Confidence**				7,803.4	660,418	5,153.5
2013 Estimated Inventory based on change applied to 2004 Inventory				9,752.7	660,418	6,440.9
Stata Estimates***						
PP	3,056.0	68,967	210.8			
DFCD	7,218.2	81,996	591.9			
DFWM & DFWD	8,078.2	170,462	1,377.0			
DFCM	10,709.9	216,633	2,320.1			
GFRC	19,537.6	50,422	985.1			
SFC,SFW	11,037.0	71,938	794.0			
TOTAL				9,507.4	660,418	6,278.9

NOTES:
***Full year growth, mortality, and harvest 2005-2012 (8 years) plus 1/2 year growth, mortality, and and harvest in measurement years 2004 and 2013 for total of 9 years.**
****Confidence Interval calculations based on reported standard error of 5.7%**
*****Forest-wide inventory estimates by strata are reported in FIA report, pages 45-50**

6. Wildfire Threat

Fire is an extremely important factor that needs to be specifically addressed in any long-range plan for the Colville Reservation forest resources, as repeatedly recognized in the IRMP:

- "Fire on the Colville Reservation can either destroy or enhance resources."[30]
- "The absence of fire has allowed the quantity of needle litter and dead woody fuels on the forest floor to increase over time. These changes have created a forest condition that is much more susceptible to catastrophic fire. When fire occurs there is an increased likelihood that the fire will burn with more intensity and be more destructive than would have occurred historically."[31]
- "Over the last century, fire suppression and selective harvesting have changed the structure, composition and density of the Reservation's forest. Historically, wildfires were a primary source of natural thinning in forests. Eliminating this natural process resulted in an accumulation of fuels in increasingly dense forest stands with an ever greater threat of catastrophic wildfires."[32]

Similarly, in the DEIS:

- "OGE thresholds were also developed for wildfires, which have a dramatic effect on the amount of ground disturbance, and in many cases, greatly exceed the acreage impact of timber harvesting within a given watershed management unit."[33]
- "Wildfires can have a dramatic effect on the amount of ground disturbance on the Reservation. Over the 2001-2014 period, 307,574 acres on the Reservation were affected by wildfire, averaging almost 22,000 acres each year."[34]
- "The primary reason for lower air quality readings is smoke from wildfires during the warmer months and from wood stoves during the winter months when inversions occur." Also, "Wildfires will continue to play a dominant role in air quality on the Reservation under all alternatives."[35]

Figure 6.1 summarizes wildfire acres across all vegetation types (forest and non-forest) on the Reservation during the period 1984-2015, by year and fire intensity, as reported by the USFS/USGS program for Monitoring Trends in Burn Severity (MTBS).[36] Table 6.1 reports total wildfire acres and forest-only wildfire acres, by year and severity class, on the Reservation during the period 1984-2015.

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[30] IRMP, p. 95.
[31] IRMP, p. 79.
[32] IRMP, p. 95.
[33] DEIS, p. 16.
[34] DEIS, p. 201.
[35] DEIS, p. 20
[36] https://www.mtbs.gov, August, 2017 data.

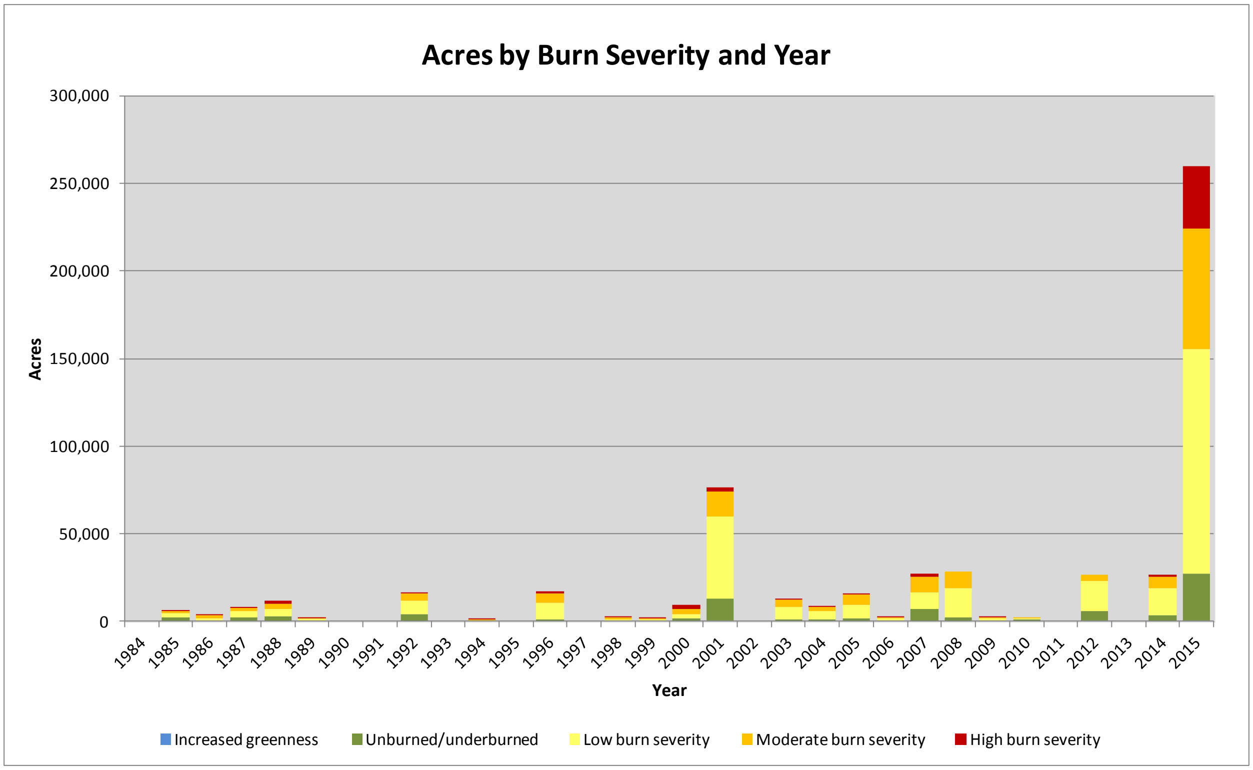

Figure 6.1. Annual wildfire acres on the Colville Reservation, 1984-2015, all vegetation types.

Table 6.1. Total wildfire acres and forest-only wildfire acres, by year and severity class, on the Colville Reservation, 1984-2015.

	Wildfire Acres -- All Vegetation Types						Wildfire Acres -- Forested Vegetation Types Only					
	Burn Severity						Burn Severity					
Year	Increased greenness	Under-burned	Low severity	Moderate severity	High severity	Total	Increased greenness	Under-burned	Low severity	Moderate severity	High severity	Total
1984	0	0	0	0	0	0	0	0	0	0	0	0
1985	8	2,373	2,143	1,240	273	6,036	0	697	811	598	199	2,306
1986	91	524	1,390	1,506	224	3,736	57	71	470	256	71	925
1987	128	2,234	3,834	1,544	276	8,015	28	555	1,253	826	128	2,790
1988	7	3,079	4,223	2,615	2,214	12,138	0	2,918	4,085	2,363	2,320	11,685
1989	9	590	927	411	16	1,953	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	13	3,954	7,907	4,319	157	16,351	14	882	1,551	1,338	43	3,829
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	14	205	427	413	16	1,076	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0
1996	33	1,406	9,206	5,206	1,309	17,161	14	797	2,220	1,409	683	5,124
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	16	534	527	1,212	431	2,720	0	0	0	14	0	14
1999	4	707	457	513	78	1,759	0	0	0	0	0	0
2000	12	1,949	2,270	3,158	1,951	9,340	14	1,779	1,509	2,733	1,921	7,956
2001	657	12,364	46,889	14,107	2,660	76,678	85	3,302	15,870	7,188	1,765	28,210
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	15	1,034	7,121	4,334	614	13,118	14	712	3,871	2,676	612	7,885
2004	2	1,108	4,958	2,308	126	8,502	0	384	2,163	655	43	3,245
2005	8	1,821	7,822	5,630	157	15,438	0	256	954	299	14	1,523
2006	15	487	1,410	646	268	2,825	14	512	783	157	57	1,523
2007	24	6,830	9,546	9,126	1,471	26,996	43	5,821	7,003	3,544	512	16,923
2008	10	2,646	16,086	9,676	0	28,419	0	1,580	8,640	7,786	0	18,005
2009	3	371	1,418	347	11	2,150	0	14	256	28	0	299
2010	7	966	775	30	0	1,778	14	982	754	14	0	1,765
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	315	5,836	17,116	3,317	0	26,583	171	2,092	4,754	783	0	7,800
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	5	3,743	14,978	6,705	1,444	26,876	14	3,402	14,703	6,533	1,438	26,090
2015	853	26,470	128,009	68,888	35,461	259,681	811	22,816	101,198	67,124	35,142	227,091

It is important to note that the MTBS acres reported in Figure 6.1 and Table 6.1 sometimes differ substantially from Figure 41 (p. 201) in the DEIS (reproduced as Figure 6.2 below). For example, MTBS data show roughly 27,000 burn acres on the Reservation in 2007, while Figure 6.2 shows nearly 50,000 acres.

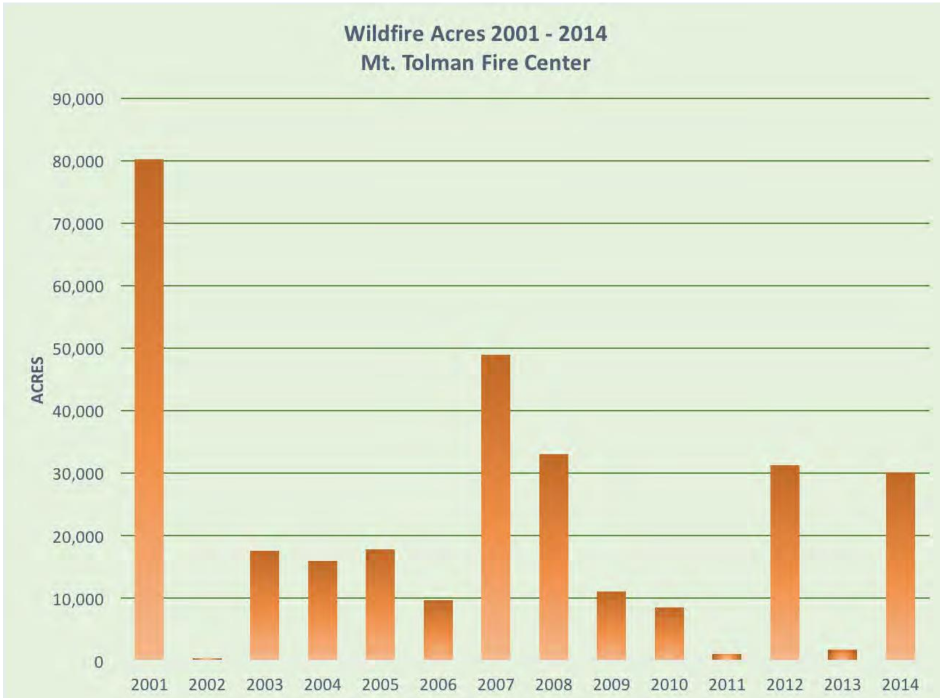

Figure 6.2. Mt. Tolman Fire Center wildfire acres 2001-2014.[37]

The title on DEIS Figure 41 implies that the wildfire acreages were supplied by the Mt. Tolman Fire Center on the Colville Reservation; the same as the indicated source for DEIS Appendix N: Fire History. But Appendix N is never referenced in the DEIS text, and the burn acreages reported therein do not correspond with Figure 41. For example, Appendix N shows no burn records for the years 2002 and 2003, even though burn acres are shown in DEIS Figure 41. Appendix N shows two fires in 2010 that total 408 acres, while Figure 41 shows around 9,000 burn acres; corresponding MTBS acres for 2010 are 1,778.

Figure 6.1 shows an upward trend of increasing wildfire acres over time. This upward trend is consistent – whether looking at total wildfire acres or forest-only wildfire acres; and whether the exceptional fire year of 2015 is included or excluded. Year 2015 was the extreme, with nearly 260,000 acres burned on the Reservation; as many as all the acres burned over the previous 20 years combined. Additionally, 14% of the 2015 burn acres were classified as high severity; more than three times the 1984-2014 average proportion of 4%. Wildfire perimeters and burn intensity for the 2015 fires are shown in Figure 6.3.

The increasing trend in burn acres has followed a period of reduced timber harvest that started in the 1980s and culminated with extremely low harvest levels in the years following the 2008 financial crisis (Figure 6.4).

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[37] DEIS Figure 41, p. 201.

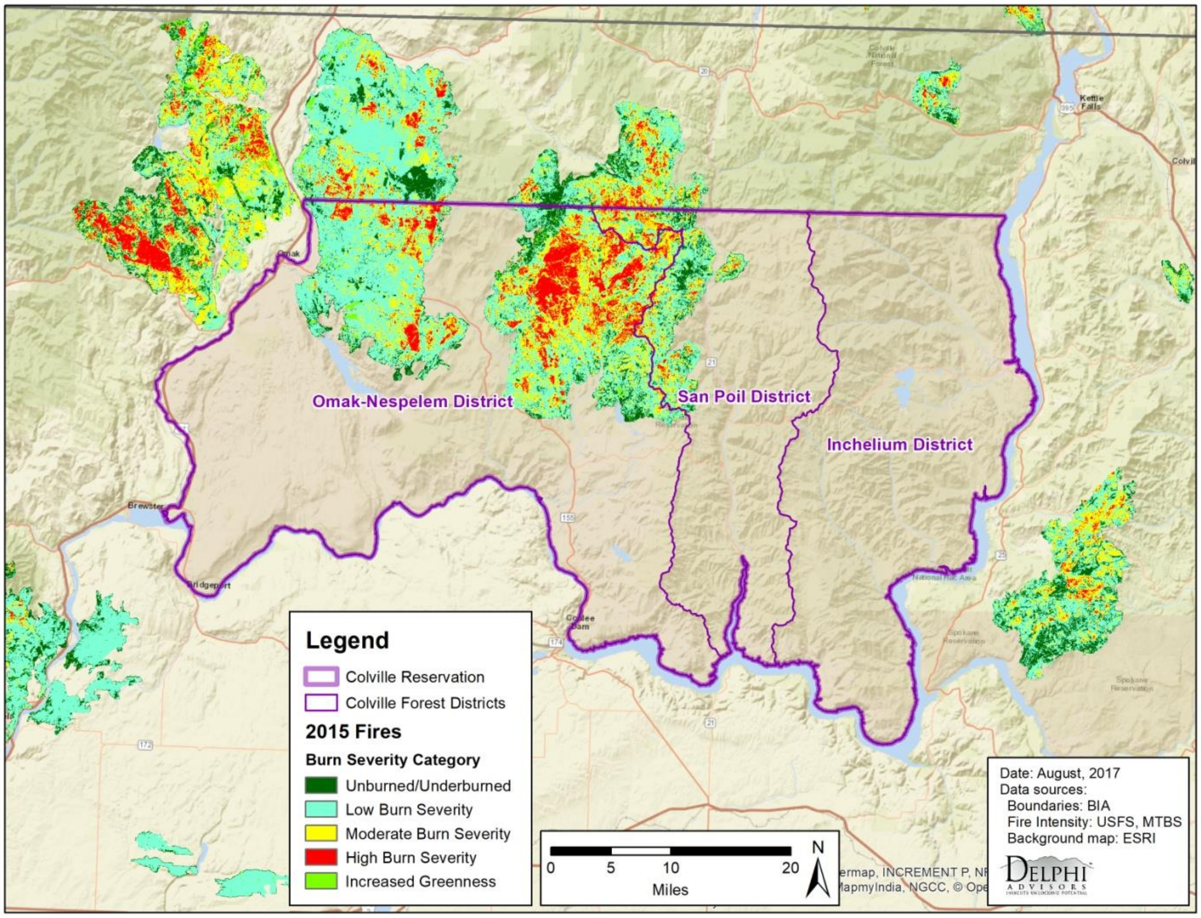

Figure 6.3. Fire perimeters and burn intensity for 2015 wildfires in and around the Colville Reservation, all vegetation types.

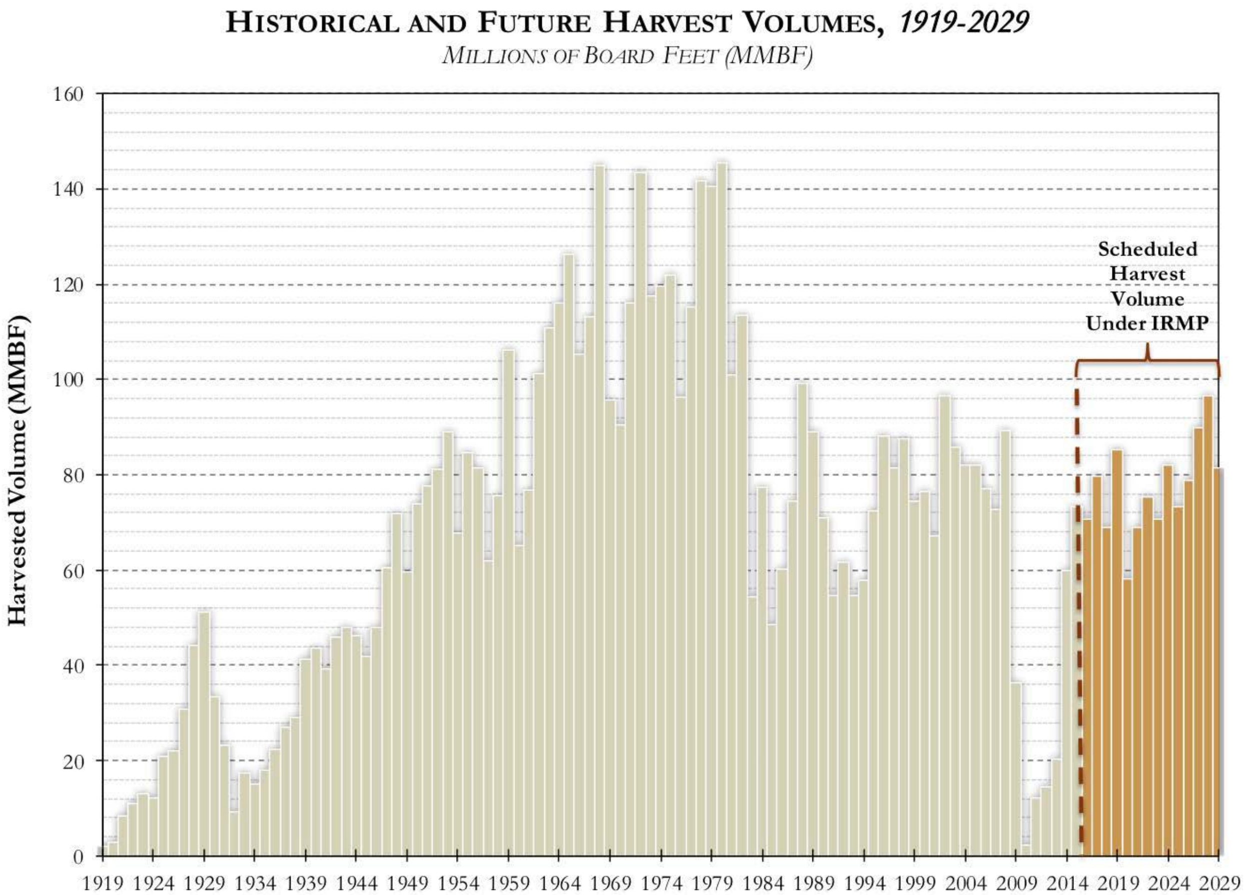

Figure 6.4. Historical and future harvest volumes, 1919-2029 (Source: IRMP, p. 88).

As previously discussed in section 3 (Allowable Cut Calculations and Sustained Yield), reduced harvest levels, combined with extended even-aged rotation lengths, have resulted in a large percentage of stands well beyond the 120-year rotation length. These stands have increased mortality rates caused by insect, disease, and other forest health issues associated with old age and overstocking, and are increasingly susceptible to catastrophic wildfire. In addition, as pointed out in both the IRMP and DEIS, past "selective" harvesting (perhaps more accurately termed high-grading), and fire exclusion have dramatically changed forest composition and structure, making the forest more susceptible to catastrophic, high intensity fires.

The USFS/DOI LANDFIRE (LF) program provides landscape-level geospatial data on vegetation, fuels, disturbance, and fire regimes for use in wildfire planning. One of the vegetative measures estimated by the LF program is Vegetation Condition Class (VCC); defined as "a discrete metric that quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions." Six primary vegetation condition classes are defined:

- I.A: Very Low, Vegetation Departure 0-16%
- I.B: Low to Moderate, Vegetation Departure 17-33%
- II.A: Moderate to Low, Vegetation Departure 34-50%
- II.B: Moderate to High, Vegetation Departure 51-66%

- III.A: High, Vegetation Departure 67-83%
- III.B: Very High, Vegetation Departure 84-100%

Figure 6.5 provides a map of the vegetation condition class for forested acres on the Colville Reservation. The map reinforces the IRMP comment that "Over the last century, fire suppression and selective harvesting have changed the structure, composition and density of the Reservation's forest." Over 90% of the existing ponderosa pine forest type group has moderate or higher departure from historical vegetation reference conditions; 80% of the existing Douglas-fir forest type group shows moderate or higher departure.

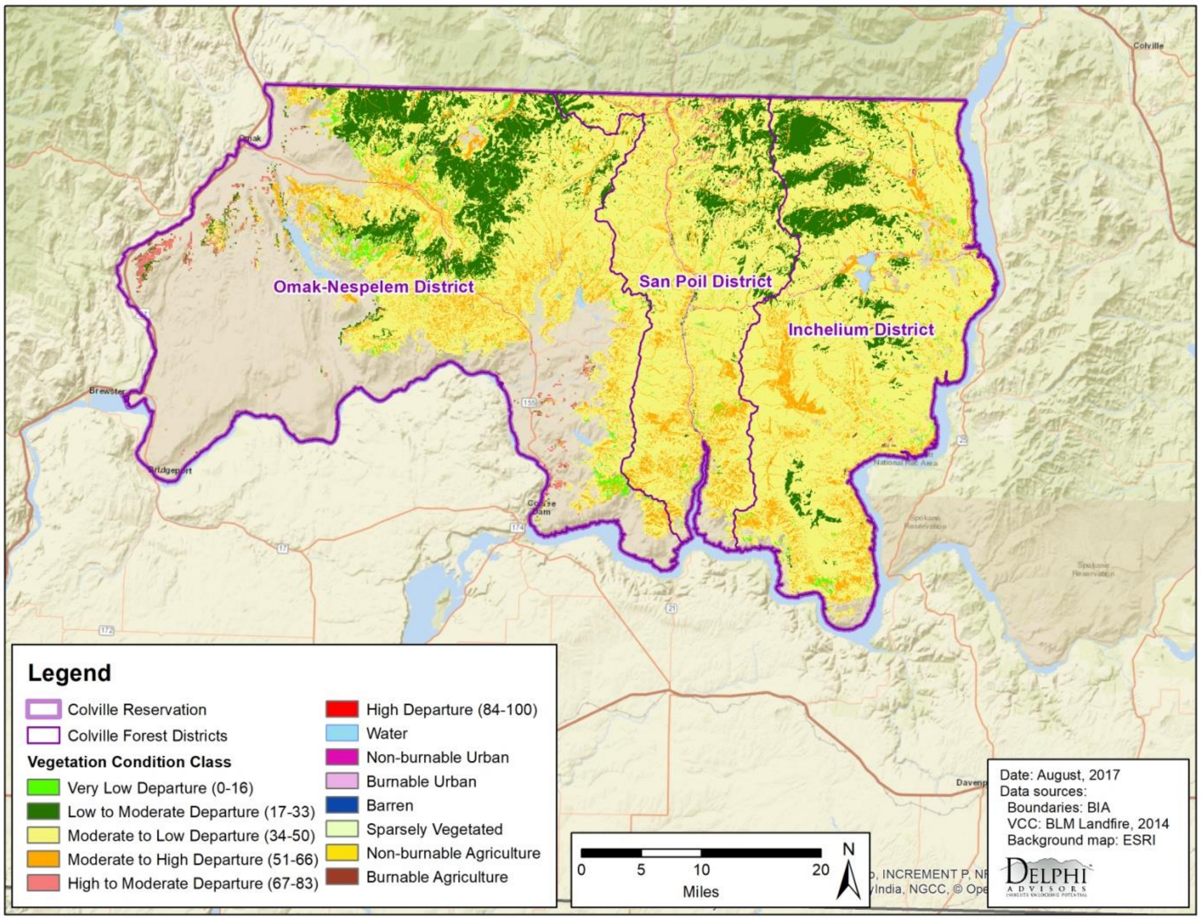

Figure 6.5. Vegetation condition class for forested acres of the Colville Reservation.

The combined impact of 1) high proportion of existing old age, decadent stands; 2) the departure of stands from their historic conditions, as reflected in the VCC ratings; and 3) low harvesting rate; results in a forest resource that is at ever-increasing risk of historically unprecedented, catastrophic, high-intensity fires.

We believe that adequately addressing existing forest health issues and decreasing the risk of catastrophic wildfire will require a much greater emphasis on forest harvest levels and silvicultural systems than is represented by any of the current DEIS alternatives. As discussed in section 3 of this report, harvest levels need to be flexible and aimed at generating a more balanced age-class distribution. Additionally, new silvicultural prescriptions need to be devised that will prevent development of overstocked, decadent stands susceptible to catastrophic wildfire, and instead generate desired stand structures and compositions consistent with the DFCs. This topic is discussed in more detail in section 10 (New Alternatives).

7. DEIS Economic Impact

The economic impact results and analysis description contained in the DEIS are confusing, difficult to evaluate, and in several instances incorrect. Consequently, we offer some observations that we hope are considered and ultimately incorporated when the analysis is re-worked following completion of the timber inventory and development of new forest management alternatives. Briefly:

- The baseline conditions defined for the analysis are flawed, hampering clear communication and apprehension of the implications of the economic impacts analyzed. Alternative 1, the status quo alternative, should represent the baseline.
- The Omak mill's value-added contribution is included in the analysis even though it is no longer operating. Even if it were operating, the calculated impact, which apparently is tied only to the 40 MMBF log supply agreement to the mill, is the same for Alternatives 1 through 4. Yet, Alternative 3's harvest plan is acknowledged to risk defaulting on the log supply agreement to the Omak mill, and so should have included a lower value attributable to the Omak mill than Alternatives 1 and 2. Conversely, Alternative 4's elevated harvest plan is not accorded additional value-added sales to the Omak mill despite the facility converting more than the 40 MMBF log supply agreement; thus, it should be reasonable to expect a higher value attributable to the Omak mill than in Alternatives 1 and 2. Regardless, the Omak mill should be dropped from the analysis.
- The Study Region, defined as Okanogan and Ferry Counties, excludes economic geographies that are relevant to the alternatives examined. This oversight contributes to an inherent bias against commercial timber production in the analysis. By excluding from the analysis mills that logically could (and do presently) receive harvested timber from the Reservation, but are located just outside the two-county Study Region, there is no value-added component included in the analysis for alternatives that generate harvest levels in excess of in-Study Region mill capacity. However, dollars generated a few miles from the Ferry County border (e.g., in Stevens County) do not stop at the county border, but instead generate value throughout the broader economic region – including Okanogan and Ferry Counties. At a minimum, Stevens County should be added to the Study Region and the value-added manufacturing conversion of CRF timber should be added for all relevant mills, not just mills in Okanogan and Ferry Counties.
- It is unclear from the descriptions in the DEIS whether the timber revenue utilized in the analysis includes all expenditures related to forest management; if not, then that is a deficiency in the analysis. In addition, the calculation methodology used to derive the real escalation rate used in the analysis is incorrect on several counts. Finally, using a single index as a real escalator for the variety of different types of revenue included in the calculation is inappropriate. The calculation deficiencies should be corrected.
- The Overview of Economic Impacts table (DEIS Table 39, p. 262) does not correspond to the reported analysis. In addition, the net present value (NPV) calculations reported in the Output/Production Table (DEIS Table 38, p. 261) is unconventional and may be incorrect; if incorrect it understates the outputs attributable to each alternative. Tables should correspond to supporting analysis and the NPV calculations should be corrected.

The sum total of these issues muddles the economic impact analysis. Each of these issues is developed in greater detail on the following pages.

Baseline Condition – Designating a baseline condition against which all alternatives are compared is a foundational step to any economic impact analysis. Properly evaluating each alternative requires understanding both the context of the baseline and the alternatives' impacts to it. Since Alternative 1 is labeled the Status Quo, and hence would be understood as setting a context against which to evaluate the other alternatives, it should be used as the baseline condition instead of the mythical baseline currently utilized in the analysis:

> ***Each of the five management alternatives were evaluated based on how they would affect a baseline regional economy and social conditions wherein the Tribes' do not utilize or manage the Reservation's natural resources***. Therefore, the values reported here reflect the entirety of the regional output, employment, and labor income that can be traced back to the adoption of each specific resource management alternative. These figures should not be construed to represent a change from 2014 or 2015 regional output, employment, and labor income.[38] (emphasis added)

Superficially, there is an appeal to having a baseline that has NONE of the current practices being employed. But practically, what does it mean? If the Tribe does not utilize or manage the Reservation's natural resources, do the resources even exist in this alternate reality? If they do exist, are they managed by federal, state, county, and/or private institutions – either in aggregate or independently? If the resources do exist, that would imply economic activity is occurring; but how they are managed and to whom the wealth – and, potentially, its other societal benefits – accrues is different than if utilized or managed by the Reservation. But that case is not a ZERO case and, presumably, the baseline assumes the Reservation exists; thus, the economic impact from this mythical baseline would still impact the Reservation population and economy.

Employing this mythical baseline also gives rise to surreal passages like the following, which acknowledges an existing state of economic activity relative to the Reservation's natural resources, and uses that knowledge to shape calculations for all other alternatives.

> ***Wherever possible, the revenue and employment inputs for each of the management alternatives were constructed from 2014's actual level of economic activity related to resource management.*** At the time this analysis was drafted, the most current data year available for all inputs was 2014. Further, it was concluded that the level of activity associated with each of the indicators and input variables utilized in this analysis over the coming 15-year planning period were best exemplified by 2014 economic input and output levels within the Study Region.[39] (emphasis added).

Unquestionably, there is some value in attempting to enumerate the full value resulting from resource use described as, "the values reported here reflect the entirety of the regional output, employment, and labor income that can be traced back to the adoption of each specific resource management alternative," but we would contend a better analysis would document the entirety of the status quo alternative in the context of the regional economy and then to contrast the remaining alternatives against the status quo.

[38] DEIS, p. 251.
[39] DEIS, p. 251.

Because of the baseline selected, statements like the following need to be issued as caveats to the analysis:

> ***In theory, under Alternative 5, all employment positions related to the management of Reservation resources would be eliminated*** (with the exception of those jobs created by the forest roads management program which is present under all five management alternatives). ***In reality, it is likely that much of the BIA's and portions of the Tribes' forestry programs would continue to operate at some level.*** In 2014, these programs directly employed approximately 70 full-time and part-time workers. These jobs reflect the BIA's on-going need to perform minimal forest health and monitoring activities for tribal and allotted forest lands irrespective of the Tribes' forest management policies. However, under Alternative 5, unaffected employment positions within the forest management programs could no longer be attributed to the Tribes' resource management policies and for that reason, they have been excluded from the model.[40] (emphasis added)

The cited text is describing the results of the analysis summarized in DEIS Table 36 (p. 258), which shows Direct, Indirect, and Induced employment of six persons. But the text indicates some 70 full-time and part-time workers within BIA and Tribe's forestry programs would likely be continued, only apparently funded by some other source – as opposed to being funded within the auspices of the other four alternatives. We suggest that having to issue such caveats, which blur economic impact differences between alternatives, is due to the mythical zero baseline. In effect, Alternative 5 is the baseline for this analysis, but even as a baseline it is flawed as currently specified and requires caveats like those stated in the excerpt cited above.

Since an alternative is being used as a baseline, we suggest the status quo alternative is better suited for such purposes and all other alternatives should be compared to it. We believe that baseline provides an important context in which to select among alternatives. For example, which of the following two statements provides greater clarity on the potential economic impact of adopting Alternative 3:

- 737 jobs will be sustained either directly, indirectly, or through induced economic effects related to the implementation of Alternative 3, OR
- Compared to the current situation, 66 persons will lose their jobs either directly, indirectly, or through induced economic effects related to the implementation of Alterative 3?

Both of these statements are equally true, yet we would argue the second portrays more-readily understood economic-impact information on which to base decisions.

Omak Mill – The Omak plywood mill is closed, yet its valued added impact is included in the economic analysis. This closure affects the estimates of employment (DEIS Table 36, p. 258), labor (DEIS Table 37, p. 260) and regional production/output (DEIS Table 38, page 261). Table 7.1 presents the revenue attributed to the Omak mill, from processing CRF timber; it represents an average of 43% of the total revenue in Alternatives 1 through 4, a consequential impact in the analysis. These revenues are used to estimate the various economic impact metrics. Consequently, the analysis of alternatives should exclude the impact of the Omak mill in light of it currently being non-operative.

[40] DEIS, p. 259.

However, let us hasten to add that the total value-added impact of processing CRF timber, whether within or outside the Study Region, should be included in the analysis, even if the Omak mill is not operating. As previously stated, we believe that excluding value-added impacts generated by mills in areas immediately outside the Study Region indicates a flaw in the **definition** of the Study Region. That issue is addressed in greater detail later in this section. For the present we simply note that assuming there are manufacturing outlets for CRF timber, whether the Omak mill or another facility, is consistent with the itemized economic impact's assumptions.[41]

Table 7.1. Omak mill revenue attributed to converted CRF timber, as a percent of total plan revenue.[42]

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
2015	45%	45%	51%	37%	0%
2016	49%	49%	53%	40%	0%
2017	42%	42%	49%	37%	0%
2018	44%	44%	47%	36%	0%
2019	40%	40%	47%	36%	0%
2020	47%	47%	47%	36%	0%
2021	44%	44%	47%	37%	0%
2022	42%	42%	48%	37%	0%
2023	44%	44%	48%	37%	0%
2024	41%	41%	48%	37%	0%
2025	43%	43%	48%	37%	0%
2026	42%	42%	48%	37%	0%
2027	39%	39%	48%	37%	0%
2028	38%	38%	48%	37%	0%
2029	41%	41%	48%	37%	0%
Average	42%	42%	48%	37%	0%
Total	42%	42%	48%	37%	0%

Momentarily setting aside the issue of the Omak mill not running, even if the Omak mill's impact were to be included in the analysis, the methodology for its inclusion was done inconsistently, leading to additional errors in the Economic Impact analysis. The DEIS states:[43]

> "…each management alternative will also effect the revenue generated by the Omak Mill and other mills throughout the Study Region that purchase and process timber harvested from the Colville Reservation. The majority of the timber harvested from the Reservation is purchased by the Omak Mill, the remaining supply is sold to other local mills within the Study Region and mills outside of the Study Region. The Omak Mill revenue figures shown in Table 33 were calculated from the mill's Fiscal Year 2015 reported gross annual revenue statistics (Omak Wood Products, 2015)."

From this statement it is unclear if the revenues reported are mill revenues attributed only to CRF timber or total mill revenues based on both CRF timber as well as timber from other sources. We also infer that

[41] DEIS, p. 509.
[42] Table 7.1 was derived by adding the revenues reported in the DEIS, Tables 32 (Timber), Table 33 (Omak Mill), Table 34 (Roads), and Table 35 (Grazing) to determine total revenue and then dividing Table 33 revenues by total revenue.
[43] DEIS, p. 254.

despite reference to other local mills in the Study Region in the cited text, our knowledge of the market area – coupled with the fact the Omak mill's reported gross annual revenue was the basis of the Local Mill revenue reported in Table 33 – means there are no other local mills in the Study Region that purchase CRF timber; i.e., all other CRF timber is sold to mills outside the Study Region.

That the Omak mill converted timber from sources other than the CRF seems clear from this statement in the DEIS:[44]

> In 2014, the Omak Mill processed 66.67 MMBF of timber, 40 MMBF (80%) of which was harvested from the Colville Reservation. It is understood that the operational feasibility of the Omak Mill is contingent upon this aspect of the lease agreement.

The reference to the 40 MMBF harvest from the CRF in the above excerpt relates to the 40 MMBF annual supply agreement elsewhere mentioned by the DEIS:[45]

> It is assumed that the annual allowable cut levels associated with management Alternatives 1, 2, and 4 would be sufficiently high enough to allow the Tribes ***to meet their annual 40 MMBF obligation to the Omak Mill***, and therefore the effect on mill revenues and output between these alternatives would be negligible. (emphasis added)

However, the next sentence expands on the prior sentence with regard to Alternative 3:[46]

> Retention of large trees under Alternative 3 could compromise fulfillment of the lease agreement with the mill. Alternative 5 would not allow the Tribes to meet the annual 40 MMBF obligation to the Omak Mill and would therefore default on their lease agreement.

Yet the paragraph goes on to state:[47]

> However, the possible closure of the mill and its impact on the broader regional economy is outside of the scope of this analysis. ***For this reason, it is assumed that Alternative 5 (which constitutes a 40 MMBF annual supply deficit to the Omak Mill) will not cause the Omak Mill to become totally financially insolvent.***"

Before moving further, a copy of Table 33 from the DEIS is shown as Table 7.2 below; the only addition compared to the DEIS' Table 33 is computation of the annual percentage change for the Omak mill revenues.[48]

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[44] DEIS, p. 255.
[45] DEIS, p. 255.
[46] DEIS, p. 255.
[47] DEIS, p. 255
[48] We note in passing the annual rate of change is 1.3%, the same referred to in the Timber Revenue section in the DEIS, p. 253. There the rate of change used was specified to be "influenced by the trailing 20 years' producer price index [PPI] for lumber products" (DEIS, p. 254). Taken literally, that would refer to the Bureau of Labor Statistics series WPU081, for all types of lumber. What that index is and how it was used as part of the analysis is covered in the Timber Revenue paragraphs of this section that follow. While there is nothing mentioned about the escalation factor used for the Omak mill revenues in the DEIS we infer from this coincidence (1.3%) the same PPI index used for Timber Revenue was used for the Omak mill. However, for the Omak mill, a plywood mill, the more appropriate PPI to use would be WPU0831, the PPI for softwood plywood and veneer.

Table 7.2. "Local Mill" (i.e., Omak mill) revenues from harvest by alternative.[49]

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	% change
2015	$24.00	$24.00	$24.00	$24.00	$0.00	
2016	$24.00	$24.00	$24.00	$24.00	$0.00	0.0%
2017	$24.31	$24.31	$24.31	$24.31	$0.00	1.3%
2018	$24.63	$24.63	$24.63	$24.63	$0.00	1.3%
2019	$24.95	$24.95	$24.95	$24.95	$0.00	1.3%
2020	$25.27	$25.27	$25.27	$25.27	$0.00	1.3%
2021	$25.60	$25.60	$25.60	$25.60	$0.00	1.3%
2022	$25.93	$25.93	$25.93	$25.93	$0.00	1.3%
2023	$26.27	$26.27	$26.27	$26.27	$0.00	1.3%
2024	$26.61	$26.61	$26.61	$26.61	$0.00	1.3%
2025	$26.96	$26.96	$26.96	$26.96	$0.00	1.3%
2026	$27.31	$27.31	$27.31	$27.31	$0.00	1.3%
2027	$27.66	$27.66	$27.66	$27.66	$0.00	1.3%
2028	$28.02	$28.02	$28.02	$28.02	$0.00	1.3%
2029	$28.38	$28.38	$28.38	$28.38	$0.00	1.3%
Average	$25.99	$25.99	$25.99	$25.99	$0.00	
Total	$389.89	$389.89	$389.89	$389.89	$0.00	

From all of these statements we draw the following conclusions:

- It is unclear from the description if the Mill Revenues reported in DEIS Table 33 are revenues only attributable to CRF volume sold to the mill or total mill revenues.
- Since only Omak mill revenues are cited as a source for Local Mill revenues, there are no other local mills in the Study Region other than the Omak mill.
- The AAC under Alternatives 1, 2, and 4 are sufficient to meet the 40 MMBF log supply obligation to the Omak mill.
- The AAC and silvicultural prescriptions under Alternative 3 could jeopardize meeting the 40 MMBF log supply obligation to the Omak mill.
- The Omak mill is converting more than 40 MMBF of timber based on the 40 MMBF sold by the Tribe to the Omak Mill in 2014 presenting 80% of total log volume converted.
- Despite no CRF volume being harvested and sold to the Omak mill under Alternative 5, the Omak mill is assumed to continue to operate ("will not become totally financially insolvent").

Based on these conclusions we would make the following observations that point to inconsistencies in this analysis:

- As noted earlier, it is unclear if the Mill Revenues in Table 33 are total mill revenue or only revenues attributable to CRF timber sold to the mill. Because mill revenue under Alternative 5 is reported as 0 in Table 33, it seems as if the revenue is attributed to CRF volume only. So for the next several observations we assume the reported mill revenue is attributable to only CRF timber sold to the Omak mill.
    - Since it is acknowledged the Tribe would be in default of its log supply obligations under Alternative 5, and this analysis as presented is assuming the Omak is running and will continue to run, there should be a cost associated with the default on the supply agreement included in the

[49] Derived from DEIS Table 33, p. 255.

analysis as part of Alternative 5. This could be reflected in a reduction in the net stumpage revenue paid to the tribe equal to the cost of the log supply default.

- Despite noting under Alternative 3 the log supply agreement might not be able to be fulfilled, the full value of the mill revenue as seen in Alternatives 1 and 2 is included as part of the economic analysis (see DEIS Table 33, p. 255). It would seem some portion of the mill revenue should be reduced, reflecting the risk of less timber being available to be sold to the Omak mill under Alternative 3.
- Further, much like the case of Alternative 5, if there is a risk of defaulting on the log supply agreement under Alternative 3, there should be an associated cost reflected in the analysis corresponding to that risk.
- Since the Omak mill is purchasing more than just CRF timber, under Alternative 4 it is logical that more than 40 MMBF would be sold to the Omak mill; thus mill revenues attributable to CRF timber sold to the mill should be higher under Alternative 4 than what is shown under Alternatives 1 and 2.

- Several contrary observations could be made if in fact the mill revenues reported in Table 33 were total mill revenues, not mill revenues attributable to the sale of just CRF timber. Those contrary observations follow.
  - If total mill revenues are being reported, then the analysis shows the economic impact of the Omak mill running, which as noted in a previously cited excerpt from the DEIS, is outside the scope of this DEIS. Further it means the economic impact analysis is including the economic impact of non-CRF timber in the local economy, again, outside the scope of the study.
  - If the total mill revenues are being reported, then Alternative 5 should also have total mill revenues reported rather than being zero as is currently the case. After all, the previously cited excerpt from the DEIS assumed the Omak mill would continue to run even without any CRF timber.

Clearly one or the other of these sets of observations is wrong. We suspect the correct set of observations relate to the mill revenues reported in Table 33 being only those attributable to CRF timber sold to the Omak mill. However, the DEIS lacks clarity on that point. If our suspicions are correct, our observations regarding necessary adjustments to mill related revenues in Alternatives 3 and 4 and log supply default penalties in Alternatives 3 and 5 apply, should the Omak mill be included in the analysis.

However, we believe the better solution to all of this is to include the value-added contribution from all mills processing CRF timber, regardless if it is the Omak mill or some other mill. We believe this is best done by expanding the Study Region to include mills that are routinely purchasing CRF timber.

Study Region – The Study Region consists of Okanogan and Ferry counties in the state of Washington. **The definition of the Study Region should be based on a logical economic geographic area.** At a minimum we would argue that such a region should include mills that are currently purchasing CRF timber, specifically Stevens County. Excluding Stevens County from the Study Region, home to mills that currently purchase CRF logs if no “local” mills are operating (as is currently the case) results in an incomplete economic impact analysis. Further, excluding those mills – particularly if the Omak mill is included in the analysis – introduces an inherent bias against alternatives that generate timber harvest levels in excess of the capacity of mills in Okanogan and Ferry counties.

While timber sold to "local" mills (with the Omak mill closed, there are none for all practical purposes) generates economic value through manufacturing value-added contributions, alternatives that generate levels of timber harvest in excess of local mill capacity are penalized because the manufacturing conversion value-added is ignored for timber sold to mills outside of the current Study Region. Such external timber sales do indeed generate positive economic benefits in the broader regional economy that does not stop at the Ferry/Stevens County lines – benefits that should be accounted for in the analysis.

Table 7.3 shows, by alternative, the percent of the total revenue attributable to timber if the Omak mill is dropped from the analysis. The fact that a mill in Kettle Falls, WA is within 15 road miles of the northeast corner of the Reservation, but not included in the Study Region, seems disingenuous when 83% of the revenue generated by Alternatives 1 through 4 is generated by sales to this mill and others – most of which reside in Stevens County – now that the Omak mill has shut down.

Table 7.3. Timber revenue's percent of total revenue after dropping Omak mill revenue.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
2015	97%	97%	96%	97%	0%
2016	97%	97%	96%	96%	0%
2017	85%	85%	81%	87%	0%
2018	78%	78%	75%	83%	0%
2019	82%	82%	75%	83%	0%
2020	76%	76%	76%	83%	0%
2021	79%	79%	76%	83%	0%
2022	81%	81%	76%	84%	0%
2023	80%	80%	76%	84%	0%
2024	82%	82%	77%	84%	0%
2025	81%	81%	77%	84%	0%
2026	82%	82%	77%	84%	0%
2027	84%	84%	77%	84%	0%
2028	85%	85%	78%	85%	0%
2029	83%	83%	78%	85%	0%
Average	83%	83%	79%	85%	0%
Total	83%	83%	79%	85%	0%

Timber-related Revenues – As discussed in the Timber Revenue section, the reported timber revenue in the DEIS – 90% of which would be paid into the Tribe's General Fund – appears to be overstated by a factor of more than 2; stumpage revenue is the source of payments to the Tribe's General Fund but the revenues reported in Table 32 in the DEIS apparently are delivered-log prices (refer to the Timber Revenues section in this report and compare sentences [2] and [3] in the excerpt cited below). However, the delivered-log prices reported in Table 32 are an appropriate component for the regional economic analysis since not only stumpage revenue but also payments to loggers and truckers create regional economic activity (see sentences [1] and [2] in excerpted cited below) . This is the relevant statement from the DEIS:[50]

> The ***annual revenue figures outlined in Table 32 represent the total revenues generated in the timber harvesting process, including: forest planning and management, sale administration, site preparation, harvest activities, and transportation of the harvested timber products to the mill.***[1] ***Alternatively, these figures can be described as the total cost to the Omak Mill and other local mills to secure raw inputs to which value is added in the milling process.***[2] ***Approximately 90% of the revenue figures described in Table 32 would be delivered to the Tribes' General Fund***, the remaining 10% plus approximately $20/MBF would be utilized for forest management activities and future sale preparation.[3] (emphasis added; sentence numbers in brackets are introduced for easy reference).

Whether all forest management costs are included in Table 32 is unclear to us. Sentence [1] in the excerpt cited above clearly makes that claim but no supporting detail are available to substantiate the claim. Sentence [3] in the excerpt cited above describes the costs as the total costs to the Omak and other mills to secure raw inputs. That statement would refer to delivered log costs only. While a portion of the stumpage revenue represented in that amount is used for forest development, it does not represent total forest management expenditures made on the CRF. If this understanding is correct, then expenditures related to forest management made over and above the 10% of net stumpage revenue is not included in any of this analysis.[51] However, for sake of argument, we assume that Table 32 does indeed include all expenditures made for forest management as is claimed; if it does not, this should be addressed in the final EIS.

Regardless, there are still significant problems with the revenues developed in Table 32 and used in the economic impact analysis. One of them is the real escalation rate used to project per-unit real (i.e. devoid of general inflation) revenues in Table 32. The DEIS states:[52]

> Based on the projected harvest volumes over the fifteen-year planning period shown in Table 31, Table 32 illustrates the gross revenues for each alternative that would result from that level of harvest. ***These estimates were derived from delivered log bids proffered to the Tribes between 1996 and 2016 by several mills located within the Study Region. An annual inflation adjustment factor of 1.3% — influenced by the trailing 20 years' producers price index for lumber products — was employed to account for price fluctuations within the timber industry and their effect on harvest revenues over the 15-year planning period***. (emphasis added).

Based on the analysis described we interpret the 1.3% "inflation adjustment" as being used as a real escalation factor on per-unit prices. Per the DEIS, the basis of the escalation factor used was the trailing 20-year producer price index (PPI) for lumber. Based on Table 7.4 it indeed appears that 1.3% was utilized

[50] DEIS, p. 254.

[51] Based on discussions with Colville Tribe Sort Yard and BIA Forestry personnel, the revenue breakdown is as follows: Delivered log price to mill less transportation and harvest costs paid to truckers and/or loggers, yielding stumpage revenue from the timber sale. $20/MBF paid to Colville Tribe Sort Yard and harvesting road maintenance costs (varies, but averages $7/MBF) are deducted from stumpage revenue, yielding net stumpage revenue. Ten percent of net stumpage revenue is allocated to BIA-Forestry for forest development activities and the remaining 90% of net stumpage revenue is allocated to the Tribe's General Fund.

[52] DEIS, p. 253.

in the analysis; the "% Change" in the far right column of Table 7.4 is the year-to-year change that is uniformly applied to the per-unit timber revenue value across all alternatives.

However, there is a problem with this calculation. The PPI series for lumber published by the Bureau of Labor Statistics (BLS) is series WPU081.[53] This series was downloaded and analyzed for the period 1994 to 2014 (21 years, 20 time periods on which to compute the compound annual growth rate (CAGR). The result between 1994 and 2014 was 0.7%, not 1.3%. The CAGR increases to 1.1% if the calculation is made between 1995 and 2014: 20 years and 19 time periods. But this change in results by shifting a single year highlights another problem with the methodology that was apparently employed.

Table 7.4. Per-unit revenues by alternative.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	% Change
2015	$ 389.63	$ 389.63	$ 389.66	$ 389.60	$ -	
2016	$ 348.02	$ 348.02	$ 348.10	$ 348.00	$ -	-10.7%
2017	$ 352.51	$ 352.51	$ 352.59	$ 352.60	$ -	1.3%
2018	$ 357.10	$ 357.10	$ 357.07	$ 357.10	$ -	1.3%
2019	$ 361.81	$ 361.81	$ 361.72	$ 361.80	$ -	1.3%
2020	$ 366.49	$ 366.49	$ 366.55	$ 366.50	$ -	1.3%
2021	$ 371.16	$ 371.16	$ 371.21	$ 371.20	$ -	1.3%
2022	$ 375.99	$ 375.99	$ 376.03	$ 376.00	$ -	1.3%
2023	$ 380.91	$ 380.91	$ 380.86	$ 380.90	$ -	1.3%
2024	$ 385.85	$ 385.85	$ 385.86	$ 385.90	$ -	1.3%
2025	$ 390.87	$ 390.87	$ 390.86	$ 390.90	$ -	1.3%
2026	$ 395.94	$ 395.94	$ 396.03	$ 396.00	$ -	1.3%
2027	$ 401.11	$ 401.11	$ 401.03	$ 401.10	$ -	1.3%
2028	$ 406.31	$ 406.31	$ 406.38	$ 406.30	$ -	1.3%
2029	$ 411.55	$ 411.55	$ 411.55	$ 411.60	$ -	1.3%

Because these markets are volatile, the PPI, as well as the price, exhibits significant swings from year to year. Figure 7.1 shows series WPU081 for the period 1994 to 2014. The 0.7% CAGR computed is from the 1994 index value to the 2014 index value; however, as has been seen, by moving ahead to the 1995 index value and re-computing the CAGR between 1995 and 2014 that rate can change dramatically.

[53] The BLS data series can be found at either https://data.bls.gov/timeseries/WPU081?data_tool=XGtable or https://fred.stlouisfed.org/series/WPU081.

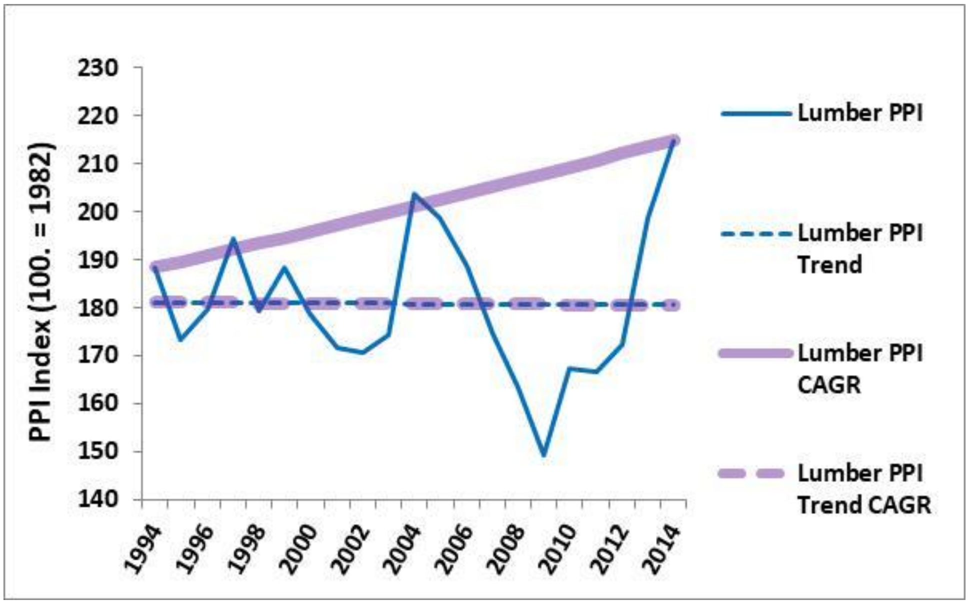

Figure 7.1. Producer price index for lumber (WPU081).

A more correct way of computing the CAGR around such series is to first compute the trend line through the series and then compute the CAGR on that trend-line. Doing that in this case, the trend has a barely negative slope (i.e., it declines very slightly over time) and the CAGR between 1994 and 2014 is 0.0%; there is no change in the CAGR if it is recomputed between 1995 and 2014 when using this method. So, the CAGR for Lumber PPI which was used as a real escalation factor should be 0.0%, not 1.3%.

There is yet another problem with the escalator used in this analysis. While the Lumber PPI was used, none of the associated revenues included in DEIS Table 32 are directly related to lumber. There are costs related to logging, costs related to hauling, and costs related to stumpage (log fiber). In addition, the Omak mill revenue was also added to the total revenue and it used the same Lumber PPI escalator as seen in Table 7.2. Each of these costs have their own escalators and some of them are quite different from the Lumber PPI that was applied to all the revenue components (Figure 7.2).

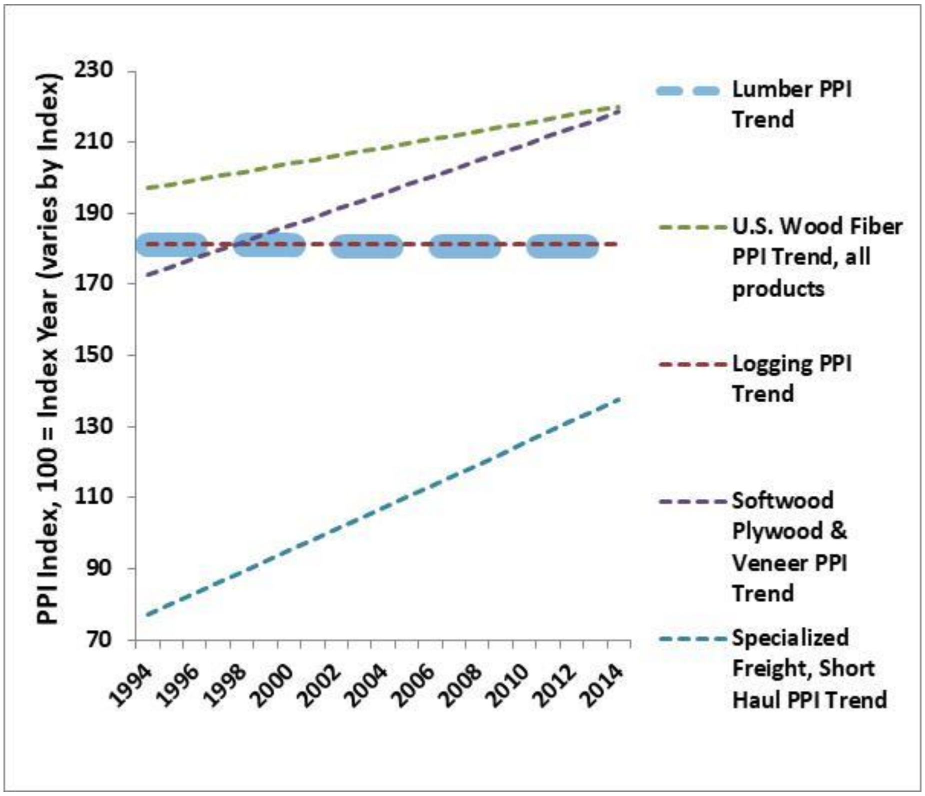

Figure 7.2. Inflation indices for various segments and products related to the Timber Revenue projection in the DEIS.

The CAGR for Logging (series PCU11331133) is 0.0%, essentially the same as for Lumber. However, the CAGR for Special Freight Transportation, Short Haul (series PCU4842248422) is 2.9%. The CAGR for the PPI on all types of wood fiber in the United States (series WPU085[54]) is 0.6%. Since the revenues were disaggregated into categories corresponding to economic activity[55] such that the appropriate multiplier could be used, it seems only logical those same revenues should be escalated by their individual categories as well.

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[54] WPU085 is the PPI for delivered wood fiber of all types (logs, bolts, pulpwood, wood chips) and all species across the United States. Thus to appropriately use it for stumpage escalation as contemplated here, at a minimum, some further calculations would be needed to remove the effects of logging and transportation. Alternatively, nominal stumpage prices (e.g., Figures S.2 and S.3 in the Timber Revenue section) could be converted to real dollars, a trend fit through the real dollar series, and then a CAGR calculated against the real trend. This would probably be a preferable approach since timber markets are generally subject to localized effects.

[55] DEIS, p. 507: "Wherever possible, these revenue/expenditure components were disaggregated to allow for the application of the most appropriate economic multiplier. For instance, harvest revenue/ expenditure can be disaggregated into four separate components: i) logging and transportation, ii) sale administration undertaken by the Colville Tribal Sort Yard, iii) 10% of stumpage recirculated into forest management activities and preparation for future sales, and iv) 90% of stumpage deposited into the Tribes' General Fund where it finances the Tribes' IT, social, and public works programs. A different set of multipliers was applied to each of these four activities to facilitate a more accurate and dynamic estimate of the regional economic impacts associated with each of the resource management alternatives."

Overview of Economic Impacts – There are several discrepancies between what is reported in the Overview of Economic Impacts table in the DEIS (Table 39, replicated in Table 7.5 below) and what is reported elsewhere in the DEIS. In Table 37 the change in labor earning paid is reported as $398.94 million for Alternative 1 but $356 million in the Overview table. Also in Table 37 the change in labor earnings paid is reported as $43.2 million for Alternative 5 but as $0 in the Overview table.

Table 7.5. Overview of economic impacts.[56]

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Annual allowable cut	77.1 MMBF	77.1 MMBF	58 MMBF	100 MMBF	0 MMBF
Livestock levels	79,594 AUMs	79,594 AUMs	79,594 AUMs	119,391 AUMs	0 AUMs
Average Annual Employment	803 jobs	803 jobs	737 jobs	937 jobs	6 jobs
*Full-Time**	690 jobs	690 jobs	634 jobs	806 jobs	5 jobs
*Part-Time**	113 jobs	113 jobs	103 jobs	131 jobs	1 jobs
Change in Labor Earnings *(gross)*	$356 million	$399 million	$342 million	$473 million	$0 million
Change in Regional Output *(npv)*	$926 million	$995 million	$885 million	$1,144 million	$0 million

*Estimated based on 2014 ratio of full-time to part-time positions

For changes in regional output for Alternative 1, Table 38 reports a net present value (NPV) of $994.55 million yet the Overview table reports an NPV of $926 million. In the case of Alternative 5 the output is reported as $0 million in the Overview table despite Table 38 reporting an NPV of $68.34 million. We can find no explanation for the discrepancies between what is reported in Tables 37 and 38 versus what is reported in the Overview table.

We do observe the drop in labor earnings for both Alternatives 1 and 5 is the same between Table 37 and the Overview table: $43.2 million. This same adjustment, if that is what it is, is not applied to the other alternatives however. Likewise the drop in NPV for both Alternatives 1 and 5 is the same between Table 38 and the Overview table: $68.34 million. Again, this same adjustment, if that is what it is, is not applied to the other alternatives. We also note that, according to the Overview table, in Alternative 5 the six jobs retained in the Tribe’s forestry program are apparently being paid nothing.

One additional observation on the table seems appropriate. We believe the lack of clarity due to the selection of the “zero” baseline is on full display in this Overview table. To someone simply looking at this table the natural inference would be there is no impact to labor earnings or regional output under Alternative 5 and a slight increase in the number of jobs created. However, if viewed against Alternative 1 (status quo) – even though it is incorrectly portrayed in the Overview table – the true tale of the tape is a loss of 797 jobs, a reduction in labor earnings of $356 million over the 15 year period, and a reduction in regional output of $926 million. The presentation of the same data under these different baselines communicates a dramatically different set of outcomes.

Finally, the NPV calculations are unconventional and may be incorrect for all of the alternatives. For the typical way an NPV is computed, the first entry is assumed to occur at time 0, i.e., no discount factor is applied; the second entry occurs at the end of the first time period so a discount factor for a single time period is applied; and so on. This calculation methodology continues throughout the entire data-entry

[56] DEIS Table 39, p. 262.

value stream in similar fashion. The results of this calculation methodology are shown in the pale green row of Table 7.6.

Table 7.6. Regional production/output.[57]

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
2015	80.20	80.20	71.67	95.80	-
2016	74.45	74.45	68.18	89.78	-
2017	85.14	85.14	74.15	96.03	5.10
2018	83.21	83.21	77.59	99.75	7.65
2019	92.51	92.51	78.49	100.93	7.65
2020	79.51	79.51	79.40	102.13	7.65
2021	86.17	86.17	80.32	103.34	7.65
2022	90.62	90.62	81.26	104.57	7.65
2023	89.13	89.13	82.21	105.81	7.65
2024	96.42	96.42	83.17	107.07	7.65
2025	92.76	92.76	84.14	108.35	7.65
2026	96.97	96.97	85.12	109.64	7.65
2027	104.44	104.44	86.12	110.95	7.65
2028	109.59	109.59	87.13	112.28	7.65
2029	101.95	101.95	88.15	113.62	7.65
TOTAL	1,363.09	1,363.09	1,207.10	1,560.04	96.87
NPV*	994.55	994.55	884.62	1,144.46	68.34
NPV Calculations and Comparisons					
Unconventional	994.54	994.54	884.62	1,144.47	68.36
Difference from Alternative 1		-	(109.92)	149.93	(926.18)
Conventional	1,034.32	1,034.32	920.01	1,190.25	71.09
Difference from Alternative 1		-	(114.31)	155.93	(963.23)
*** As reported**					

The results of an unconventional NPV calculation are shown in the pale yellow row in Table 7.6. In this calculation the first entry is taken to be at time period 1 rather than time period 0 and so a discount factor over a single year is applied. This pattern is repeated for all data entries.

As can be seen in the table, the reported NPV most closely corresponds to the unconventional calculation of NPV. This may be intentional but we observe the NPV calculation methodology employed diminishes the difference from the "baseline" (of zero) as well as from what we have argued is a more appropriate baseline, Alternative 1. We would point out that If the unconventional calculation is the intention it should be expressly indicated to be the case in the DEIS text; if not, it should be corrected.

In summary, we have pointed out the zero baseline confuses the interpretation and apprehension of differing economic impacts between the alternatives. The treatment of the Omak mill between varying

[57] Derived from DEIS Table 38, p. 261.

alternatives was biased against higher timber production alternatives. However, because the mill is no longer operating, this flaw can be easily remedied by dropping it from the analysis. The Study Region's definition also needlessly penalized higher timber production alternatives by excluding the economic impact of value-added conversion for CFR timber sold to mills located just outside the Study Region. This shortcoming should be remedied by including Stevens County in the Study Region. We identified a number of methodological flaws employed in the calculation of the projected timber revenues. Finally, the Overview of Economic Impacts table should correspond to analyses cited previously. Also, if the NPV of regional output is correct as presented, the unconventional methodology used to calculate it should be documented. If it is incorrect, it should be corrected.

On balance, we believe that when the inventory has been completed, new forest management alternatives developed and examined, and these recommendations for the economic impact analysis implemented, the size of the opportunity cost between an essentially status quo alternative (e.g., the preferred alternative) and a more aggressive forest management alternative will be large enough both on ecological and economic grounds to prompt adoption of the more aggressive forest management alternative.

8. Timber Revenues and Market Responsiveness

In this section we examine the likelihood of achieving the forecasted stumpage revenue results in the IRMP and explore the upside potential for increased stumpage revenue to the tribe by being more market responsive. Our analysis finds reported timber-related revenue for the IRMP's alternatives is approximately 2.4 times a plausible revenue stream. At issue is a methodological problem: the IRMP used delivered-log prices as the basis of the revenue projections, not stumpage values. The market-responsiveness analysis suggests that even under a highly constrained set of assumptions, a market responsive implementation plan results in increased revenue over and above the preferred alternative's expected revenue 59% of the time.

The *2015 Forest Management Plan* (FMP) reports harvest and stumpage revenue from 1950 to 2013 (Figure 8.1) and 1980 to 2013 (Table 8.1). Note from Figure 8.1 that annual revenue peaked at $25 million in 1980, and more recently, has been gradually rising from near zero in 2010.

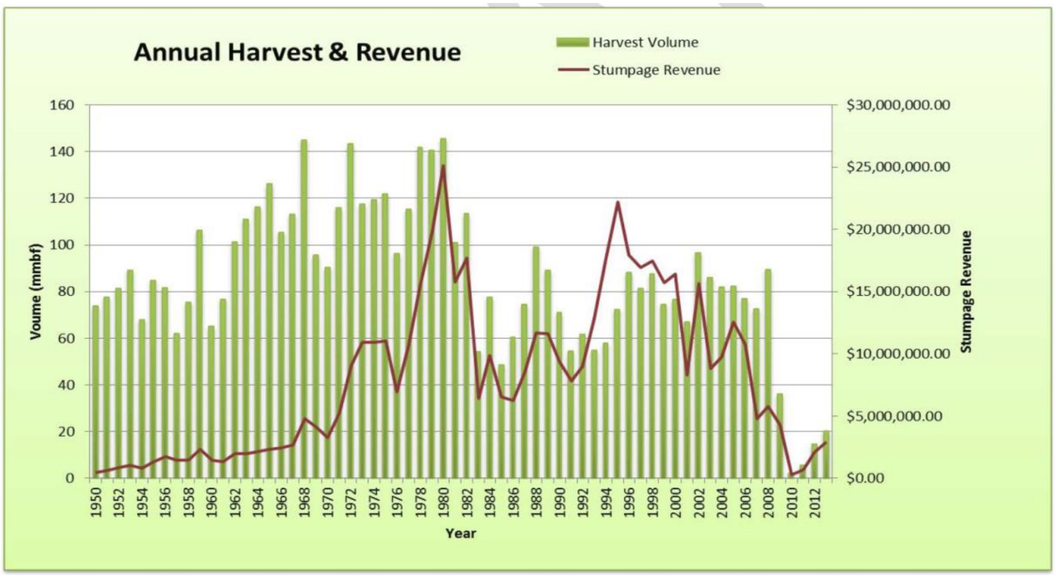

Figure 8.1. Historical (1950-2013) harvest volume and value.[58]

[58] FMP Figure 5, p. 66.

Table 8.1 shows both totals and annual averages of 1980-to-2013 harvest volume and stumpage revenue. If the total periodic volume and revenue values are correct,[59] implied 1980-2013 annual average stumpage value was $160.77/MBF.

Table 8.1. Historical (1980-2013) harvest volume and value.[60]

Harvest Volume & Value, 1980 to 2013			
Average Annual Volume =	*69.8 mmbf*	Total Volume =	***2.3 billion board feet***
Average Annual Stumpage Revenue =	*$10,8775,865*	Total Revenue =	***$369,779,416***

The implied stumpage values represented in Table 8.1 are consistent with our own independent analysis. Figures 8.2 and 8.3 show historical stumpage prices of Douglas-fir and ponderosa pine reported in Washington Department of Revenue (WADOR) Stumpage Value Determination Tables[61] for eastern Washington (Stumpage Value Areas 6 and 7 in older reports), corresponding to the two predominant tree species harvested and sold from the Reservation. As can be seen, the current trend prices of $202/MBF for Douglas-fir and $133/MBF for ponderosa pine in aggregate correspond reasonably well to the historical stumpage values implied in Table 8.1.

[59] The average annual estimates displayed in Table 8.1 exhibit multiple errors, mainly centered on whether the period from "1980 to 2013" contains 33 or 34 years. If the intended meaning of "1980 to 2013" is 1980 ***through*** 2013, the period contains 34 years (2013-1980+1); if the intended meaning is 1980 ***up to, but excluding*** 2013, the period contains 33 years. Table 8.1 appears to reflect mixed assumptions, with a 34-year period for revenue (moreover, "$10,8775,865" contains an extra "7") but a 33-year period for harvest. The implied stumpage value of $160.77 mentioned in the text is computed by dividing $369,779,416 by 2,300,000 MBF.
[60] FMP Table 16, p. 67.
[61] http://dor.wa.gov/content/findtaxesandrates/othertaxes/timber/forst_stump.aspx

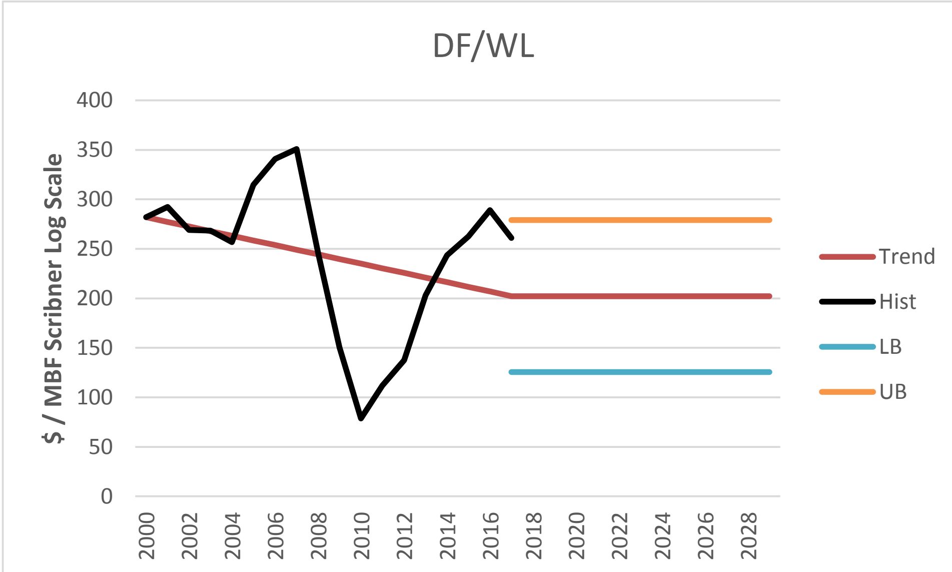

Figure 8.2. Stumpage prices for Douglas-fir / western larch (DF/WL).

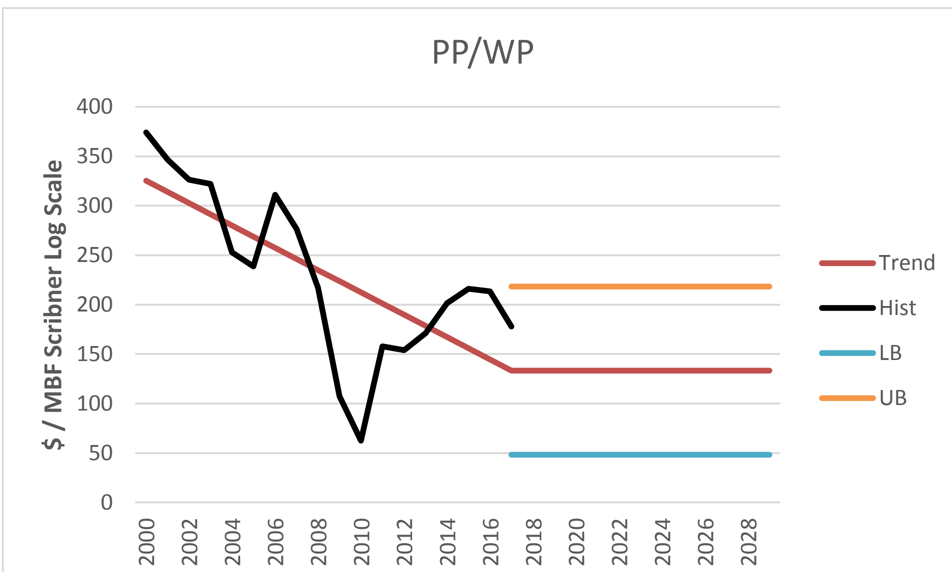

Figure 8.3. Stumpage prices for ponderosa pine / western white pine (PP/WP).

By comparison, the DEIS presents on p. 28 and elsewhere what are described as total harvest revenues deriving from the various management alternatives during the 2015-2029 planning period (Table 8.2).

Table 8.2. Total timber harvest revenue 2015-2029.[62]

Total Timber Harvest Revenue 2015 - 2029		
Alternative	Annual Average	Total Revenue
1: Status Quo-2000 IRMP	$29,290,000	$439,300,000
2: Enhanced & Improved IRMP	$29,290,000	$439,300,000
3: Forest & Rangeland Health	$22,020,000	$330,340,000
4: Expanded Production	$37,970,000	$569,550,000
5: Eliminate Harvest & Grazing	$0	$0

Readers of the DEIS could justifiably infer from Table 8.2 and supporting text in the DEIS that the amounts shown in that table represent revenue available for distribution to the Tribe's General Fund, particularly in light of the following quote from DEIS p. 27 (which immediately precedes the "Total Timber Harvest Revenue" table shown above, and is repeated on DEIS p. 252):

> The level of harvest has a direct effect…in the regional economy. ***And, because 90% of stumpage revenue realized from harvest activities is paid into the Tribes' General Fund***, …the level of revenue and output within each of these industries is also directly correlated to the harvest volume. (emphasis added)

However, it appears the values reported in Table 8.2 are based on delivered-log prices, not stumpage prices. Delivered-log prices include cost of stumpage (i.e., the value of standing trees paid to the timber owner[63]), harvesting cost, and transportation cost of harvested trees to a mill. The DEIS makes the following statements as to how per-unit revenues used to compute total "timber revenue" were developed:[64]

> These estimates were derived from ***delivered log bids*** proffered to the Tribes between 1996 and 2016 by several mills located within the Study Region. (emphasis added)
>
> The annual revenue figures outlined in Table 32 represent the total revenues generated in the timber harvesting process, ***including: forest planning and management, sale administration, site preparation, harvest activities, and transportation of the harvested timber products to the mill. Alternatively, these figures can be described as the total cost to the Omak Mill and other local mills to secure raw inputs to which value is added in the milling process***. (emphasis added)

From those statements, it is clear that the genesis of the per-unit revenue estimates used to compute total revenue estimates related to the several IRMP alternatives considered was not stumpage, but rather delivered-log bids – which include costs of transportation to mills and harvesting costs. If the revenues in Table 8.2 were stumpage, and not delivered log cost, the total "revenue" of the preferred alternative ($439.3 million) would imply average stumpage values of $380.91/MBF ($439,300,000 / 1,153,300 MBF,

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[62] DEIS, p. 28.
[63] https://www.merriam-webster.com/dictionary/stumpage
[64] DEIS, p. 253.

from DEIS Tables 31 and 32 – which are replicated in Figures 8.4 and 8.5 below). Obviously, that planning-period average of $380.91/MBF is radically different from the historical $160.77/MBF. All of this confirms the revenues reported are not stumpage, as should be the case, but delivered-log costs. As a result, anticipated revenue is inflated by roughly 2.4 times.

Since the "revenues" presented in DEIS Table 32 implicitly include both the true stumpage values as well as other costs, Table 32 should be labeled "Total Outlays by Receiving Mills for Delivered Logs." **Hence, to claim that 90% of the planning-period "revenue" of $439.3 million would be delivered to the Tribe's General Fund, and the other 10% utilized for other activities is an incorrect and misleading statement.**

An additional error involves describing costs incurred in the management of the forest as "revenues." Costs such as forest planning and management, sale administration, slash disposal, roading costs related to timber harvest, and site preparation all must be deducted from stumpage revenues; in the case of the CRF, $20/MBF from the gross stumpage revenue is allocated to the Colville Tribal Sort Yard as well as approximately $7/MBF on average for harvest road costs. After those deductions 10% of the remaining stumpage revenues are allocated to defraying the aforementioned forest management costs, with the remaining 90% paid into the Tribe's General Fund.

Figure 8.4. DEIS p. 253.

Table 31: Estimated Harvest Volumes by Alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
2015	73.3	73.3	58.0	100.0	0.0
2016	70.6	70.6	58.0	100.0	0.0
2017	79.8	79.8	58.0	100.0	0.0
2018	69.0	69.0	58.0	100.0	0.0
2019	85.1	85.1	58.0	100.0	0.0
2020	58.2	58.2	58.0	100.0	0.0
2021	69.0	69.0	58.0	100.0	0.0
2022	75.4	75.4	58.0	100.0	0.0
2023	70.7	70.7	58.0	100.0	0.0
2024	82.0	82.0	58.0	100.0	0.0
2025	73.4	73.4	58.0	100.0	0.0
2026	78.9	78.9	58.0	100.0	0.0
2027	89.9	89.9	58.0	100.0	0.0
2028	96.6	96.6	58.0	100.0	0.0
2029	81.4	81.4	58.0	100.0	0.0
Average	*76.9*	*76.9*	*58.0*	*100.0*	*0.0*
Total	**1,153.3**	**1,153.3**	**870.0**	**1,500.0**	**0.0**

Source: 2015 FMP - Page 105 Note: All figures expressed in MMBF

The harvest volumes shown in Table 31 for each management alternative were utilized as base model variables in the impact analysis. Harvest volumes associated with management Alternatives 1 and 2 were extracted directly from the 2015 Colville Tribes Draft Forest Management Plan (Hunt, 2015), and are therefore based on an established program of harvest which specifies the geographical areas of the harvest, the treatment type, and an estimate of the quantity of each species to be extracted. For this reason, Table 31 presents a level of detail for these two management alternatives that was not available for Alternatives 3 and 4. Alternative 5 presents a management alternative where there is a complete absence of forest thinning or timber harvesting (commercial or otherwise).

Based on the projected harvest volumes over the fifteen-year planning period shown in Table 31, Table 32 illustrates the gross revenues for each alternative that would result from that level of harvest. These estimates were derived from delivered log bids proffered to the Tribes between 1996 and 2016 by several mills located within the Study Region. An annual inflation adjustment factor of 1.3% — influenced by the trailing 20 years' producers price index for lumber products — was employed to account for price fluctuations within the timber industry and their effect on harvest revenues over the 15-year planning period. In reality, net revenues realized by the Tribe over the 15-year planning period may vary from year to year depending on the quality and species of the timber being har-

Figure 8.5. DEIS p. 254.

vested.[1] Harvest revenues/expenditures may also fluctuate relative to the dynamics and adversity of the terrain within individual harvest areas. To the greatest extent possible, this effect has been normalized over the 15-year period by utilizing actual Reservation harvest revenue figures from the previous 15-year planning period (i.e., 2000-2014).

The annual revenue figures outlined in Table 32 represent the total revenues generated in the timber harvesting process, including: forest planning and management, sale administration, site preparation, harvest activities, and transportation of the harvested timber products to the mill. Alternatively, these figures can be described as the total cost to the Omak Mill and other local mills to secure raw inputs to which value is added in the milling process. Approximately 90% of the revenue figures described in Table 32 would be delivered to the Tribes' General Fund, the remaining 10% plus approximately $20/MBF would be utilized for forest management activities and future sale preparation.

Table 32: Harvest Revenue/Expenditures by Alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
2015	$28.56	$28.56	$22.60	$38.96	$0.00
2016	$24.57	$24.57	$20.19	$34.80	$0.00
2017	$28.13	$28.13	$20.45	$35.26	$0.00
2018	$24.64	$24.64	$20.71	$35.71	$0.00
2019	$30.79	$30.79	$20.98	$36.18	$0.00
2020	$21.33	$21.33	$21.26	$36.65	$0.00
2021	$25.61	$25.61	$21.53	$37.12	$0.00
2022	$28.35	$28.35	$21.81	$37.60	$0.00
2023	$26.93	$26.93	$22.09	$38.09	$0.00
2024	$31.64	$31.64	$22.38	$38.59	$0.00
2025	$28.69	$28.69	$22.67	$39.09	$0.00
2026	$31.24	$31.24	$22.97	$39.60	$0.00
2027	$36.06	$36.06	$23.26	$40.11	$0.00
2028	$39.25	$39.25	$23.57	$40.63	$0.00
2029	$33.50	$33.50	$23.87	$41.16	$0.00
Average	$29.29	$29.29	$22.02	$37.97	$0.00
Total	**$439.30**	**$439.30**	**$330.34**	**$569.55**	**$0.00**

Note: All figures expressed in 2016 millions

In addition to the revenue figures shown in Table 32, each management alternative will also effect the revenue generated by the Omak Mill and other mills throughout the Study Region that purchase and process timber harvested from the Colville Reservation. The majority of the timber harvested from the Reservation is purchased by the Omak Mill, the remaining supply is sold to other local mills within the Study Region and mills outside of the Study Region. The Omak Mill revenue figures shown in Table 33 were calculated from the mill's Fiscal Year 2015 reported gross annual revenue statistics (Omak Wood Products, 2015).

1 Species, quality, and diameter all affect log delivery bids/prices and therefore also affect harvest revenues. Because market demand for individual species and size classes will vary over the 15-year planning period, a set level of harvest by species or size class for each of the management alternatives was not available.

A more reasonable estimate of true stumpage revenue is presented in Table 8.3 (originally Table 17 and associated text from p. 69 of the *2015 Forest Management Plan*):[65]

Table 8.3. Estimated forest management revenues and costs.[66]

FOREST MANAGEMENT REVENUES & COSTS 15 Year Planning Period (2015 – 2030)	
Sources of Revenue & Cost	**Dollar Amount**
Gross Stumpage Revenue	$415,800,000
Logging Costs	-$277,200,000
Net Stumpage Revenue	*$138,600,000*
Mill Lease Payment Revenue	*$8,910,000*
TOTAL REVENUE	***$147,510,000***

> The 2015 IRMP Alternative will continue with the current harvest level of 77.1 million board feet per year. This means that revenues and economic impact will closely resemble the last 15 year planning period, assuming no large economic downturns as those that occurred in 2009-2011.…
>
> Table [8.3] outlines the estimated revenue that will occur from Forest Management Activities over the 15 year planning period outlined in the IRMP. Gross stumpage revenue is the value of the Tribes timber before logging costs. The net stumpage expresses the actual value the Tribe will receive after logging costs are paid to get the timber to the mill. ***Net stumpage the Tribe will receive after logging costs over the 15 year planning period is estimated to be $138,600,000***. (emphasis added)

As indicated in the highlighted quote, the 15-year planning-period revenue of $138.6 million reported on the "Net Stumpage Revenue" line is the relevant number from Table 8.3; it appears to be the best estimate of stumpage value with no other cost added or deducted. That translates to annual revenue of $9.24 million ($138,600,000 / 15 years), or implied net stumpage of $119.84/MBF ($9,240,000 / 77.1 MMBF). Based on our independent trend analysis, this amount is slightly low. However, because this estimate of future implied stumpage value is much closer to the average historical $160.77/MBF and the trend average of $174.59/MBF, the annual revenue of $9.24 million is also a more reasonable expectation than the $29.290 million shown in Table 8.2; it also matches well with the revenue trajectory shown in Figure 8.1. Based on our own independent analysis, deducting the $20/MBF paid to the sort yard, the $7/MBF for harvest roads, 90% of the remaining funds paid into the Tribe's General Fund would be $162.3 million, or an average of $10.8 million per year under the preferred alternative.

This determination that the Tribe will almost certainly receive far less than DEIS's reported $439.3 million in stumpage revenue during the course of the planning period should provide motivation to identify ways to improve the likelihood of increasing that source of revenue. One approach to accomplishing that goal

[65] The IRMP makes no reference to the mill lease payment shown in this schedule as the plywood mill currently is not running. When this schedule was prepared as part of the Forest Management Plan, the Omak Wood Products plywood mills was still operating.
[66] FMP Table 17, p. 69; the reference to 2030 should instead be 2029.

involves allowing the annual harvest to fluctuate in response to market conditions. I.e., instead of adhering to the pre-determined annual harvest schedule presently employed, Reservation harvest could instead be reduced when log markets are soft and, conversely, increased when log prices rise.

To explore the potential impact of adopting such an approach, two scenarios were constructed. Appendix D explains in detail the data and methodology used, along with the results. Those aspects are more briefly presented here.

In both cases, stumpage prices in 2015 and 2016 are as published in the WADOR price histories. For the remainder of the planning period, stumpage prices are allowed to follow a uniform probability distribution within the “lower bound” and “upper bound” columns shown in Table 8.4 (i.e., all prices within the range are equally likely; the projected portion of the charts in Figures 8.2 and 8.3 portray a graphical depiction.).

Table 8.4. Scenario forecast price ranges, by WADOR species group.

Species Group	Lower Bound	Upper Bound
	---------- $ / MBF ----------	
DF/WL	125.52	278.98
WH/LP	138.42	248.38
PP/WP	48.25	218.45

In terms of annual harvest, the following conditions applied:

- **Base-case scenario** –
  - The annual cut is deterministically defined; i.e., the 2015-2029 annual harvest schedule shown in DEIS Table 31 is followed.
- **Five-year-average cut comparison scenario** (dubbed “5YA_Cut”) –
  - Harvest levels in 2015 and 2016 are taken as given in DEIS Table 31, since they are history; however, the 2017-2029 harvest levels are allowed to follow a normal probability distribution in response to changing forecast stumpage prices. The average cut for 2017 and 2018 is 78.0 MMBF (average of the DEIS planned harvest during 2017, 2018 and 2019). To ensure the scenario remains true to the annual allowable cut (AAC) of 77.1 MMBF, the cut every fifth year (i.e., 2019, 2024 and 2029) is constrained to bring the five-year average cut back on top of the periodic cut allowed by the AAC. Per the annual harvest schedule, the 2020-2024 cut averages 71.1 MMBF, and 2025-2029 cut averages 84.0 MMBF; a standard deviation of ± 9.5 MMBF is defined around the mean of each forecast period’s non-reconciliation year.[67]
  - Stochastically generated harvest volumes follow a normal probability distribution with the aforementioned means and standard deviations, and are moderately and positively correlated with prices so that harvest rises during years with higher stumpage prices and falls during years with lower stumpage prices.

[67] See Appendix FA for derivations of assumptions used.

In short, in both cases the prices varied. In the base case, harvest was implemented as planned. In the five-year average cut case, the annual harvest were allowed to adjust within specified boundaries corresponding to price movements.

Scenarios were "run" within Oracle's Crystal Ball[68] simulation add-on to Microsoft's Excel spreadsheet program. Given the assumptions described above (and in more detail in Appendix D), base-case stumpage revenue amounts to nearly $211.5 million during the 2015-2029 planning period (Table 8.5). For the "5YA_Cut" scenario, the likeliest planning-period stumpage revenue is $214.1 million, which translates to a 58.7% probability of exceeding the base-case outcome (Figure 8.6).

A nearly $2.6 million increase in revenue over the 15-year planning period may not seem very impressive, but recall that constraints were placed on the "5YA_Cut" scenario requiring harvest during each five-year period to not exceed the AAC.

As the Tribe continues to implement its stand-level inventory, the ability of harvests to be more responsive to markets will increase even more than shown in this example. Thus, even if the AAC does not increase as a result of changes advocated elsewhere in this report, adjusting harvest levels to coincide with expected changes in stumpage values could boost revenues to the Tribe's General Fund.

Table 8.5. Total 2015-2029 harvest, by scenario; also corresponding minimum, 50th percentile, and maximum 2015-2029 stumpage revenue.

	Scenario	
Metric	Deterministic Cut ("Base_Case")	Stochastic 5-Yr Average Cut ("5YA_Cut")
Total Cut (*MMBF*)	1,153.3	1,156.5
Total Revenue (*million $*)		
Minimum	168.196	171.014
50th Percentile	211.518	214.081
Maximum	253.204	255.577

[68] http://www.oracle.com/us/products/applications/crystalball/overview/index.html

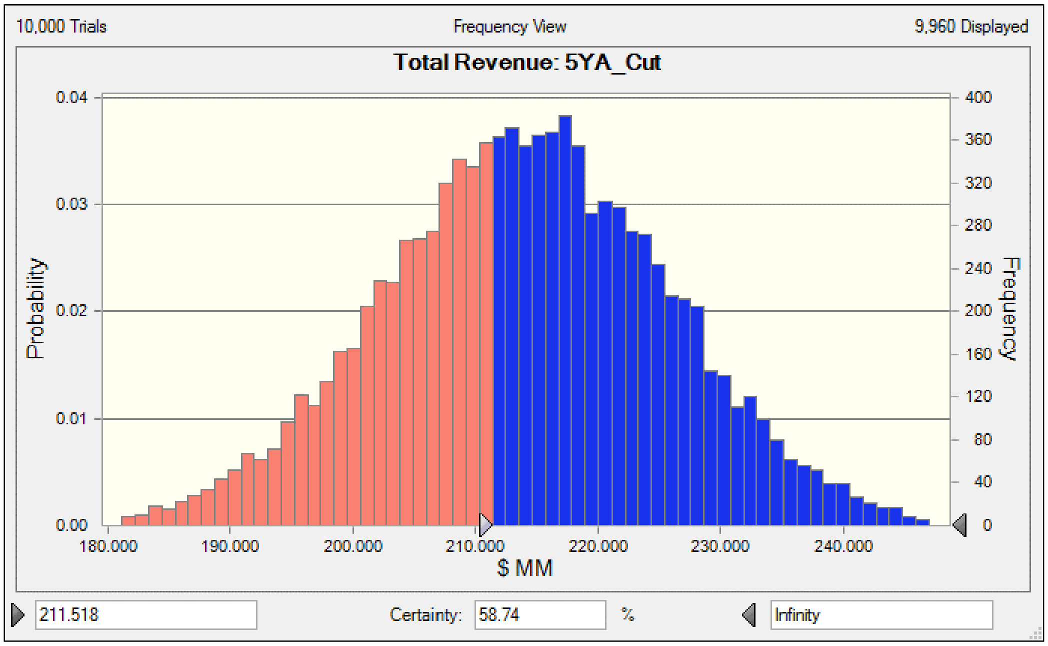


Figure 8.6. Probability distribution of "5YA_Cut" scenario total-revenue simulation outcomes, with the likelihood of exceeding the base-case median total revenue.

9. Miscellaneous Observations

Open Ground Equivalency Thresholds – The DEIS indicates that the preferred alternative will "[a]djust the harvest schedule using current Geographic Information System (GIS) layers, Open Ground Equivalency (OGE) Models and Continuous Forest Inventory (CFI) data."[69] As the Environmental Consequences section of the DEIS elaborates:[70]

> The ability of a watershed to absorb the changes brought about by natural as well as human caused events and yet recover to a stable former state is a measure of its stability. Stability in this sense is defined by the interaction of geology, soils, vegetation, climate and a range of other factors. From this principle has come the concept of an open ground equivalency (OGE) threshold or tolerance value as the point beyond which there is a high risk that recovery potential may be permanently impaired through changes in specified physical, chemical and biological factors brought about by management activities or natural events.

The DEIS goes to great lengths in Appendix L detailing OGE ratings of acres subjected to either harvest activity or wildfire. It provides estimates of watershed management unit acreages affected by harvest activity and/or wildfire between 2000 and 2014, along with the degree to which different assumed OGE thresholds were exceeded. However, there is no presentation of economic tradeoffs related to remaining within versus exceeding the thresholds specified in this analysis.

In light of this deficiency, we find it difficult to understand why planning-period harvests should be influenced by a rather ambiguously applied concept, especially when the DEIS admits:[71]

> Currently, not enough is known to determine with absolute certainty when the OGE threshold of hydrologic sensitivity or capacity for a particular watershed has been reached or what the consequences are if this threshold is exceeded for either short or long periods of time.

In any event, IRMP Alternatives 1, 2 and 4 – while apparently raising the risk of exceeding OGE thresholds from harvesting – would, presumably, simultaneously lower the risks of OGE exceedance via stand-replacing wildfire; regeneration harvesting and stand-replacing wildfire are on roughly equal footing in terms of OGE ratings. In a sense, Alternative 5 could be construed as the worst of all possibilities: The heightened risk of OGE exceedance from wildfires has no counterbalance from timber harvesting – or economic benefit that typically accompanies harvest activity.

We recommend that, as part of revising the DEIS to address criticisms raised elsewhere in this document, economic tradeoffs of OGE threshold exceedance be included in the analysis.

Alternatives 1 & 2 – The vast majority of these comments have been aimed at Alternative 2, and due to the similarity to it for forest management, Alternative 1. In our opinion, just to be clear, adopting the status quo to cope with a deteriorating forest health situation is ill advised. From our reading of the proposals it appears this status quo conundrum has been created because of defining sustained yield as

[69] DEIS, p. 44.
[70] DEIS, p. 198.
[71] DEIS, p. 199.

the following: non-declining even-flow harvest; non-decreasing inventories, even if the forest is recognized to be overstocked; net growth must equal or exceed harvest; and no stand can be managed below a minimum rotation age at any time. The forest will not be restored to health as long as such ideas persist unless it is regenerated "accidently" by catastrophic fire.

It is also important to underscore that the AAC is for the "green" cut – i.e., living trees. We recognize that, in practice, salvaged timber volume is frequently included in the annual harvest that is compared to the AAC. However, salvaged timber volume should be counted as incremental to (i.e., over and above) the AAC, except in extraordinary salvage scenarios like after the 2015 wildfire season. If salvage volume is routinely included in the AAC, the harvest prescribed to deliver ecological benefits by managing stocking and stand age is undercut, replaced by dead timber. This proviso applies to any alternative that includes timber harvesting. While salvage volumes are generally small, in situations where forest health is an issue this can result in meaningfully undershooting intended "green harvest" targets.

Alternative 3 – It is curious that an alternative being considered involves increased use of intermediate harvesting practices that were rejected several decades ago because they promoted unhealthy forest health due in part to a lack of regeneration harvesting (see quotes below). That being said, there are likely some silvicultural prescriptions consistent with those advocated within Alternative 3 that should be employed on a limited basis within the context of some of the new alternatives to be developed.

> IRMP Exec Summary, p. 17:
>
> Although Alternative 3 has a lower AAC (58 MMBF), the forest-wide thinning approach does not provide a predictable recruitment of new age classes and may not be sustainable in the long-term.
>
> Forest Management Plan, p. 15:
>
> As foresters began to recognize the need to shift management away from selection harvesting in the 1970's and 1980's they began implementing regeneration harvesting on a relatively small scale across the Reservation. Throughout the 1980's and 1990's regeneration harvesting (plantation forestry) became much more common.

Alternative 4 – The principle issue here is the inappropriate application of non-declining even flow in concert with an inflexible rotation age. In light of the old and aging forest and the forest's 20-to-60-year age-class gap, applying the definition of sustained yield as being non-declining even flow in combination with an inflexible rotation age predisposed to failure any alterative that dealt with the forest more aggressively than the preferred plan.

In essence, this alternative was dismissed out of hand because the overly restrictive definition of sustained yield management prevented it from being seriously considered. I.e., an alternative that would address forest health issues more aggressively, potentially provide an expanded source of stable timber supply, and increase employment in the area due to greater harvest boosting economic activity was rejected because it was judged to be "unsustainable" by the definitions imposed upon it.

Further, due to an expanded base of timber supply under the more intensive timber production alternative, it is possible either or both the Omak mill and the Colville Indian Precision Pine mill could be refurbished and begin operation once again. Should that occur, employment would be further expanded; also, with increased demand for timber in the area, stumpage prices would likely to rise, thereby boosting stumpage revenue paid into the Tribe's General Fund.

In short, decisions made 20 to 60 years ago to emphasize selective harvesting and to NOT practice regeneration forestry contributed to today's forest health crisis. Further, because of these age-class deficits stemming from decisions made decades ago, forest managers' hand are tied in terms of addressing the forest health issue because of a lack of flexibility in how sustained yield forest management is being interpreted.

> IRMP Exec Summary, p. 17:
>
> Alternative 4 would significantly increase the annual harvest to 100 MMBF, well above the level of sustained yield determined for the 2000 and 2015 IRMPs. The expanded harvest level would not be sustainable in the long run and would likely result in significantly reduced harvest levels in the future.

As has been repeatedly pointed out, sustained yield management does not require harvest levels to remain invariant or even for harvest levels to never decline if harvest level changes are being executed within the context of an overarching sustained yield plan. Thus, the claim that Alternative 4 is unworkable because it cannot maintain an elevated level of harvest indefinitely is interesting information, but it should not deter consideration of more flexible harvest plans that include a higher harvest level of a period of time. There is more on this point in the New Alternatives section of this report.

Alternative 5 – The excerpts below are taken from DEIS pp. 38-39:

> Alternative 5 would effectively end commercial timber harvesting and livestock grazing on tribal trust lands. Results of the 2014 Community Survey showed that 10 percent of respondents preferred this alternative. Asked about forest management, only 6 percent felt that the forest should be allowed to return to its natural state with no management or fire suppression.
>
> Eliminating much of forest practices such as thinning, insect and disease control, and planting would not likely restore the forest to historic conditions. Fuels buildup would increase the likelihood of catastrophic wildfires.
>
> Alternative 5 ***avoids many environmental impacts*** by effectively ending commercial timber harvesting and livestock grazing. However, this would also result in a dramatic reduction in revenue, employment and income. (emphasis added)

A choice of "no management" carries with it environmental consequences. Some of these are alluded to in the above quotes as well as others throughout the IRMP documents. But it is easy to discount probabilities as speculative. Wildfire strikes randomly and so it is easy to imagine it may not be as bad as some people say. To move past speculation and to reality, we offer up a few charts showing the effects of the no-management experiment currently unfolding on 3.7 million acres of wilderness in Idaho's National

Forest lands. Idaho's Inland West forests are similar in many respects to the Inland West forests of eastern Washington.

As can be seen in Figure 9.1, net annual growth on Idaho's unmanaged wilderness forest lands is negative: the annual mortality exceeds the gross annual growth. Idaho's managed National Forest lands are not faring much better as a significant share of these acres were classified as Roadless in 2008[72] and so are being managed as "stealth wilderness" despite continuing to be reported as open to management by the USFS's Forest Inventory and Analysis Evalidator Program, the source of the data shown in Figures 9.1 to 9.4. As a consequence the annual mortality is climbing on the "managed" portions of USFS lands as well. State-managed lands provide a reasonable counterbalance to conditions on the USFS, and particularly the unmanaged Wilderness Area forests.

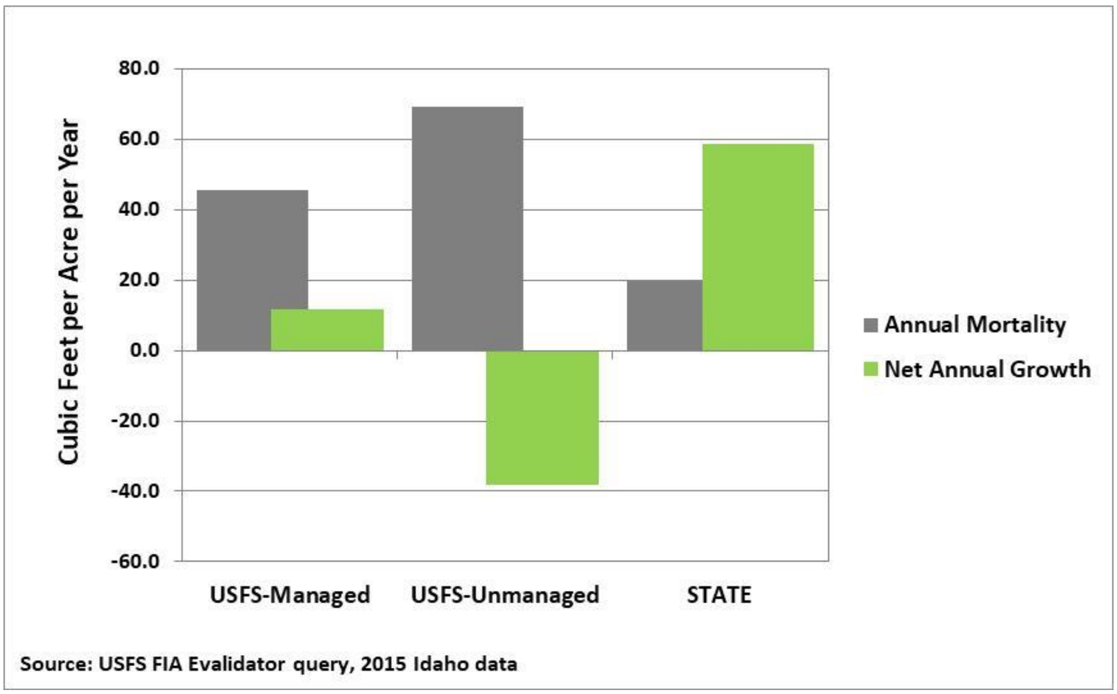


Figure 9.1. Comparison of annual mortality and net annual growth on Idaho's National Forest managed and unmanaged (mostly wilderness) forest lands versus State forest lands.

[72] https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5053193.pdf

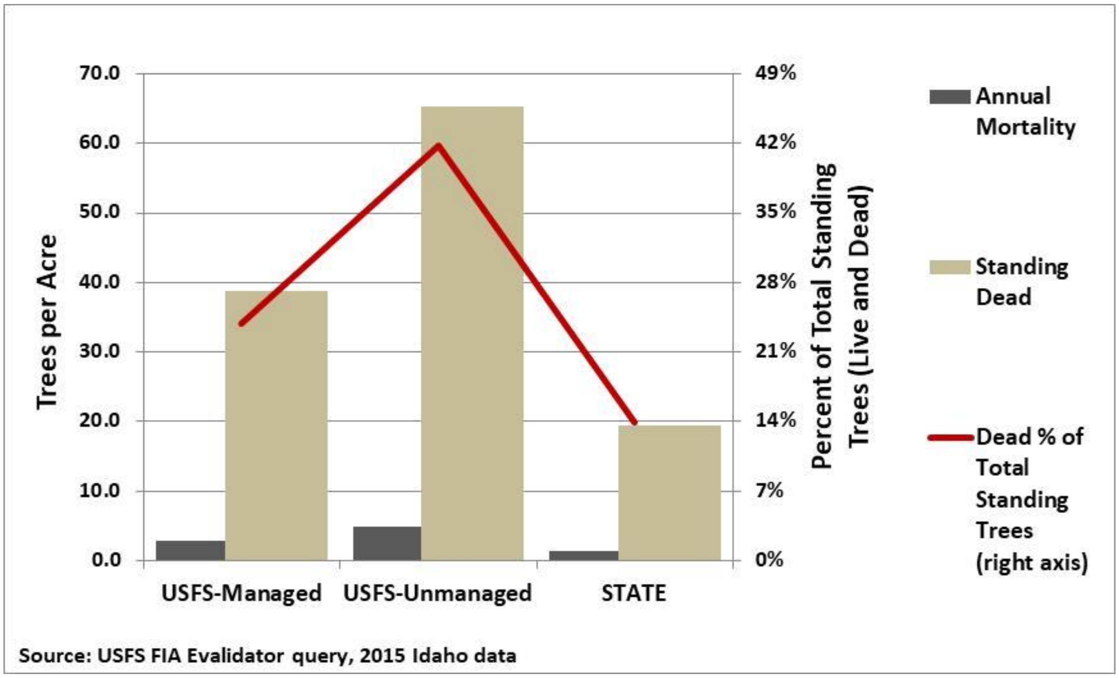


Figure 9.2. Comparison of annual tree mortality, standing dead trees, and the percentage of standing dead trees of all standing trees on Idaho's National Forest managed and unmanaged (mostly wilderness) forest lands versus State forest lands.

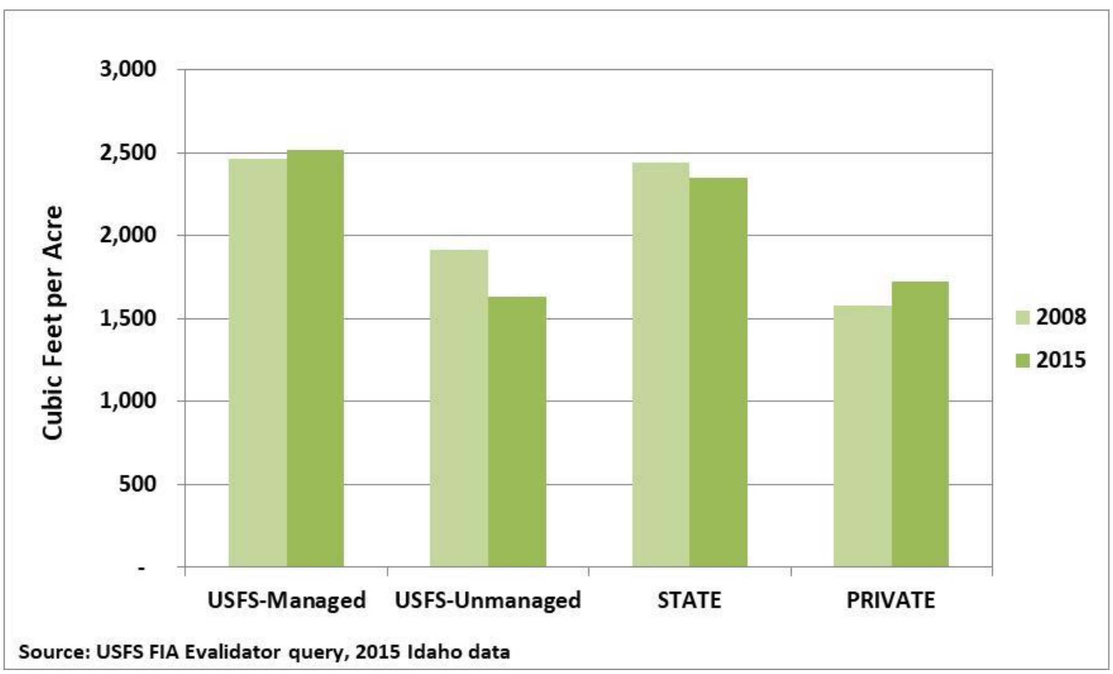
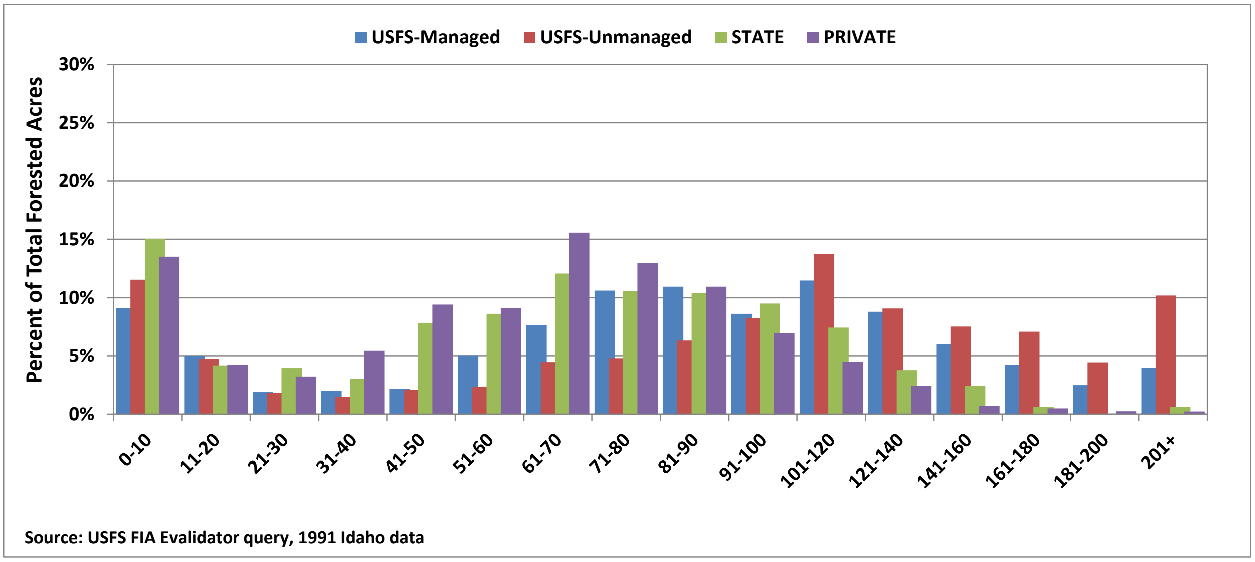


Figure 9.3. Comparison of growing stock volume (inventory) changes between 2008 and 2015 for National Forest managed and unmanaged (mostly wilderness) forest lands, State forest lands, and private forest lands.

Figure 9.2 shows that 43% of the standing trees on National Forest Wilderness Areas are dead. Figure 9.3 shows that while growing-stock inventories on managed USFS, State, and private forest acres have remained mostly stable – and in some cases increased – since 2008, growing stock inventories on Idaho's Wilderness Acres have plunged by nearly 15% between 2008 and 2015. Recognize the plunge in Wilderness Ares growing stock inventory is due only to mortality, not harvest. Harvest at varying levels is occurring on all other forested ownerships shown and is reflected in the changes in inventory seen between 2008 and 2015.

Finally, Figure 9.4 shows the age class distribution between 1991 and 2015. Note that the 0-to-10-year age class for the unmanaged USFS lands has skyrocketed and is more than twice the level of any other ownership category. This is entirely due to wildfire losses as harvesting is prohibited in these unmanaged areas. Note, too, that age classes 160 years and older on the unmanaged acreage have been nearly halved between 1991 and 2015.

In view of the above, clearly there are significant environmental consequences to no management.



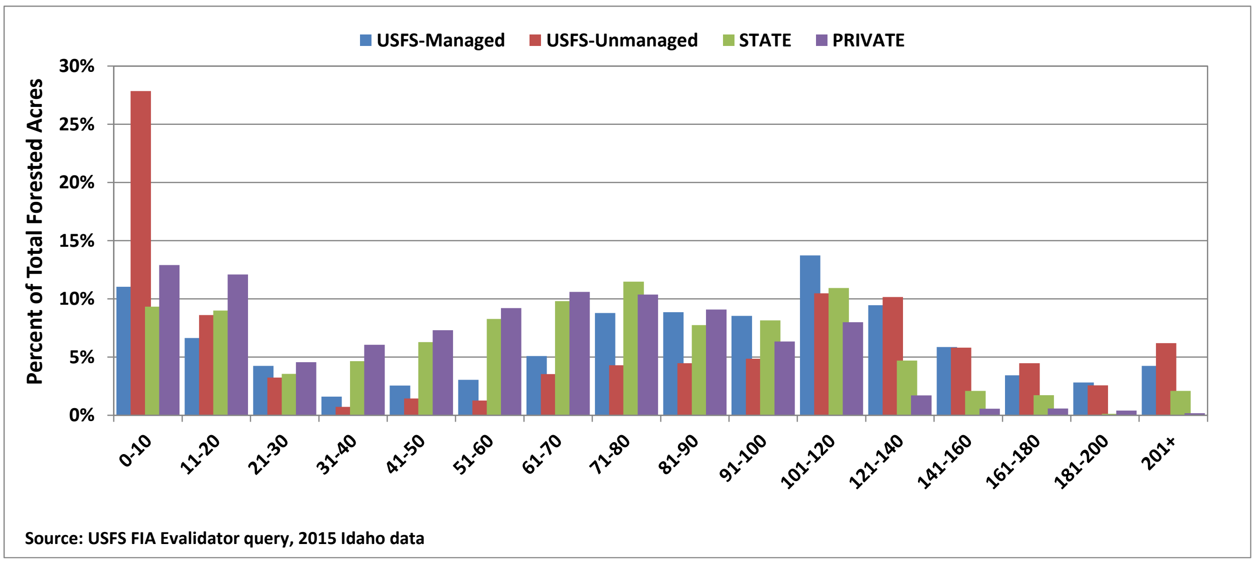


Figure 9.4. Age-class distributions of managed and unmanaged National Forest (mostly wilderness) forest land, State land, and private land in 1991 (top) and 2015 (bottom).

10. Fiduciary Responsibilities

The CRF is a valuable Tribal asset, as revenues from annual net stumpage paid to the Tribe's General Fund support a number of public services on the Reservation. Assessing the performance of a valuable asset would seem appropriate but no such evaluation is included within the DEIS. We provide a preliminary range of estimates but additional information would be needed to develop a more in-depth assessment.

For this assessment we used the estimated stumpage revenue developed in the Timber Revenue section of this report, an average of $14 million per year. This amount is before Sort Yard and harvest road maintenance deductions, as those costs will be accounted for elsewhere in the estimate.

Forest management costs, including costs related to timber sales, harvest administration, and timber sale prep would be deducted from this stumpage revenue. These costs include some of the activities performed by the Sort Yard, the harvest road maintenance costs, the 10% forest development cost, and Federal funding for BIA and Tribal forestry activities. Lacking data on BIA-forestry expenditures, we estimated such activities would range in cost from $10 to $15 per acre, or $6.7 to $10.2 million per annum. It should be noted these cost estimates are intended to reflect the full cost of the forestry and timber harvest program, not simply what is funded by the federal government. Thus, these costs represent allocated funds deducted from stumpage revenue to support components of the forestry and timber harvest program in addition to federal funding.

Based on the $14 million per annum in stumpage revenues and the range in forest management costs we estimate an operating cash-flow ("EBITDA," or earnings before interest, taxes, depreciation and amortization) from the property in the range of $4.3 to $7.8 million per annum.

To determine asset value we developed three estimates.

- The highest estimate was developed utilizing appraisal methods by valuing bare-land values, pre-merchantable values, and standing inventory values. The market estimate from that approach yielded a value of $1,247 per acre.
- The middle estimate is based on NCREIF's timberland index[73] fourth quarter 2016 market value estimate for the Pacific Northwest (PNW), which was $2,788 per acre. This index is comprised of 85 properties totaling nearly 2.0 million acres, including both Westside PNW properties as well as Inland West properties. Given the inclusion of Westside properties in the average we applied a discount factor to the NCREIF PNW estimate to account for CRF being an Inland West property. The discount relative to the PNW average was based on our experience derived from prior work, and yielded an estimate of $1,115 per acre.
- The lowest estimate was based on a rough discounted cash flow valuation based on typical market parameters currently being applied to value timberlands. That methodology yielded an estimate of $996 per acre.

Based on these estimates, CRF's market value is in a range between $0.689 and $0.862 billion.

Table 10.1 summarizes a range of cash returns (EBITDA) as a percentage of asset value using the aforementioned estimates. As can be seen, the returns range from 0.44% to 1.05% with an average return

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73 https://www.ncreif.org/data-products/timberland/

of 0.73%. This compares to an average PNW industry EBITDA return of 0.75% for fourth quarter 2016, essentially equal to what institutional timber investors are yielding at present on their timber assets.

Table 10.1. Range of EBITDA returns on assets.

		Mgmt Cost per Acre		
	$/Acre Valuation	**9.75**	**11.95**	**14.75**
	996	1.05%	0.83%	0.55%
	1,115	0.94%	0.74%	0.49%
	1,247	0.84%	0.66%	0.44%

Although management objectives differ between the CRF and the institutional timberland investors that comprise the NCREIF universe of returns, it is still instructive to gauge how CRF's financial performance compares. While CRF's returns are comparable to the EBITDA returns of institutional timberland investors, institutional investors have another return component that accrues benefit: appreciation return. NCREIF reports 4Q2016 appreciation return for the PNW of 1.33%, or roughly double the EBITDA return. This brings the total return of timberland institutional investors to 2.08%. While appreciation returns are influenced by stumpage markets, which also affect EBITDA returns, other market forces also come into play.

Because the CRF is unlikely to be monetized to any material degree through land sales, ongoing appreciation for timberland land will not boost returns for the CRF asset as it does for institutional timberland investors. Worse still, the escalating market value for timberland will depress EBITDA returns over time if CRF's EBITDA does not steadily improve. We believe this is achievable by strategically harvesting older, slower growing timber – thereby reducing the standing value of the asset while promoting better growth over time, and so generally improving cash flow.[74] So, as discussed above, while the differing management objectives between CRF and institutional timberland investors complicate direct comparisons, such benchmarks provide quantifiable metrics and benchmarks against which financial performance, not just ecological performance, can be assessed.

Lifting financial performance can be accomplished in a variety of ways:

- **Reducing management costs** – Although a worthwhile consideration, our experience indicates that focusing solely on cutting costs rarely provides sufficient savings to achieve desired financial returns. In general, BIA forestry operations tend to be underfunded so the prospect of significant cost savings is probably minimal.
- **Improving per-unit stumpage value realizations** – This can be achieved by ensuring timber goes to the highest net realization for the tribe; to do that requires identifying higher end-use markets and taking care to not eat up stumpage profits with high haul costs to distant mills. Another way stumpage realizations can be improved is by supporting the prudent expansion of timber converting facilities. Increasing competitive converting capacity in the market area increases demand and supports higher stumpage prices.

[74] This is not meant to imply cash flows may have to drop from time to time to enact forest restoration activities. The generalities stated here are viewed from the perspective as over the entire planning horizon of 150 years.

- **Increasing harvest levels** – In the case of the CRF this is not necessarily a bad thing for a period of time given the forest health issues plaguing the Reservation. By our calculations, lifting the harvest to 100 MMBF for a period of time[75] would, an increase of 30 percent, would increase the average EBITDA return from 0.73% to 1.25%. Increasing the cut by 20 percent, to 92.5 MMBF, would increase the EBITDA return to 1.08%, a 48 percent increase.

In reality, all of these factors, as well as others, would be involved in a plan to improve and maintain financial returns from the CRF. Understanding its financial performance against industry benchmarks and selecting alternatives that protect or improve that performance should be included in the criteria considered when selecting from among alternatives. Moreover, while near-term financial measures are important, we also suggest metrics aimed at measuring "financial sustainability" be developed, calculated, and monitored as well ecological sustainability.

As an example, one such measure of financial sustainability could be to compute a series of net present values (NPV) over the planning horizon of individual forest management alternatives, and then compare results among the different alternatives. The first NPV would be the cash flows from years 1 to 30 plus an ending market value equal to the NPV of years 31 to 60. The second NPV would be the cash flows from years 31 to 60 with an ending market value equal to the NPV of years 61 to 90; however these calculations would be made as if year 31 was year 1, year 32 was year 2, etc. for purposes of discounted value. The third NPV would encompass cash flows from years 61 to 90 with an ending market value equal to the NPV of years 91 to 120. As was the case for the second NPV, for purposes of calculation, cash flow in year 61 would be year 1, cash flow in year 62 would be year 2, etc. The fourth NPV would encompass cash flows from years 91 to 120 with an ending market value equal to the NPV of years 121 to 150. As was the case for the second and third NPVs, for purposes of calculation, cash flow in year 91 would be year 1, cash flow in year 92 would be year 2, etc.

This results in four NPVs for each alternative consisting of 60-year periods covering the planning horizon. The decision criteria between alternatives with this metric would be the size of the NPV, the change in NPV from period to period, and the directional trend of the NPVs over time. All three elements would be important in judging the relative attractiveness of competing alternatives in terms of financial sustainability.

The key point is the CRF is not only an invaluable ecological and cultural asset to the Colville Tribe, it is also a valuable financial asset. As such, financial metrics as well as ecological metrics need to be developed, assessed, and monitored to sustain – and if possible, improve – the entire range of goods and services derived from the CRF for the community.

[75] This is not a recommendation for an allowable cut level. It is shown simply to give sense of scale of what would need to change to achieve the current industry financial return standard.

11. New Alternatives

To deal with the CRF's forest-health issues, an alternative definition of sustained yield management must be adopted. Based on the 2015 IRMP and references to the 2000 IRMP, it appears the forest-health issue has been on the Tribe's natural-resource-management "front windshield" for some time. The conundrum in dealing with this issue includes the following:

- It is generally agreed that the forest is overstocked and too old (beyond biological maturity rotation age).
- These conditions have contributed, and continue to contribute, to an expanding and increasing forest-health problem on the CRF, resulting in trees more inclined to die.
- Increased mortality, in combination with overstocked conditions and so increased fuel loads, increases the threat of catastrophic, stand-replacing, and uncharacteristic wildfire once ignited.
- However, forest management has been inclined toward maintaining net growth in excess of harvest, which increases inventory over time, thus contributing further to the already overstocked forest conditions.

This situation will continue to spiral out of control until a more holistic perspective of sustained yield management replaces the notions of ever-increasing inventory, non-declining even-flow timber harvest, and net growth in excess of harvest. A fresh approach is required, in which new alternatives are developed that include the possibility of adjusting harvest levels up and down over time, coupled with forest-condition metrics that measure progress toward attaining a desired set of future conditions. We suggest including the following characteristics as part of a collection of new alternatives:

- Seek to maximize the net present value of forest cash flows at 3% discount rate (equal to the gross biological growth rate of the current forest). It appears the current alternatives are focused on biological yield only. Including an economic component will help focus attention on the CRF as an important tribal financial asset in addition to an ecological and cultural asset.
- Minimum floors on required forest conditions should be set in accordance with DFCs. These may be varied between alternatives to model and assess the different rates of attaining DFCs.
- A minimum harvest flow should be set to ensure (1) minimum level of Tribe funding and (2) minimum level of Reservation harvest to satisfy any future supply contracts. Suggestion would be 50 MMBF per annum but varying that level could result in a variety of alternatives.
- Set limits on harvest levels within project areas corresponding to mitigating the risk of exceeding OGE levels. These limits could be varied between alternatives in comparison to analogous impacts seen from wildfire (which is the worst-case alternative to harvest) – e.g., alternatives where in one case limits are set at 50% OGE of catastrophic wildfire compared to setting it at 75% of catastrophic wildfire.
- Employ a sequential lower bound of 10% on period to period harvests (i.e., the harvest is permitted to drop by up to 10% between any consecutive periods). This prevents dramatic swings in revenue that would adversely impact tribal operations and the workforce needed to manage the forest, yet it still provides increased flexibility over the non-declining even-flow methodology.
- Review yield table stocking levels and ensure they are consistent with the objective of reduced forest stocking to emulate DFC.

- Develop new prescriptions designed to provide necessary DFC structures and stocking levels over time, including allowing commercial thinning in 90- to 130-year-old timber. In addition allow flexibility for rotations as short as 60 years; with a 3% discount rate the rate of growth on managed stands should exceed the discount rate so the only reason to harvest "prematurely" would be to help fill the age class gap.

In closing this section, we offer the following "thought experiment" depicted in Table 11.1 to clarify what a range of possible alternatives might encompass. When talking about establishing harvest levels for a specified period time that purposely reduce forest-wide inventory, there may be concerns the forest's integrity and biological vitality might be compromised. Hopefully this range of scenarios helps to alleviated some of those concerns.

Table 11.1. "Thought experiment" on possible new management alternatives.

2013 CFI	BF/ac/year	% of Strata-based Inventory Estimate		
Gross Growth	260	3.0%	171.7	MMBF per yeaer
Mortality	86	1.0%	56.9	MMBF per yeaer
Net Growth	174	2.0%	114.8	MMBF per yeaer
Harvest on CFI Plots	49	0.6%	32.5	MMBF per yeaer

Annual Cut to Achieve Designated Percent Inventory Reduction within Specified Number of Years

ReduceReservation-wide Inventory by/to		Annual Cut to Reduce Inv by x% within y years			
		30	45	60	75
0%	8,785	77	71	64	55
8%	8,083	101	89	80	69
12%	7,731	117	**103**	93	82
16%	7,380	129	113	101	90

ReduceReservation-wide Inventory by/to		Base NET Annual Growth Rate adjusted below =				2.0%
0%	8,785	1.3%	1.2%	1.1%	0.9%	
8%	8,083	1.5%	1.4%	1.3%	1.1%	
12%	7,731	1.7%	1.6%	1.5%	1.3%	
16%	7,380	1.8%	1.7%	1.6%	1.4%	

To assist in interpreting the table, the following examples are offered regarding the Annual Cut alternative enclosed in the bold box in the table.

- We propose a cut of 103 MMBF/yr over next 45 years. This would reduce inventory by an estimated 12% compared to current levels.
- The calculations assume net annual growth would average 1.6% over the next 45 years. The reduction in growth from the current net growth rate of 2.0% is due to the continuing aging of the forest and the reduction in forest ingrowth as the current 20- to 60-year-old age-class gap approaches biological maturity.

- The average growth factors also consider that, as more timber is harvested (presumably from the older age classes on the forest), the remaining growing stock is younger on average and will grow faster than otherwise would have been the case.
- Under the scenario described in the bold box, the inventory would be reduced from 8,785 board feet per acre to 7,731 board feet per acre. That stocking level is still higher than the lowest level seen on the forest since 1958 (Figure 11.1).
- Note that even under the most-extreme scenario of harvesting 129 MMBF per annum for the next 30 years, and with the net annual growth rate falling from its current level of 2.0% to 1.8%, the inventory per acre is still nearly 7,400 board feet per acre. Further, the forest plan will be re-visited at the mid-point of that period so any necessary adjustments in harvest level can be made.

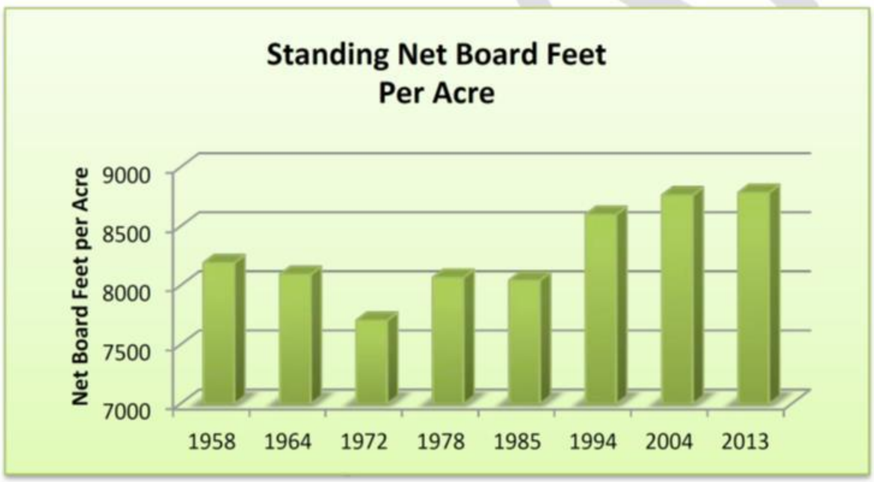

Figure 11.1. Inventory per acre, 1958 to 2013.[76]

- After the 45-year period of harvest at the 103 MMBF level the harvest might drop back to 65 MMBF for the next 30-years as the 20-to-60-year age-class gap reaches biological maturity (average of that age class is 40 years now, placing the average at 115 years old in 75 years) and is regenerated. Coupled with this may be the harvest of some younger-aged stands (perhaps 60 years old) that would boost the acres in the 20- to 60-year-old age-class gap so that it no longer exists.
- Once this 30-year time period is past, the harvest may move back up to something like 110 MMBF per annum as gross growth increases with a younger forest (a 5% improvement in gross growth would increase it to 273 board feet per acre per year) and a healthier forest would reduce mortality (a 10% drop in mortality would decrease it to 77 board feet per acre per year) for an increase in net growth. Combining the two estimates above, the net growth would be 273 – 77 = 196 board feet per acre per year; extended across the 660,418 acres of commercial forest land that translates into net annual growth of 129 MMBF per annum – certainly enough to support a 110 MMBF harvest.

[76] Forest Management Plan Figure 3, p. 18.

Obviously, this is not a full-fledged alternative plan or even strictly consistent with our proposed guidelines, as the periodic changes in harvest include drops of more than 10% between consecutive timber periods; within a modeling context, if a harvest pattern like the one described in this thought experiment were identified as desirable the model would "smooth" period-to-period transitions to correspond to the stipulated consecutive period flow restrictions. However, what is shown and described is intended to illustrate that increasing harvest above 77.1 MMBF, and allowing the harvest and rotation age to fluctuate over time, can begin moving the forest toward a healthier condition without sacrificing its ability to be perpetuated for future generations; an added benefit is that it concurrently provides additional revenue for the Tribe's General Fund.

Appendices

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Appendix A. Definition of Sustained Yield

What follows here is a more in-depth discussion of what sustained yield encompasses. As a starting point, here are some other readily available definitions of sustained yield:

DEFINITION A:

1. The continuing supply of a natural resource, as timber, through scheduled harvests to insure replacement by regrowth or reproduction.
2. The amount of a resource obtained from such a schedule without depleting the resource.[77]

DEFINITION B: Sustained yield use allows people to obtain benefits from forests and other reserves of natural resources without undermining their ecological integrity.[78]

DEFINITION C: production of a biological resource (such as timber or fish) under management procedures which ensure replacement of the part harvested by regrowth or reproduction before another harvest occurs[79]

DEFINITION D: The term sustainable yield refers to the harvest of a specific (self-renewing) natural resource – for example, timber or fish. Such a yield is one that can in principle be maintained indefinitely because it can be supported by the regenerative capacities of the underlying natural system.[80]

As can be seen, while there are similarities between these four definitions and the definition used in the IRMP, there are also some differences:

- Definition A offers two possible definitions with the second, more restrictive definition stating there can be no depletion of stock.
- Definition B is more generalized, simply saying yields are such that ecological integrity is not undermined; nothing about the depletion of existing stocks.
- Definition C could be interpreted to be very restrictive depending on how the "part harvested" being replaced before another harvest occurs is to be understood.
- Definition D's focus is on the yield level, which can be maintained indefinitely, rather than the stock level.
- The IRMP definition (see report Section 3) emphasizes the idea of continuous yield and introduces the concept of the level ("intensity") of management, a concept not explicitly recognized in the other four definitions, and introduces the concept of "transition time" ("earliest practical time") to some goal where increment (growth) and harvest are in balance with one another.

So, what is clear from all of this is that while sustained yield carries with it the concept of being able to perpetuate both harvests and stocks from which they are extracted, there are nuances and variances in the specifics of what constitutes sustained yield. But how should these principles be applied in practice?

[77] http://www.dictionary.com/browse/sustained-yield
[78] http://www.worldatlas.com/articles/sustained-yield-use-in-forestry-and-natural-resource-management.html
[79] https://www.merriam-webster.com/dictionary/sustained%20yield
[80] https://www.britannica.com/topic/sustainability#ref1225911

Davis' practical guidelines regarding sustained yield management (see discussion in Section 3) are consistent with this extended definition of sustainable yield by the Organization for Economic Cooperation and Development (OECD):[81]

> Definition:
>
> The sustainable yield of renewable natural resources is traditionally defined as the extraction level of the resource which does not exceed the growth.
>
> Context:
>
> However, ***this definition is too restrictive in many cases***. For a given stock of a biological resource, many sustainable yields can be defined in principle. Forests have several functions besides logging (such as, habitat protection, recreation and biodiversity) ***and the sustainable yield has to be defined on the basis of a particular objective***. Ideally, the sustainable yield should be determined by forest experts on the basis of modelling, but if no such information is available natural growth can be used as a proxy. With respect to timber, the sustainable yield refers to fellings which are not more than growth of timber during the accounting period (i.e., net growth is positive or zero).
>
> The sustainable yield refers to total fellings and not only to timber removed for own consumption and use. Another way of putting this is to say that if the closing stock is at least as high as the opening stock the yield for the accounting period is sustainable. ***During transitional periods (for example, after afforestation) the sustainable yield will differ from natural growth. The same may apply during transition from a previously virgin forest to a regularly managed forest***. (emphasis added)

The key for developing an AAC under sustained yield management is developing a harvest and regeneration strategy that will provide a continuous, perpetual, but not necessarily invariant, flow of forest products and services over time that satisfies land owner objectives for the forested property. The common features of the IRMP, the Davis, and the OECD definitions are the recognition of the forest first being transformed into a condition where ultimately the more conventional measures of sustained yield can be appropriately employed. Sustained yield cannot be understood apart from existing forest conditions and land owner objectives; managing a forest such that net growth and harvest are in balance or net growth exceeds harvest, or that that inventory is maintained or increases over time does not ensure the forest is being managed under sustained yield. Such commonly applied measures of sustainability are only appropriate **after** a forested property has been managed such that the distribution of tree ages and sizes are consistently distributed to perpetuate the forest as well as the products and services from it. Until the forest has been transformed into that condition the singular focus on net growth and harvest being in balance and inventory being maintained is premature.

[81] https://stats.oecd.org/glossary/detail.asp?ID=6588

Appendix B. Desired Future Condition Tables

Table B.1.

Table 19. Ponderosa Pine Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	1,309 - 6,543	-	-	-	-	-
(<1" dbh)		1.0% - 5.0%	-	-	-	-	-
	DFC	3,926 - 9,160	-	-	-	-	-
		3.0% - 7.0%	-	-	-	-	-
2	HRV	1,309 - 13,086	-	-	-	-	-
(1-5" dbh)		1.0% - 10.0%	-	-	-	-	-
	DFC	7,652 - 17,012	-	-	-	-	-
		6.0% - 13.0%	-	-	-	-	-
3	HRV	1,309 - 13,086	-	-	-	-	-
(5-10" dbh)		1.0% - 10.0%	-	-	-	-	-
	DFC	7,652 - 17,012	-	-	-	-	-
		6.0% - 13.0%	-	-	-	-	-
4	HRV	26,172 - 39,258	6,543 - 19,629	-	-	-	-
(10-20" dbh)		20.0% - 30.0%	5.0% - 15.0%	-	-	-	-
	DFC	26,172 - 39,258	13,086 - 19,629	-	-	-	-
		20.0% - 30.0%	10.0% - 15.0%	-	-	-	-
5	HRV	45,801 - 65,430	6,543 - 13,086	-	-	-	-
(>20" dbh)		35.0% - 50.0%	5.0% - 10.0%	-	-	-	-
	DFC	32,715 - 49,726	3,926 - 10,469	-	-	-	-
		25.0% - 38.0%	3.0% - 8.0%	-	-	-	-

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.

2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total PP PAG acreage of: 130,860

Summation of table percentage numbers

	HRV							DFC						
	E-S	E-M	M-S	M-M	L-S	L-M	Ttl	E-S	E-M	M-S	M-M	L-S	L-M	Ttl
1 HRV	3.0%						3.0%							
1 DFC								5.0%						5.0%
2 HRV	5.5%						5.5%							
2 DFC								9.5%						9.5%
3 HRV	5.5%						5.5%							
3 DFC								9.5%						9.5%
4 HRV	25.0%	10.0%					35.0%							
4 DFC								25.0%	12.5%					37.5%
5 HRV	42.5%	7.5%					50.0%							
5 DFC								31.5%	5.5%					37.0%
	81.5%	17.5%	0.0%	0.0%	0.0%	0.0%	99%	80.5%	18.0%	0.0%	0.0%	0.0%	0.0%	99%

Table B.2.

Table 20. Douglas-fir Warm Dry Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	309 - 1,546	-	-	-	-	-
(<1" dbh)		1.0% - 5.0%	-	-	-	-	-
	DFC	928 - 2,165	-	-	-	-	-
		3.0% - 7.0%	-	-	-	-	-
2	HRV	309 - 3,093	-	-	-	309 - 3,093	-
(1-5" dbh)		1.0% - 10.0%	-	-	-	1.0% - 10.0%	-
	DFC	1,856 - 4,020	-	-	-	309 - 3,093	-
		6.0% - 13.0%	-	-	-	1.0% - 10.0%	-
3	HRV	309 - 3,093	-	-	-	309 - 3,093	-
(5-10" dbh)		1.0% - 10.0%	-	-	-	1.0% - 10.0%	-
	DFC	1,856 - 4,020	-	-	-	309 - 3,093	-
		6.0% - 13.0%	-	-	-	1.0% - 10.0%	-
4	HRV	10,824 - 15,463	309 - 3,093	-	-	309 - 3,093	309 - 3,093
(10-20" dbh)		35.0% - 50.0%	1.0% - 10.0%	-	-	1.0% - 10.0%	1.0% - 10.0%
	DFC	10,824 - 13,917	309 - 1,546	-	-	309 - 1,546	309 - 1,546
		35.0% - 45.0%	1.0% - 5.0%	-	-	1.0% - 5.0%	1.0% - 5.0%
5	HRV	7,732 - 12,370	309 - 3,093	-	-	309 - 3,093	309 - 1,546
(>20" dbh)		25.0% - 40.0%	1.0% - 10.0%	-	-	1.0% - 10.0%	1.0% - 5.0%
	DFC	4,330 - 8,969	309 - 1,237	-	-	309 - 1,237	309 - 1,237
		14.0% - 29.0%	1.0% - 4.0%	-	-	1.0% - 4.0%	1.0% - 4.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.
2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total DFWD PAG acreage o 30,926

Summation of table percentage numbers

HRV						
E-S	E-M	M-S	M-M	L-S	L-M	Ttl
3.0%						3.0%
5.5%				5.5%		11.0%
5.5%				5.5%		11.0%
42.5%	5.5%			5.5%	5.5%	59.0%
32.5%	5.5%			5.5%	3.0%	46.5%
89.0%	11.0%	0.0%	0.0%	22.0%	8.5%	131%

DFC						
E-S	E-M	M-S	M-M	L-S	L-M	Ttl
5.0%						5.0%
9.5%				5.5%		15.0%
9.5%				5.5%		15.0%
40.0%	3.0%			3.0%	3.0%	49.0%
21.5%	2.5%			2.5%	2.5%	29.0%
85.5%	5.5%	0.0%	0.0%	16.5%	5.5%	113%

Table B.3.

Table 21. Douglas-fir Warm Moist Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	2,355 - 11,773	-	-	-	-	-
(<1" dbh)		1.0% - 5.0%	-	-	-	-	-
	DFC	7,064 - 16,483	-	-	-	-	-
		3.0% - 7.0%	-	-	-	-	-
2	HRV	2,355 - 23,547	-	-	-	2,355 - 11,773	-
(1-5" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	14,128 - 30,610	-	-	-	2,355 - 11,773	-
		6.0% - 13.0%	-	-	-	1.0% - 5.0%	-
3	HRV	2,355 - 23,547	-	-	-	2,355 - 11,773	-
(5-10" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	14,128 - 30,610	-	-	-	2,355 - 11,773	-
		6.0% - 13.0%	-	-	-	1.0% - 5.0%	-
4	HRV	23,547 - 58,866	23,547 - 47,093	-	-	2,355 - 23,547	11,773 - 35,320
(10-20" dbh)		10.0% - 25.0%	10.0% - 20.0%	-	-	1.0% - 10.0%	5.0% - 15.0%
	DFC	23,547 - 47,093	11,773 - 35,320	-	-	2,355 - 11,773	11,773 - 23,547
		10.0% - 20.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	5.0% - 10.0%
5	HRV	82,413 - 117,733	11,773 - 35,320	-	-	2,355 - 11,773	11,773 - 35,320
(>20" dbh)		35.0% - 50.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	5.0% - 15.0%
	DFC	37,674 - 61,221	7,064 - 30,610	-	-	2,355 - 9,419	7,064 - 21,192
		16.0% - 26.0%	3.0% - 13.0%	-	-	1.0% - 4.0%	3.0% - 9.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.

2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total DFWM PAG acreage c 235,464

Summation of table percentage numbers

	HRV							DFC						
	E-S	E-M	M-S	M-M	L-S	L-M	Ttl	E-S	E-M	M-S	M-M	L-S	L-M	Ttl
1 HRV	3.0%						3.0%							
1 DFC								5.0%						5.0%
2 HRV	5.5%				3.0%		8.5%							
2 DFC								9.5%				3.0%		12.5%
3 HRV	5.5%				3.0%		8.5%							
3 DFC								9.5%				3.0%		12.5%
4 HRV	17.5%	15.0%			5.5%	10.0%	48.0%							
4 DFC								15.0%	10.0%			3.0%	7.5%	35.5%
5 HRV	42.5%	10.0%			3.0%	10.0%	65.5%							
5 DFC								21.0%	8.0%			2.5%	6.0%	37.5%
Total	74.0%	25.0%	0.0%	0.0%	14.5%	20.0%	134%	60.0%	18.0%	0.0%	0.0%	11.5%	13.5%	103%

Table B.4.

Table 22. Douglas-fir Cool Dry Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	2,355 - 11,773	-	-	-	-	-
(<1" dbh)		1.0% - 5.0%	-	-	-	-	-
	DFC	7,064 - 16,483	-	-	-	-	-
		3.0% - 7.0%	-	-	-	-	-
2	HRV	2,355 - 23,547	-	-	-	2,355 - 11,773	-
(1-5" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	14,128 - 30,610	-	-	-	2,355 - 11,773	-
		6.0% - 13.0%	-	-	-	1.0% - 5.0%	-
3	HRV	2,355 - 23,547	-	-	-	2,355 - 11,773	-
(5-10" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	14,128 - 30,610	-	-	-	2,355 - 11,773	-
		6.0% - 13.0%	-	-	-	1.0% - 5.0%	-
4	HRV	23,547 - 58,866	23,547 - 47,093	-	-	2,355 - 23,547	11,773 - 35,320
(10-20" dbh)		10.0% - 25.0%	10.0% - 20.0%	-	-	1.0% - 10.0%	5.0% - 15.0%
	DFC	23,547 - 47,093	11,773 - 35,320	-	-	2,355 - 11,773	11,773 - 23,547
		10.0% - 20.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	5.0% - 10.0%
5	HRV	82,413 - 117,733	11,773 - 35,320	-	-	2,355 - 11,773	11,773 - 35,320
(>20" dbh)		35.0% - 50.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	5.0% - 15.0%
	DFC	37,674 - 61,221	7,064 - 30,610	-	-	2,355 - 9,419	7,064 - 21,192
		16.0% - 26.0%	3.0% - 13.0%	-	-	1.0% - 4.0%	3.0% - 9.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.
2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total DFCD PAG acreage of 235,464

Summation of table percentage numbers

SIZE CLASS	COND.	HRV E-S	HRV E-M	HRV M-S	HRV M-M	HRV L-S	HRV L-M	HRV Ttl	DFC E-S	DFC E-M	DFC M-S	DFC M-M	DFC L-S	DFC L-M	DFC Ttl
1	HRV	3.0%						3.0%							
	DFC								5.0%						5.0%
2	HRV	5.5%				3.0%		8.5%							
	DFC								9.5%				3.0%		12.5%
3	HRV	5.5%				3.0%		8.5%							
	DFC								9.5%				3.0%		12.5%
4	HRV	17.5%	15.0%			5.5%	10.0%	48.0%							
	DFC								15.0%	10.0%			3.0%	7.5%	35.5%
5	HRV	42.5%	10.0%			3.0%	10.0%	65.5%							
	DFC								21.0%	8.0%			2.5%	6.0%	37.5%
		74.0%	25.0%	0.0%	0.0%	14.5%	20.0%	134%	60.0%	18.0%	0.0%	0.0%	11.5%	13.5%	103%

Table B.5.

Table 23. Douglas-fir Cool Moist Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	2,508 - 25,075	-	-	-	-	-
(<1" dbh)		1.0% - 10.0%	-	-	-	-	-
	DFC	15,045 - 27,583	-	-	-	-	-
		6.0% - 11.0%	-	-	-	-	-
2	HRV	2,508 - 25,075	-	-	-	2,508 - 12,538	-
(1-5" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	15,045 - 27,583	-	-	-	2,508 - 12,538	-
		6.0% - 11.0%	-	-	-	1.0% - 5.0%	-
3	HRV	2,508 - 25,075	-	-	-	2,508 - 12,538	-
(5-10" dbh)		1.0% - 10.0%	-	-	-	1.0% - 5.0%	-
	DFC	15,045 - 27,583	-	-	-	2,508 - 12,538	-
		6.0% - 11.0%	-	-	-	1.0% - 5.0%	-
4	HRV	62,688 - 100,301	25,075 - 50,150	-	-	2,508 - 25,075	12,538 - 25,075
(10-20" dbh)		25.0% - 40.0%	10.0% - 20.0%	-	-	1.0% - 10.0%	5.0% - 10.0%
	DFC	50,150 - 75,226	12,538 - 37,613	-	-	2,508 - 12,538	2,508 - 12,538
		20.0% - 30.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	1.0% - 5.0%
5	HRV	62,688 - 100,301	12,538 - 37,613	-	-	2,508 - 12,538	2,508 - 12,538
(>20" dbh)		25.0% - 40.0%	5.0% - 15.0%	-	-	1.0% - 5.0%	1.0% - 5.0%
	DFC	27,583 - 57,673	2,508 - 22,568	-	-	2,508 - 10,030	2,508 - 10,030
		11.0% - 23.0%	1.0% - 9.0%	-	-	1.0% - 4.0%	1.0% - 4.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.
2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total DFCM PAG acreage o 250,753

Summation of table percentage numbers

	HRV							DFC						
	E-S	E-M	M-S	M-M	L-S	L-M	Ttl	E-S	E-M	M-S	M-M	L-S	L-M	Ttl
1 HRV	5.5%						5.5%							
1 DFC								8.5%						8.5%
2 HRV	5.5%				3.0%		8.5%							
2 DFC								8.5%				3.0%		11.5%
3 HRV	5.5%				3.0%		8.5%							
3 DFC								8.5%				3.0%		11.5%
4 HRV	32.5%	15.0%			5.5%	7.5%	60.5%							
4 DFC								25.0%	10.0%			3.0%	3.0%	41.0%
5 HRV	32.5%	10.0%			3.0%	3.0%	48.5%							
5 DFC								17.0%	5.0%			2.5%	2.5%	27.0%
Total	81.5%	25.0%	0.0%	0.0%	14.5%	10.5%	132%	67.5%	15.0%	0.0%	0.0%	11.5%	5.5%	100%

Table B.6.

Table 24. Grand Fir Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2]					
		E-S	E-M	M-S	M-M	L-S	L-M
		Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040	Yr 2040
1	HRV	582 - 2,912	-	-	-	-	-
(<1" dbh)		1.0% - 5.0%	-	-	-	-	-
	DFC	1,747 - 6,406	-	-	-	-	-
		3.0% - 11.0%	-	-	-	-	-
2	HRV	582 - 2,912	-	582 - 5,824	-	582 - 2,912	-
(1-5" dbh)		1.0% - 5.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
	DFC	1,747 - 6,406	-	582 - 5,824	-	582 - 2,912	-
		3.0% - 11.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
3	HRV	582 - 2,912	-	582 - 5,824	-	582 - 2,912	-
(5-10" dbh)		1.0% - 5.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
	DFC	1,747 - 6,406	-	582 - 5,824	-	582 - 2,912	-
		3.0% - 11.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
4	HRV	5,824 - 11,648	2,912 - 8,736	8,736 - 17,471	5,824 - 11,648	582 - 2,912	582 - 2,912
(10-20" dbh)		10.0% - 20.0%	5.0% - 15.0%	15.0% - 30.0%	10.0% - 20.0%	1.0% - 5.0%	1.0% - 5.0%
	DFC	5,824 - 11,648	2,912 - 5,824	4,659 - 8,736	2,912 - 4,659	582 - 2,912	582 - 2,912
		10.0% - 20.0%	5.0% - 10.0%	8.0% - 15.0%	5.0% - 8.0%	1.0% - 5.0%	1.0% - 5.0%
5	HRV	5,824 - 11,648	582 - 5,824	5,824 - 11,648	2,912 - 8,736	582 - 2,912	582 - 2,912
(>20" dbh)		10.0% - 20.0%	1.0% - 10.0%	10.0% - 20.0%	5.0% - 15.0%	1.0% - 5.0%	1.0% - 5.0%
	DFC	3,494 - 5,824	582 - 2,912	3,494 - 5,824	2,330 - 2,912	582 - 1,747	582 - 1,747
		6.0% - 10.0%	1.0% - 5.0%	6.0% - 10.0%	4.0% - 5.0%	1.0% - 3.0%	1.0% - 3.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.

2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total GF PAG acreage of: 58,240

Summation of table percentage numbers

HRV						
E-S	E-M	M-S	M-M	L-S	L-M	Ttl
3.0%						3.0%
3.0%		5.5%		3.0%		11.5%
3.0%		5.5%		3.0%		11.5%
15.0%	10.0%	22.5%	15.0%	3.0%	3.0%	68.5%
15.0%	5.5%	15.0%	10.0%	3.0%	3.0%	51.5%
39.0%	15.5%	48.5%	25.0%	12.0%	6.0%	146%

DFC						
E-S	E-M	M-S	M-M	L-S	L-M	Ttl
7.0%						7.0%
7.0%		5.5%		3.0%		15.5%
7.0%		5.5%		3.0%		15.5%
15.0%	7.5%	11.5%	6.5%	3.0%	3.0%	46.5%
8.0%	3.0%	8.0%	4.5%	2.0%	2.0%	27.5%
44.0%	10.5%	30.5%	11.0%	11.0%	5.0%	112%

Table B.7.

Table 25. Subalpine Fir Historic Range of Variability, and Desired Future Conditions.

SIZE CLASS	COND.[1]	SERAL/STRUCTURAL STAGE[2] E-S Yr 2040	E-M Yr 2040	M-S Yr 2040	M-M Yr 2040	L-S Yr 2040	L-M Yr 2040
1	HRV	851 - 8,513	-	-	-	-	-
(<1" dbh)		1.0% - 10.0%	-	-	-	-	-
	DFC	5,108 - 9,364	-	-	-	-	-
		6.0% - 11.0%	-	-	-	-	-
2	HRV	4,257 - 8,513	-	851 - 8,513	-	851 - 4,257	-
(1-5" dbh)		5.0% - 10.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
	DFC	5,108 - 9,364	-	851 - 8,513	-	851 - 4,257	-
		6.0% - 11.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
3	HRV	4,257 - 12,770	-	851 - 8,513	-	851 - 4,257	-
(5-10" dbh)		5.0% - 15.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
	DFC	5,108 - 9,364	-	851 - 8,513	-	851 - 4,257	-
		6.0% - 11.0%	-	1.0% - 10.0%	-	1.0% - 5.0%	-
4	HRV	6,810 - 21,283	2,554 - 10,216	10,216 - 23,837	4,257 - 12,770	851 - 8,513	2,554 - 8,513
(10-20" dbh)		8.0% - 25.0%	3.0% - 12.0%	12.0% - 28.0%	5.0% - 15.0%	1.0% - 10.0%	3.0% - 10.0%
	DFC	6,810 - 12,770	2,554 - 6,810	6,810 - 15,324	1,703 - 5,959	851 - 4,257	851 - 4,257
		8.0% - 15.0%	3.0% - 8.0%	8.0% - 18.0%	2.0% - 7.0%	1.0% - 5.0%	1.0% - 5.0%
5	HRV	6,810 - 15,324	1,703 - 10,216	4,257 - 12,770	4,257 - 17,026	851 - 4,257	851 - 8,513
(>20" dbh)		8.0% - 18.0%	2.0% - 12.0%	5.0% - 15.0%	5.0% - 20.0%	1.0% - 5.0%	1.0% - 10.0%
	DFC	1,703 - 7,662	851 - 5,108	1,703 - 10,216	1,703 - 5,108	851 - 3,405	851 - 3,405
		2.0% - 9.0%	1.0% - 6.0%	2.0% - 12.0%	2.0% - 6.0%	1.0% - 4.0%	1.0% - 4.0%

[1] Condition: HRV – Historic Range of Variability; DFC – Desired Future Conditions on Reservation.

2 Structural Stage: E-S: Early Seral/Single Storied; E-M: Early Seral/Multi-Storied;
M-S: Mid-Seral/Single Storied; M-M: Mid-Seral/Multi-storied;
L-S Late Seral/Single Storied; L-M: Late Seral/Multi-Storied.

Acreage values in above table assume total SF PAG acreage of: 85,132

Summation of table percentage numbers

	HRV E-S	E-M	M-S	M-M	L-S	L-M	Ttl	DFC E-S	E-M	M-S	M-M	L-S	L-M	Ttl
1 HRV	5.5%						5.5%							
1 DFC								8.5%						8.5%
2 HRV	7.5%		5.5%		3.0%		16.0%							
2 DFC								8.5%		5.5%		3.0%		17.0%
3 HRV	10.0%		5.5%		3.0%		18.5%							
3 DFC								8.5%		5.5%		3.0%		17.0%
4 HRV	16.5%	7.5%	20.0%	10.0%	5.5%	6.5%	66.0%							
4 DFC								11.5%	5.5%	13.0%	4.5%	3.0%	3.0%	40.5%
5 HRV	13.0%	7.0%	10.0%	12.5%	3.0%	5.5%	51.0%							
5 DFC								5.5%	3.5%	7.0%	4.0%	2.5%	2.5%	25.0%
	52.5%	14.5%	41.0%	22.5%	14.5%	12.0%	157%	42.5%	9.0%	31.0%	8.5%	11.5%	5.5%	108%

Appendix C. Alternative Inventory Estimates

The timber inventory used to develop forest management alternatives considered in the IRMP is based on the CFI. The FIA report, which summarizes the timber inventory, describes the latest measurement used in the analysis as follows:[82]

> Starting in the summer of 2013, 445 CFI plots on the Colville Reservation were measured. This was the 8th measurement for these permanent plots. There were 826 plots measured in 2004 [the last re-measurement], but only 445 were measured this period due to budget constraints…There is funding in place to complete the rest of the 826 plots in the summer of 2015. Instead of waiting to complete a CFI Report with the full dataset, this document is being written to aid the Tribe in revising its Integrated Resource Management Plan, which is due to be complete by the end of 2015. The following report will analyze the data, outline basic forest statistics, calculate an Annual Allowable Cut (AAC), and show some forest trends over time. It will end with a discussion of silvicultural issues and long term harvest planning.

Thus, the inventory on which the current plan is based relies on a data set with roughly half the number of plots as the 2004 data set. Provided the plots re-measured in 2013 proportionally cover the range of forest types and conditions on the forest, the estimate provided should still be statistically accurate – although the standard error around the estimate will likely be greater than desired. The map of plot coverage from the FIA report (Figure C.1) suggests coverage extended across the range for forest conditions, so – at least based on the geographic distribution across the CRF – it is reasonable to expect the inventory estimate is accurate.

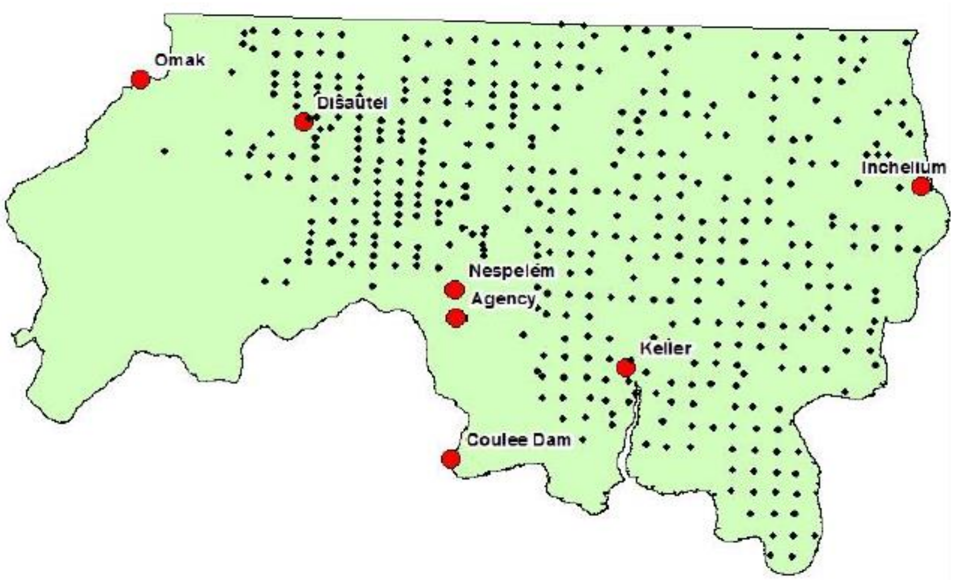


Figure C.1. CFI plot locations measured in the 2013 re-measurement.[83]

[82] FIA report, p. 6.
[83] Adapted from FIA report Figure 2, p. 8.

The reported Reservation-wide inventory is 8,784.8 BF/ac (Figure C.2), or 5,802 MMBF total. This represents a slight increase over 2004's per-acre board-foot inventory:

> Not much has changed in the standing net volume from the last measurement period. Ponderosa pine and Douglas-fir make up the majority of the volume, with Douglas fir having a slightly higher volume…. The standing volume increased from 5.7 to 5.8 billion board feet from 2004 to 2013.[84]
>
> One notable inventory trend is the steady increase in standing net volume per acre…. The standing volume per acre has been steadily increasing since 1985. This is because the harvest level has been less than the growth…. Even with an increase in mortality during the 2004 and 2013 measurements, the total standing volume inventory is slightly higher than 2004, and almost higher than it has ever been.[85]

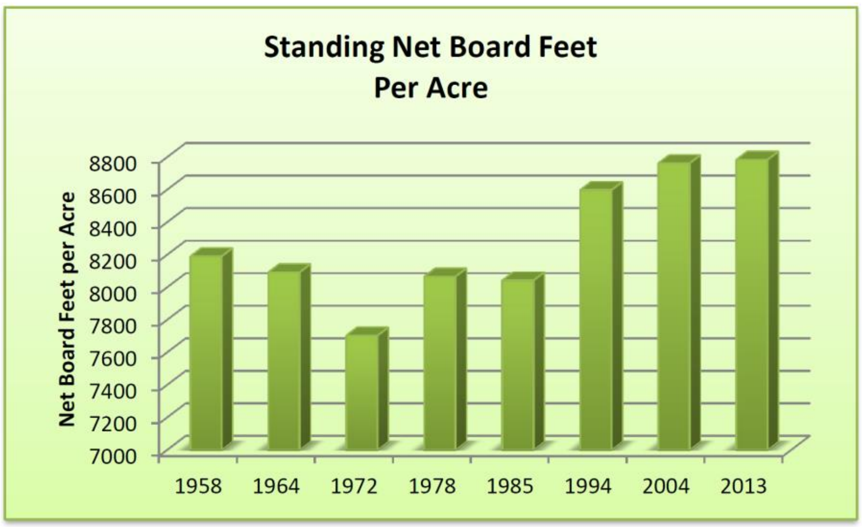


Figure C.2. Board foot volume per acre over time based upon repeated CFI re-measurements.[86]

Despite the likelihood of the inventory being statistically accurate (more on this below), there is something of a mystery that needs to be solved. In addition to the total inventory the 2013 inventory also recorded and reported inventory components of change between the 2004 and 2013 re-measurements. Gross annual growth, annual mortality, net annual growth, and annual average harvest recorded on re-measured CFI plots between 2004 and 2013 measurements is presented in Table C.1 on both per-acre and total-forest bases. This information is another set of clues central to the mystery that needs to be solved.

[84] FIA report, p. 11.
[85] FIA report, p. 13.
[86] FIA report Table 7, p. 13; also Forest Management Plan, p. 18.

Table C.1. Growth, mortality and harvest for the 2013 CFI data.[87]

	Bd Ft/Per Acre/year	Total Million Board Feet/year
Gross Growth	260	171.7
Mortality	86.2	56.9
Net Growth	**173.8**	***114.8***
Harvest Volume	49.15	32.5

The FIA report provides the following commentary regarding these results:[88]

> Gross growth… has steadily climbed over the last 3 measurement periods. There was a decrease in net growth during the 1994-2004 period, but the net and gross growth increased substantially in the 2013 measurement. This could be a data issue related to the large decrease in the number of plots measured in 2013. The decrease in harvest levels for several years may also play a part. Note that the harvest level has been well below growth.

The text is referring to both Table C.1 as well as Figure C.3 (which was also included in the introduction to this report). Based on the excerpted text from the FIA report and the Figure C.3, gross growth increased between the 2004 and 2013 re-measurements, mortality remained about the same, net growth increased, and harvest decreased. In the report introduction we pointed out that on trend this chart (Figure C.3) suggests mortality has tended to increase as harvest has declined. Some of the mortality increase is due to increases in stocking and stand age, some due to increased wildfire mortality, and some likely due to lower percentages of mortality being salvaged as the harvest declines so dead trees on the CFI plots are recorded as dead due to mortality rather than recorded as being harvested.[89]

[87] FIA report Table 2, p. 9.
[88] FIA report, p. 9.
[89] On a CFI plot, a harvested tree is noted because a stump remains where a tree had been when last measured. There is typically no way of knowing if the harvested stump was from a dead tree that was salvaged or a live tree. In that way harvest derived from CFI plots can mask mortality. In extreme cases that effect can also inflate the estimate of net growth by underestimating mortality, ascribing it instead to harvest. This is less likely to occur under even-aged management regimes, however.

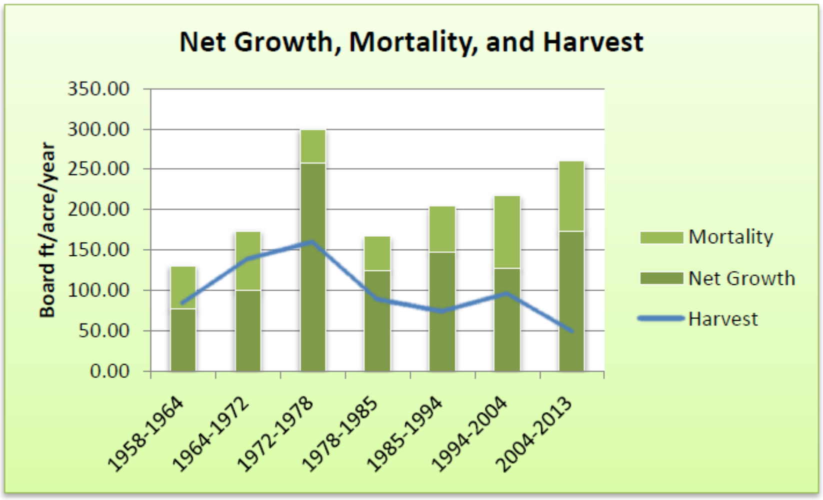


Figure C.3. Net growth, mortality, and harvest trends over time.[90]

The FIA report commentary mentions reduced harvest being a possible contributing factor to then-increased growth (both gross and net) observed during this re-measurement cycle (2004 to 2013) compared to the prior re-measurement cycle (1994 to 2004). This is certainly possible since lower harvest levels will leave more trees per acre to grow and, as long as they do not die (due to overcrowding and inter-tree competition), contribute to increased gross and net growth. However, the FIA report also identifies the significantly lower number of plots between the 2013 inventory and the 2004 inventory could also contribute to the changes in gross growth and mortality estimates. In particular, we would expect the reduction in sample plots would have an inordinately large effect on the mortality estimate as mortality tends to have greater variability in a forest population than live volume – or in the case of estimating growth, the change in live volume. Completing the rest of the inventory should refine both the mortality estimate as well as its standard error.

But the main point to be highlighted here are the estimates of net growth and CFI harvest volume. Based on Table C.1, the net growth (i.e., mortality already deducted) less harvest is 124.6 BF/ac. This represents the average rate at which the inventory changed between 2004 and 2013 re-measurements; because it is positive, the 2013 standing board feet per acre is (not surprisingly) more than the 2004 board feet per acre. However, the 124.6 BF/ac of change is a recorded difference that occurred **per year** from the last measurement to this one. Thus to calculate the full change that occurred between measurements based on these observations, the 124.6 has to be multiplied by 9 years (net growth and harvest in the years 2005-2012, inclusive, plus one-half year net growth and harvest in both 2004 and 2013). That represents a change of an additional 1,121.4 BF/ac between the two inventories.

The standing board feet per acre in Figure C.2 does not depict a difference that large between 2004 and 2013; hence the mystery to be solved. Based on the text in the FIA report and the chart, we know the 2004 inventory was slightly less than the 2013 inventory; the total 2004 inventory is described as being 5.7 billion board feet while the 2013 standing inventory is 5.8 billion board feet.[91] Dividing the 2004

[90] FIA report Figure 3, p. 10.
[91] FIA report, p. 11.

inventory of 5.7 billion board feet by the 660,418 commercial forest acres produces an estimated average of 8,630.9 BF/ac. Adding the computed change of net growth and CFI harvest to this estimate of 2004's inventory provides another estimate of the 2013 inventory: 9,752.3 BF/ac.

Stated another way (Table C.2 may be a helpful reference for what follows in this paragraph), for the 2013 inventory to be 8,784.8 BF/ac and the 2004 inventory to be 8,630.9 BF/ac, the net annual change can be only 17.1 BF/ac/yr,[92] not 124.6 BF/ac/yr. With the CFI harvest at 32.5 MMBF per annum, which seems plausible in light of the economic downturn that occurred during this time period, the annual CFI harvest estimate of 49.2 BF/ac/yr seems reasonable. That means gross growth must be much lower and/or mortality must be much higher than is otherwise reported to result in a net change calculation of 17.1 BF/ac/yr. Specifically, net growth would have to be 66.3 BF/ac/yr instead of 173.8 BF/ac/yr to result in a net change calculation of 17.1 BF/ac/yr with CFI harvest of 49.2 BF/ac/yr.

Table C.2. Discrepancies amongst 2013 CFI measurements.

	Reported Data	If Reported 2004 Inventory & "Change" Are Correct	If Reported 2004 & 2013 Inventories are Correct
	BF/ACRE	BF/ACRE	BF/ACRE
2004 Inventory*	8,630.9	8,630.9	8,630.9
	BF/ACRE/YR	BF/ACRE/YR	BF/ACRE/YR
Gross growth	260.0	260.0	
Mortality	86.2	86.2	
Net Growth	173.8	173.8	66.3
CFI Harvest	49.2	49.2	49.2
Net Change	124.7	124.7	17.1
	YEARS	YEARS	YEARS
Years between Measurments**	9	9	9
	BF/ACRE	BF/ACRE	BF/ACRE
Net Change			
between per ACRE	153.9		153.9
as measured on CFI	1,121.9	1,121.9	
2013 Inventory	8,784.8	9,752.7	8,784.8
* 5.7 billion board feet divided by 660,418 commercial forest acres			
**full year growth in 2005 to 2012, inclusive, and 1/2 year growth in 2004 and 2013.			

[92] The difference between the 2013 and 2004 inventories is 153.9 BF/ac (8,784.8 – 8,630.9). 153.9 divided by 9 years of growth, mortality, and harvest = 17.1 BF/ac/yr in net growth and CFI harvest change between the 2004 and 2013 reported per-acre inventories.

If the two 2004 and 2013 per-acre inventories are correct, this would signal either a significant slowdown in growth rates, a significant acceleration in mortality rates, or a lesser combination of both. In any event, if the 2013 standing inventory estimate is correct and so the growth estimates are too high and/or the mortality estimates are too low; this is not good news regarding forest conditions in light of the forest health crisis known to exist on the forest. However, a slowdown of that magnitude during the course of the past nine years would be astounding. For an order-of-magnitude estimate, if the changes required were applied evenly to both gross growth and mortality per acre per year, gross growth would have to slow to 206.2 BF/ac/yr (compared to 260) and mortality would increase to 140.0 BF/ac/yr (compared to 86.2), yielding a net annual growth of 66.2 BF/ac/yr.

Before commenting further on this, we want to add another set of clues to the mystery. Note that p. 18 in the FIA report produces yet another 2013 inventory estimate of the forest although it is not readily apparent from the table on that page:

> Plant Association Groups discussed above are used to break the forest into individual strata that can be used to analyze the CFI data and calculate an Annual Allowable Cut. The basic statistics for each strata by volume and basal area are shown in Table 8 [refers to Table in the FIA report text]. Indian Affairs Manual, Part 53, Chapter 8, describes the statistical requirements for Forest Inventory Analysis. Basal area estimates for un-stratified commercial timberland [are] required to be less than or equal to 5%. Commercial timberland strata should be less than or equal to 15% for the primary unit of volume (net board feet per acre for this analysis). The GFRC and PP strata are slightly under the required standard error due to a small number of plots being implemented.

Table C.3 is reproduced from the Table 8 referred to in the text cited above, but includes some additional information – namely, estimates of total inventory by stratum, based on each stratum's per acre estimates and GIS acres. Note the GIS acres by strata add to the reported commercial forest acres.

The FIA text and Table C.2 are describing the technical details of the forest inventory sample used to estimate the forest inventory. From the text, BIA policy is to achieve sampling intensity such that the BA per acre on the forest has a standard error no greater than 5% and the primary unit of volume for each commercial timberland strata should be no greater than 15%. As reported in the text, all but two volume-per-acre strata satisfy the BIA's inventory policy guidelines for sampling intensity. This is what suggests to us the per-acre average, which is what is being sampled in the CFI, is accurate. However, given the limited number of sample plots taken due to budget constraints, the key question is how precise is the estimate on an absolute volume-per-acre basis?

Table C.3. Table of statistical precision of sample estimates by significant metrics and strata.[93]

Derived from Table 8 in the FIA report. Strata used for analysis. Expresses average volume and basal area per acı Percent standard error is shown in parenthesis. Green cells indicate metrics and strata that meet BIA forest management inventory policy. Yellow cells indicate metrics and strata that fail to meet BIA forest management inventory policy.				
Strata	**Average Net Board Feet/acre (% standard error)**	**Basal Area/acre (% standard error)**	**Strata Acres**	**TOTAL NET BF MMBF**
PP	3,056 (20.4%)	30.8 (16.7%)	68,967	210.763
DFCD	7,218.2 (10.8%)	64.2 (7.6%)	81,996	591.864
DFWM & DFWD	8,078.2 (14.6%)	66.1 (10.1%)	170,462	1,377.026
DFCM	10,709.9 (7.3%)	82.9(6.2%)	216,633	2,320.118
GFRC	19,537.6 (16.3%)	109.6 (11.9%)	50,422	985.125
SFC,SFW	11,037 (12.8%)	93.2 (10.5%)	71,938	793.980
Reservation Wide	8,784.8 (5.7%)	71.6 (4.1%)	660,418	5,801.640
95% confidence	9,766.2			
Interval	7,803.4			
				Strata-Inventory Added together
ACREAGE-WEIGHTED STRATA ESTIMATE	9,507.4	74.0	660,418	6,278.875
Volume-weighted Strata Average vs. Reservation-Wide Average				8.2%

According to this table, the Reservation-wide estimate of volume per acre, the standard error is 5.7%, or 500.7 BF/ac. A 95% statistical confidence interval around the per-acre estimate indicates the true inventory could be as low as 7,803.4 BF/ac or as high as 9,766.2 BF/ac. This places the estimate derived by adding reported net change to the 2004 inventory estimate narrowly inside the top end of the 95% confidence interval range.

But there is another element in this table to consider. One of the implications of the reduced number of sample plots means acreage estimates by forest types are less refined than would be the case had all plots been measured. However, this component of the total inventory estimate is refined when per-acre strata estimates are computed using CFI plots and the GIS-based acres, rather than using a less-precise average acres per plot as is implicitly done in the case of the Reservation-wide per-acre estimate. It is interesting that when the stratum-based inventory estimates in Table C.2 are added together,[94] the total is not 5.8 billion board feet but 6.3 billion board feet, or 9,507.4 BF/yr. This estimate falls inside the aforementioned 95% confidence interval range of the Reservation-wide estimate and is closer to the estimate gained when net growth and CFI harvest are applied to the more intensively sampled 2004 inventory.

Table C.4 takes the analysis a step further, comparing the implied strata acres based on a constant-acres-per-CFI-plot expansion factor and the GIS strata acres. As can be seen, relative to GIS strata acres, the Douglas-fir Cool Dry (DFCD) strata was significantly over-sampled (by more than 10%) but its volume-per-acre average was well below the Reservation-wide average. On the other hand, the Douglas-fir Cool Moist (DFCM), the grand fir-red cedar (GFRC), and the sub-alpine fir (SFW and SFC) strata were significantly under-sampled and their per-acre stratum averages were significantly above the Reservation-wide

[93] Developed from FIA report Table 8, p. 18.
[94] The stratum-level estimates are also reported in the FIA report on pp. 45-50.

average. Presumably the implied acreage estimates from the CFI will come into better alignment with the GIS acres when the CFI is completed. It must be emphasized this comments about "over-sampled" and "under-sampled" are with respect to estimated PAG acreage compared to GIS PAG acreage; only the PP and GFRC PAGs were under-sampled with respect to BIA strata policy because their standard errors exceeded 15%.

Table C.4. GIS strata acres vs. implied strata acres.

Strata	Average Net Board Feet/acre (% standard error)	No. of Sample Plots	GIS Strata Acres	Implied Acres*	% Variance from GIS
PP	3,056 (20.4%)	40	68,967	63,655	-7.7%
DFCD	7,218.2 (10.8%)	75	81,996	119,353	45.6%
DFWM & DFWD	8,078.2 (14.6%)	116	170,462	184,599	8.3%
DFCM	10,709.9 (7.3%)	105	216,633	167,094	-22.9%
GFRC	19,537.6 (16.3%)	27	50,422	42,967	-14.8%
SFC,SFW	11,037 (12.8%)	36	71,938	57,289	-20.4%
Non-stocked Acres*	(273)	16	NR	25,462	not defined
Reservation Wide	8,784.8 (5.7%)	415	660,418	660,418	
Constant Acres per Plot (used in Implied Acres)			1,591		
Totals by Strata excluding Non-stocked Acres*		399	660,418	634,956	
Reservation PER ACRE Inventory Estimates based on Strata-estimates and weighted by...					
IMPLIED ACRES	8,785				
GIS ACRES	9,507				
*Non-stocked acres were supplied as a strata to reconcile missing plots from strata total to total plots and implied acres weighted PER ACRE value to Reservation-wide inventory.					

When applying what should be more-accurate acreage weights to the per-acre stratum averages, however, the total inventory estimate is higher than the Reservation-wide estimate: 9,507 BF/ac compared to the 8,785 BF/ac reported. This stratum-based estimate is consistent with the finding that when reported growth, mortality, and harvest are applied to the prior 2004 inventory the total inventory estimate increases relative to what is reported as the Reservation-wide inventory.

The allowable-cut analysis cited in the Forest Management Plan, and employed as the basis for the recommendation to maintain the AAC at 77.1 MMBF, used the per-acre stratum estimates and the strata inventories. Thus, this higher inventory estimate was implicitly included in the AAC calculations. That is why we said earlier the principle impact of this finding is likely related to community perception rather than analytical results. Nevertheless, the questions raised do support completing the CFI and revisiting the analysis of both it and the AAC.

One area of ambiguity with respect to the AAC analysis is the 16 sample plots not included in the strata estimates (see last row of Table C.4, the "non-stocked" strata). We supplied the term "non-stocked" to this collection of missing sample plots but it is unclear what they represent. The negative volume per acre shown in the table is the value needed to force the strata averages weighted by the implied acres to equal the reported Reservation-wide per acre inventory. If the average of those plots is set to zero, rather than the forced negative number, the weighted per-acre average for the Reservation based on the implied strata acres is 8,795 BF/ac, i.e., 10 BF/ac greater than the reported Reservation-wide average. Because the GIS strata acres are used as part of the AAC analysis, and those GIS strata acres total the reported commercial forest base, even if those plots are currently non-stocked it seems they should be factored into the PAG strata estimates. The reason why they are not factored in is unclear and should be resolved when the AAC is revisited after the inventory has been completed.

In summary, based on these alternative estimates derived from change measurements, the Reservation-wide estimate and its associated standard error, an inventory derived from per-acre strata estimates and GIS (this is methodology used by BIA-forestry to calculate the AAC), and the recognition the 2013 inventory only re-measured about half of the CFI plots, we conclude it is reasonable to expect when all CFI plots are re-measured and re-analyzed, the inventory will be nearer to 9,500 BF/ac than the reported 8,784.8 BF/ac. The different estimates of the timber inventory are summarized in Table C.5.

Table C.5. Comparison of Reported and Calculated 2013 Inventory Data and Estimates

	REPORTED			CALCULATED		
	Per Acre	GIS	Forest-wide	Per Acre	GIS	Forest-wide
	BF/ACRE	ACRES	MMBF	BF/ACRE	ACRES	MMBF
2004 Inventory	8,630.9	660,418	5,700.0			
Components of Change	PER YEAR for Components of Change			Between 2004 & 2013 Inventories*		
Annual Gross Growth	260.0	660,418	171.7	2,340.0	660,418	1,545.4
Annual Mortality	86.2	660,418	56.9	775.8	660,418	512.4
Net Annual Growth	173.8	660,418	114.8	1,564.2	660,418	1,033.0
CFI Harvest	49.2	660,418	32.5	442.4	660,418	292.1
Net Change	124.7	660,418	82.3	1,121.9	660,418	740.9
2013 Inventories	8,784.8	660,418	5,801.6			
Lower 95% Confidence**				9,766.2	660,418	6,449.8
Higher 95% Confidence**				7,803.4	660,418	5,153.5
2013 Estimated Inventory based on change applied to 2004 Inventory				9,752.7	660,418	6,440.9
Stata Estimates***						
PP	3,056.0	68,967	210.8			
DFCD	7,218.2	81,996	591.9			
DFWM & DFWD	8,078.2	170,462	1,377.0			
DFCM	10,709.9	216,633	2,320.1			
GFRC	19,537.6	50,422	985.1			
SFC,SFW	11,037.0	71,938	794.0			
TOTAL				9,507.4	660,418	6,278.9

NOTES:
***Full year growth, mortality, and harvest 2005-2012 (8 years) plus 1/2 year growth, mortality, and and harvest in measurement years 2004 and 2013 for total of 9 years.**
****Confidence Interval calculations based on reported standard error of 5.7%**
*****Forest-wide inventory estimates by strata are reported in FIA report, pages 45-50**

Appendix D. Timber Revenues and Market Responsiveness

Table D.1 (DEIS Table 21, p. 206) presents preferred-alternative harvest volumes by plan year. Volumes vary from year to year, influenced by historical management practice; i.e., individual compartments or stands are visited on a somewhat-fixed schedule, with some portion of the standing volume removed during each entry.

Table D.1. DEIS planned harvest schedule.[95]

Table 21: Planned Harvest Schedule 2015 - 2029	
Harvest Year	Volume (MMBF)
2015	73.3
2016	70.6
2017	79.8
2018	69.0
2019	85.1
2020	58.2
2021	69.0
2022	75.4
2023	70.7
2024	82.0
2025	73.4
2026	78.9
2027	89.9
2028	96.6
2029	81.4

To determine whether there might be an advantage to allowing more market-responsive flexibility in the harvest plan, two scenarios were constructed, with conditions described below.

[95] DEIS Table 21, p. 206.

Simulation Methodology – Harvest Volumes

In the base-case scenario, volumes are harvested as per the DEIS planned harvest schedule presented in Table D.1 and “Base_Case” (IRMP) Cut column of Table D.2.

As Table D.2 shows, the difference between the planned harvest and the annual allowable cut (AAC) exhibits a standard deviation of 9.5 MMBF.

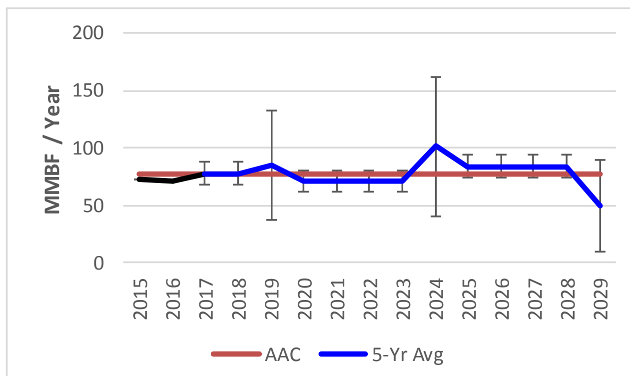
Table D.2. Standard deviation of annual differences between the DEIS planned harvest and the annual allowable cut; also, annual average cuts, by period.

Year	"Base_Case" (IRMP) Cut	AAC	Difference	Periodic Average
	----------------------------	*MMBF*	----------------------------	
2015	73.3	77.1	-3.8	73.3
2016	70.6	77.1	-6.5	70.6
2017	79.8	77.1	2.7	78.0
2018	69.0	77.1	-8.1	78.0
2019	85.1	77.1	8.0	78.0
2020	58.2	77.1	-18.9	71.1
2021	69.0	77.1	-8.1	71.1
2022	75.4	77.1	-1.7	71.1
2023	70.7	77.1	-6.4	71.1
2024	82.0	77.1	4.9	71.1
2025	73.4	77.1	-3.7	84.0
2026	78.9	77.1	1.8	84.0
2027	89.9	77.1	12.8	84.0
2028	96.6	77.1	19.5	84.0
2029	81.4	77.1	4.3	84.0
Standard Deviation			**9.5**	

In the five-year-average cut ("5YA_Cut") scenario, harvest levels in 2015 and 2016 are taken as given (Table D.3), since they are history. However, the 2017-2029 harvest levels are allowed to follow a normal probability distribution in response to stochastic forecast stumpage prices. The average cut for 2017 and 2018 is 78.0 MMBF (average of the DEIS planned harvest during 2017, 2018 and 2019, as shown in Table D.2). To ensure the scenario remains true to the annual allowable cut (AAC) of 77.1 MMBF, the cut every fifth year (i.e., 2019, 2024 and 2029) is constrained to bring the five-year average cut back on top of the periodic cut allowed by the AAC. Per the annual harvest schedule (Table D.2), the 2020-2024 cut averages 71.1 MMBF, and 2025-2029 cut averages 84.0 MMBF; a standard deviation of ± 9.5 MMBF is defined around the mean of each forecast period's non-reconciliation year (Table D.2). Standard deviations during reconciliation years are shown as being wider because they require greater "flex" to accommodate the prior years' deviations from the AAC.

Table D.3. Initial harvest conditions of the stochastic five-year-average ("5YA_Cut") scenario.

Year	5-Yr Avg Cut	AAC	Deviation Annual	Deviation Cumulative
	MMBF			
2015	73.3	77.1	-3.8	-3.8
2016	70.6	77.1	-6.5	-10.3
2017	78.0	77.1	0.9	-9.4
2018	78.0	77.1	0.9	-8.6
2019	85.7	77.1	8.6	0
2020	71.1	77.1	-6.0	-6.0
2021	71.1	77.1	-6.0	-12.1
2022	71.1	77.1	-6.0	-18.1
2023	71.1	77.1	-6.0	-24.2
2024	101.3	77.1	24.2	0
2025	84.0	77.1	6.9	6.9
2026	84.0	77.1	6.9	13.9
2027	84.0	77.1	6.9	20.8
2028	84.0	77.1	6.9	27.8
2029	49.3	77.1	-27.8	0



Simulation Methodology – Stumpage Prices

Using Washington Department of Revenue (WADOR) Stumpage Value Determination Tables[96] for eastern Washington (Stumpage Value Areas 6 and 7 in older reports), price histories of selected species groups were assembled for the period 2000 through 2017 (the black line in Figures D.1 to D.3):

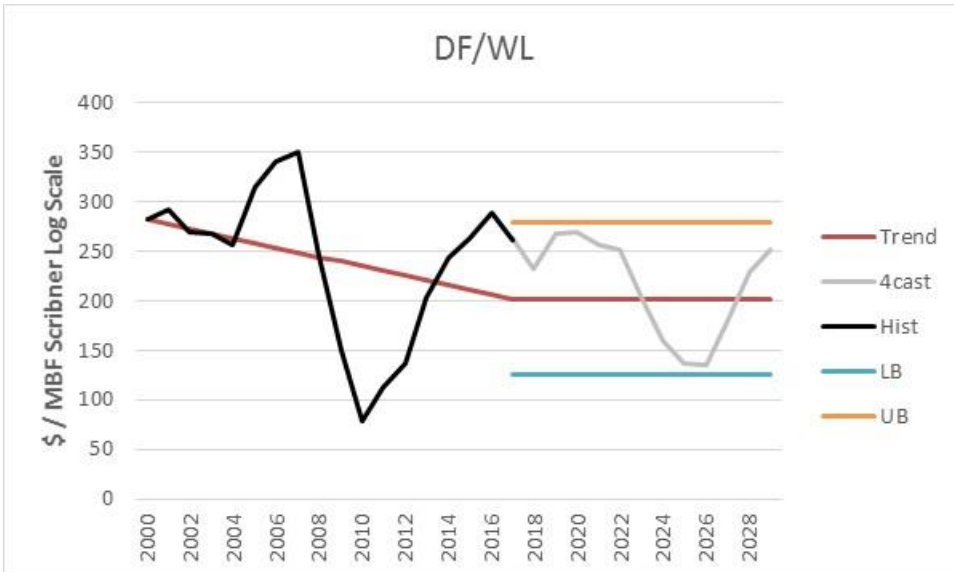


Figure D.1. Stumpage prices for Douglas-fir / western larch (DF/WL).

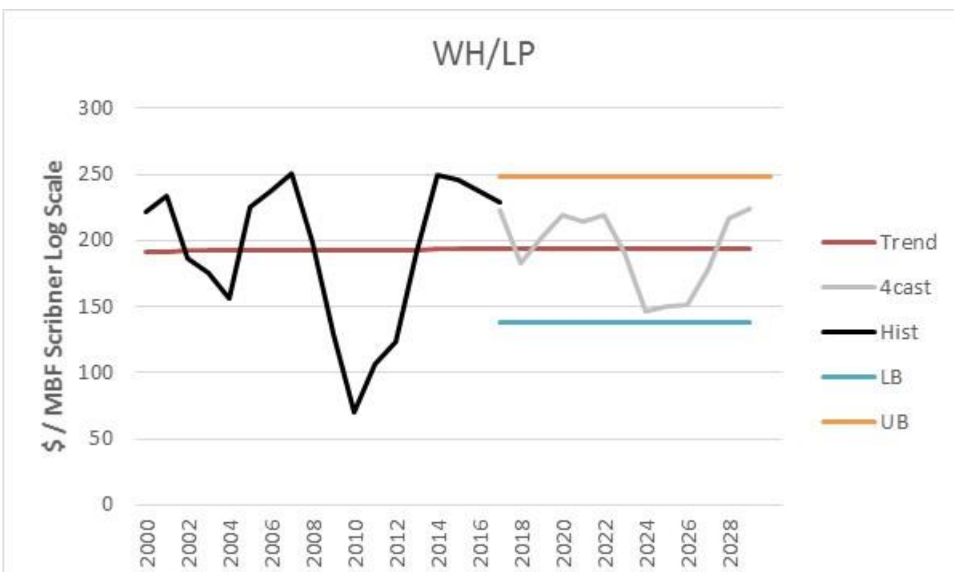


Figure D.2. Stumpage prices for western hemlock / lodgepole pine (WH/LP).

96 http://dor.wa.gov/content/findtaxesandrates/othertaxes/timber/forst_stump.aspx

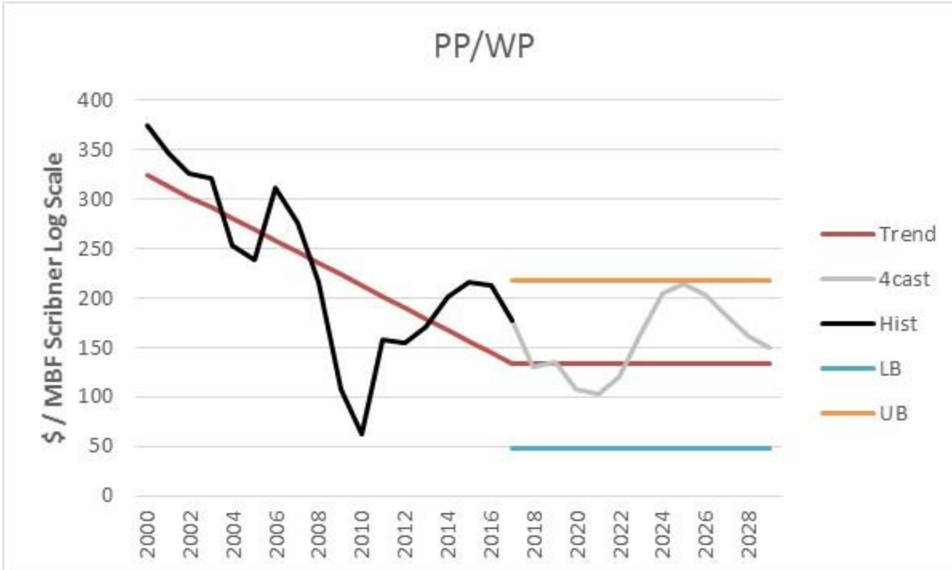


Figure D.3. Stumpage prices for ponderosa pine / western white pine (PP/WP).

As Figures D.1 to D.3 show, stumpage prices have varied considerably over the 2000-2017 historical period, and – except for WH/LP – have failed to regain their pre-Great Recession highs. Hence, prices have trended flat-to-downward since 2000 (the red line in each graph).

Note: Historical prices reported by WADOR may not be indicative of prices received for Reservation timber. The prices do seem reasonably representative, however, based on available tribal information.

Although a plausible forecast of stumpage prices may be formulated by combining autoregressive techniques with business-cycle patterns (the grey line in Figures D.1 to D.3), each such forecast is admittedly only one of nearly infinite possible outcomes. In recognition of future uncertainty, a sensible approach involves allowing prices to vary within a range around the most-recent trend price.

The above-mentioned range is derived by first estimating for each species group the standard deviation among the associated historical prices. Table D.4 presents the standard deviations in each species group's 2000-2017 prices.

For the base-case and "5YA_Cut" scenarios, forecast prices were assumed to be uniformly distributed within the lower and upper bounds specified in Table D.4. I.e., for any forecast year, DF/WL prices, for example, have an equal probability of lying anywhere between $125.52 and $278.98 per MBF. In Figures D.1 to D.3 above, the lower bound is represented by the blue line; the midpoint by the flat portion of the red line; and the upper bound by the orange line.

Table D.4. Standard deviations associated with historical stumpage prices, by WADOR species group; also, forecast price ranges used in the scenarios, by WADOR species group.

		Forecast Prices		
Species Group	Historical Std Dev	Lower Bound	Midpoint	Upper Bound
	---------- $ / MBF ----------			
DF/WL	76.73	125.52	202.25	278.98
WH/LP	54.98	138.42	193.40	248.38
PP/WP	85.10	48.25	133.35	218.45

Simulation Methodology – Combining Harvest and Stumpage Prices

Although the DEIS quantifies the total volume to be cut each year, it does not provide species-level detail. For purposes of this analysis, individual species harvest in the forecast was assumed to be proportional to its reported standing inventory (Table D.5).

Table D.5. Standing inventory by species.[97]

Species	Basal Area per Acre	Net bf vol/ac	Total Net Board Feet
Ponderosa Pine	25.3	3,375.6	2,229,307,001
Douglas fir	33.3	3,535.5	2,334,907,839
Western Larch	5.2	695.1	459,056,552
Other Conifers (spruce, true fir, cedar, lodgepole)	7.7	1,178.6	778,368,655
TOTAL	*71.5*	*8,784.8*	*5,801,640,047*

For each species listed in Table D.5, the proportion of annual harvest, the associated WADOR species-group, and historical correlations among the other species stumpage prices (also based upon WADOR historical data) are presented in Table D.6. Species composition/proportion of harvest is held constant during all years in both scenarios.

[97] FIA report Table 4, p. 11.

Table D.6. Proportion of annual harvest, by species; associated WADOR species group; and historical correlations among species stumpage prices.

	% of	WADOR	Historical Stumpage Price Correlations			
Species	Harvest	Spp Group	PP	DF	WL	OC
Ponderosa pine	38.4	PP/WP	1.000	0.773	0.773	0.593
Douglas-fir	40.2	DF/WL		1.000	0.900	0.887
Western larch	7.9	DF/WL			1.000	0.887
Other Conifer	13.4	WH/LP				1.000

The range of correlation values shown in Table D.6 indicates that prices among the species are moderately to strongly, and positively, correlated; i.e., if the stumpage price of one species rises or falls, prices of the other species generally to nearly always follow suit. Note that – since in the WADOR data, Douglas-fir and western larch are assigned the same price – the correlation between those two species is functionally 1.0; to allow some variability between their prices during the simulations, that correlation was reduced to 0.9 instead.

In keeping with the premise of adjusting harvest levels to market conditions, correlations of +0.5 were defined between harvest levels and stumpage prices. This means harvest levels are higher, on average, during stochastic-cut simulation iterations associated with higher stumpage prices, and lower, on average, during stochastic-cut simulation iterations with lower stumpage prices.

It is important to note that both scenarios were "run" concurrently in Oracle's Crystal Ball[98] simulation add-on to Microsoft's Excel spreadsheet program, and that the stumpage prices of each iteration were identical across scenarios; i.e., if the 2021 ponderosa pine price in iteration/trial 3,000 was $79.35 in the base case, it was also $79.35 in the "5YA_Cut" scenario. This constraint allows for a true "apples-to-apples" evaluation of how the different harvest levels defined in those scenarios influence total revenue.

[98] http://www.oracle.com/us/products/applications/crystalball/overview/index.html

Simulation Results

Table D.7 reports the results of the two scenarios undertaken in this study.

Table D.7. Annual cut and total revenue, by scenario.

	Deterministic Cut	Stochastic 5-Year Average Cut		
	Name: "Base_Case"	Name: "5YA_Cut"		
Year		Min	50 %tile	Max
	Cut (MMBF)			
2015	73.3	73.3	73.3	73.3
2016	70.6	70.6	70.6	70.6
2017	79.8	45.0	78.0	117.2
2018	69.0	44.4	77.9	115.6
2019	85.1	33.7	85.4	139.8
2020	58.2	33.4	71.1	105.6
2021	69.0	59.7	78.0	94.7
2022	75.4	32.3	71.2	117.4
2023	70.7	29.8	70.9	107.2
2024	82.0	30.7	94.5	167.3
2025	73.4	48.7	84.0	117.3
2026	78.9	46.9	83.9	117.4
2027	89.9	58.7	78.0	96.1
2028	96.6	59.8	78.0	95.0
2029	81.4	3.3	61.7	116.3
Total Cut	1,153.3		1,156.5	
Total Revenue (*million $*)				
Min	168.196	171.014		
50 %tile	211.518		214.081	
Max	253.204			255.577

Median ("50 %tile") planning-period total revenue for the base-case is $211.5 million, with a minimum of $168.2 million and a maximum of $253.2 million. The "5YA_Cut" scenario provides further latitude to adjust annual harvest volumes to fluctuations in stumpage prices, while still adhering overall to the annual allowable cut. The 50 %tile total revenue of this scenario is $214.1 million, with a minimum of $171.0 million and maximum of $255.6 million. Those results mean total revenue from the "5YA_Cut" exceeds its base-case counterpart 58.7% of the time (Figure D.4). Put another way, allowing a greater degree of flexibility in the annual harvest volumes based upon consideration of market conditions could – on average – produce an additional $2.6 million in total revenue over the course of the plan period.

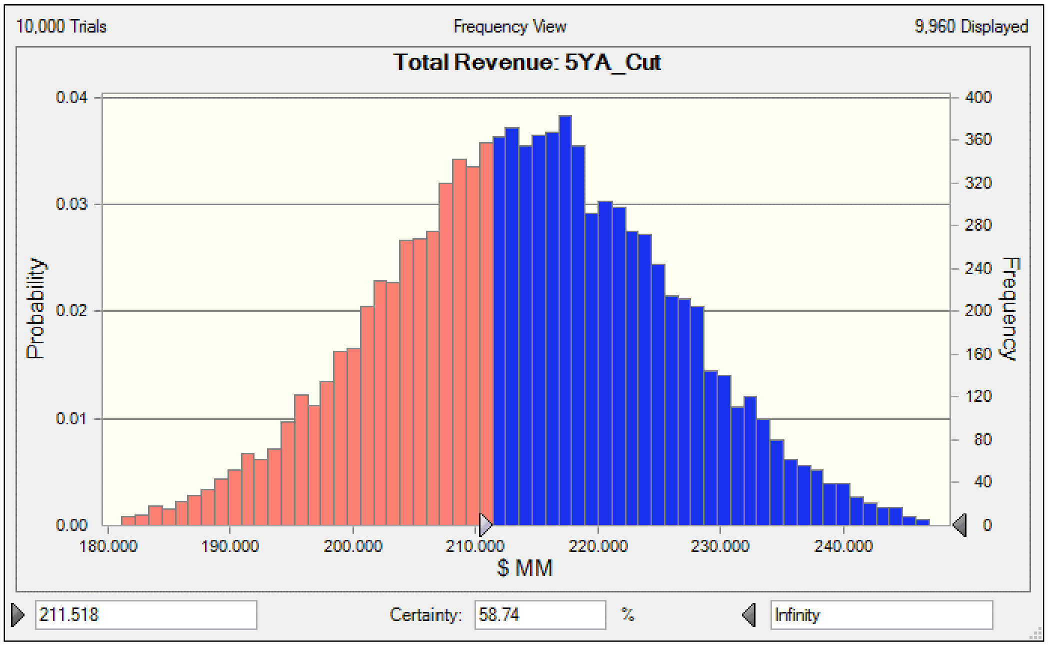


Figure D.4. Probability distribution of "5YA_Cut" scenario total-revenue simulation outcomes, with the likelihood of exceeding the base-case median total revenue.