# Evaluation of Kootenai Forest Stakeholder Coalition Vegetative Guidelines Relative to Harvest Levels in the Kootenai National Forest Plan Preferred Alternative

**Prepared for:**

Kootenai Forest Stakeholder Coalition
Libby, MT

**Prepared by:**

Kendrick Greer

Mason, Bruce & Girard, Inc.
707 SW Washington St., Suite 1300
Portland, Oregon 97205
Project 0101032

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**Since 2004, Mason, Bruce & Girard (MB&G) has been working under contract with** Region 1 of the USDA-Forest Service developing and running *Spectrum* harvest scheduling models in support of their forest plan revision efforts. We've built models for a majority of the National Forests in Region 1, including the Kootenai National Forest (KNF). Consequently, members of the Kootenai Forest Stakeholder Coalition (KFSC) approached MB&G with the following questions for possible evaluation and analysis as part of their collaborative involvement with KNF plan revision:

1. Are Kootenai Forest Stakeholder Coalition vegetative guidelines compatible with the preferred alternative identified in the Kootenai National Forest plan?
2. Assuming there are no budgetary restraints, will KFSC vegetative guidelines allow an annual harvest (ASQ) on the KNF of 70-90 mmbf?
3. Will application of KFSC regeneration sideboards affect KNF ASQ by allowing more acres to be treated annually?
4. Will KFSC old growth designations and wildlife corridors potentially reduce or increase ASQ?

After reviewing the KFSC vegetative guidelines and the KNF plan standards and guidelines (S&Gs), it was determined that MB&G's efforts could be most effectively spent focusing quantitatively on questions 2 and 3 above. Briefly, KFSC guidelines call for treating more acres, but removing less volume per acre treated, compared to KNF plan S&Gs. To measure the potential difference these two approaches would have on annual timber harvest and the number of acres treated, the existing KNF *Spectrum* model was used. KNF plan S&Gs are represented in the model essentially as constraints on the harvest schedule. For informational purposes, a sensitivity analysis was conducted on each of these constraints to measure their effect on ASQ and treated acres. The model was then reformulated to reflect utilization of KFSC vegetative guidelines rather than KNF plan S&Gs. Multiple runs of the reformulated model were then made to measure the sensitivity of ASQ and acres treated to a variety of assumptions relative to forest management objectives and available budget. The short answer to questions 2 and 3 above is "yes" with certain qualifications that will be discussed further.

## *Modeling KNF Plan Standards and Guidelines*

A review of the existing KNF *Spectrum* model for the Preferred Alternative (PA) determined the following list of constraints to be in use. Some, but not all, of these constraints relate to representing Forest Plan S&Gs.

- Allowable Sale Quantity – Harvest levels are constrained to be equal to 47.5 mmbf/year in the KNF PA for the first ten years. This is approximately 95% of the maximum possible timber harvest in that period.
- Budget – Available budget is limited to $6,870,000 per year (includes timber sale costs, reforestation costs, and pre-commercial thinning costs).
- Watershed Openings – 20% of the acres within a watershed can be in openings created by vegetation treatment and stand replacing wildfire in any decade. Openings can remain open for up to 6 decades depending on the type of treatment. A maximum of approximately 154,000 acres can be in watershed openings in any one decade. **Table 1** shows what proportion of a treated acre is considered to be an opening for each of the treatment types modeled in *Spectrum*. Natural disturbance in Table 1 is stand replacing wildfire.

**Table 1. Acres of watershed openings created per acre treated over time by vegetative treatment type.**

| *Decade Following Treatment* | *Even-aged Management* | *Natural Disturbance* | *Uneven-aged Management* | *Commercial Thinning* |
|---|---|---|---|---|
| 0 | 1.00 | 1.00 | 0.20 | 0.20 |
| 1 | 0.75 | 0.75 | 0.10 | 0.10 |
| 2 | 0.55 | 0.55 | 0.05 | 0.00 |
| 3 | 0.40 | 0.40 | 0.00 | |
| 4 | 0.30 | 0.30 | | |
| 5 | 0.20 | 0.20 | | |
| 6+ | 0.00 | 0.00 | | |

- Wildlife Openings – Four wildlife zones are recognized in the KNF PA *Spectrum* model: bear management units and caribou management units; lynx habitat; deer winter range; and other (no bear, caribou, lynx, or winter range requirements). Created wildlife openings in wildlife zones are limited to 8% per decade in BMU/CMU zones; 25% in winter range; and 25% in other. In lynx habitat, a maximum of 15% of the area can receive any type of vegetative treatment in any 10 year period. Also, no pre-commercial thinning is allowed in lynx habitat. Openings created in

wildlife zones remain in an open condition for 3 decades following treatment. **Table 2** shows what proportion of a treated acre is considered to be a wildlife opening for each type of vegetative treatment modeled in *Spectrum*.

**Table 2. Acres of wildlife openings created over time per acre treated by vegetative treatment type.**

| *Decade Following Treatment* | *Even-aged Management* | *Uneven-aged Management* | *Commercial Thinning* |
|---|---|---|---|
| 0 | 1.00 | 0.20 | 0.20 |
| 1 | 1.00 | 0.20 | 0.20 |
| 2 | 1.00 | 0.20 | 0.20 |
| 3+ | 0.00 | 0.00 | 0.00 |

- Operational Limits – Three types of operational limits are included in the KNF PA *Spectrum* model. Commercial thinning is limited to a maximum of 4,000 acres per year during the first 3 decades. Uneven-aged management (selection harvest) is limited to a maximum of 500 acres per year over all decades (there are 25 decades represented in the KNF *Spectrum* model). Prescribed burning is limited to a maximum of 10,000 acres per year in all decades.
- Limited Harvest of Very Large Trees – No harvest is allowed in the Very Large (20"+ dbh) tree size class with the exception of uneven-aged management in the Douglas-fir/ponderosa pine cover type.
- Natural Disturbance – Constraints are used to represent and distribute stand replacing fire events across vegetation cover types and size classes as well as across timber land suitability classes. Natural disturbance averages about 3,500 acres per year.
- Timber Harvest Policy Constraints – The KNF model has harvest flow constraints that require non-declining flow of timber harvest at or below the long-term sustained yield capacity of the Forest as well as ending inventory constraints that require sufficient inventory volume to be retained at the end of the 250 year planning horizon to support harvest at the long-term sustained yield level in perpetuity. These are standard constraints found in virtually all Forest Service *Spectrum* models to ensure harvest is sustainable.

## *Modeling KFSC Vegetative Guidelines*

Modeling the KFSC guidelines calls for retaining more volume on-site following even-aged regeneration harvest than would occur under the KNF plan guidelines. While this results in lower volumes per acre removed from harvested acres it also allows for harvesting more acres because fewer acres of watershed and wildlife openings are created when harvesting in accordance with KFSC guidelines.

Of all of the above listed constraints, the following four were modified or removed in order to model the KFSC guidelines and test their effects on harvest levels and total acres available for vegetative treatment.

- ASQ constraints – relaxation of this constraint (47.5 mmbf/year) is required in order to measure the sensitivity of harvest levels to changes in other constraints and the application of KFSC guidelines.
- Budget constraints – relaxation facilitates increased harvest levels and an increase in the number of acres that can be treated each year. Removing budgetary restraints is an assumption inherent in addressing question 2.
- Operational limits on the amount of uneven-aged harvest – relaxation of this constraint (500 acres/year) allows more acres of vegetation treatment consistent with KFSC guidelines. Members of the coalition felt the limit of 4,000 acres per year on commercial thinning set by the Forest Service was a reasonable limit.
- Opening limits within watersheds and wildlife zones – relaxation permits more acres of vegetative treatments to be carried out consistent with KFSC guidelines. The opening limits themselves (e.g., a maximum of 20% of watersheds in openings per decade) are not relaxed under the KFSC guidelines. Instead, more volume is retained on-site following even-aged harvest, thus reducing the amount of opening created by an acre of treatment under the KFSC guidelines.

KFSC guidelines were further modeled by reformulating the KNF PA *Spectrum* model in the following way:

- Even-aged regeneration harvest volumes per acre contained in *Spectrum* timber yield tables were reduced by 25%.
- Watershed and wildlife openings created by even-aged regeneration harvesting were reduced by 25%. The even-age management coefficients found in Tables 1 and 2 were reduced by 25%. For example, under the KFSC guidelines, an even-aged regeneration harvest would create 0.75 acres of watershed openings for every acre harvested instead of 1.0 acres of openings in the decade of the treatment. In the decade following treatment, instead of 0.75 acres of openings remaining, there would be 0.75 x 0.75 or 0.5625 acres of openings remaining.
- Even-aged reforestation costs per acre were reduced by 25%.

## *Analysis*

In order to derive a solution to a *Spectrum* model, an objective function must specified. An objective function either maximizes or minimizes an output or a condition represented in the model subject to satisfying all of the specified constraints. For example, a solution can be derived that maximizes timber harvest subject to timber harvest policy constraints and budget constraints. In a more complex model formulation, a set of vegetative conditions can be specified as goals, and the model solved by minimizing deviations from these goals. For example, we might specify the goal of having 20% of the vegetation on the landscape to be in each of five different age classes over time.

In the case of the KNF preferred alternative *Spectrum* model, a desired vegetative condition was described in terms of a range of acres to be in each of seven cover types and five size classes. For example, one goal might be to have between 100,000 and 150,000 acres in the Very Large size class over time. The objective function would then seek to minimize deviation from this goal, subject to satisfying whatever constraints might be specified. This type of model formulation is called goal programming.

Sensitivity analyses were conducted for informational purposes to determine the effect of each of the four constraints identified in the previous section (ASQ, budget, operational limits, and opening limits), on attaining KNF forest plan desired future vegetative condition (DFC), allowable sale quantity, and acres treated.

In all, twelve series, or subsets, of sensitivity analyses were carried out to evaluate constraints related to KNF plan S&Gs and KFSC guidelines. Three different objective functions were employed both with and without budget constraints. Please refer to **Table 3** below for a listing of all *Spectrum* runs made by series. The three objective functions employed were:

- Max DFC Attainment – this objective function minimizes deviations from DFC goals, thus maximizing DFC attainment over time. A DFC "score" of zero would mean that all desired future condition goals are being met in each of the 25 decades represented in the *Spectrum* model. The larger the score, the farther the forest landscape is from DFC through time. This was the objective function used in modeling the KNF forest plan preferred alternative.
- Max Timber – maximizes first decade ASQ measured in board feet. Use of this objective function identifies the maximum effect on ASQ of a given constraint.
- Max Timber/Max DFC Rollover – in this case, a solution is derived first by maximizing ASQ in decade 1. That harvest level is then set as a constraint that must be met in the first decade and the model is re-solved maximizing DFC attainment. This approach was used to calculate the DFC score for runs that used the Max Timber objective function. A Max Timber *Spectrum* run does not produce a DFC score, hence the need for the rollover run.

Run 00 in **Table 3** is the KNF preferred alternative and serves as an overall baseline for comparison to all other runs. All of the constraints listed in *Modeling KNF Plan Standards and Guidelines* apply to this run.

Series 1 uses the Max DFC attainment objective function and the PA annual budget constraint of $6,870,000 is in effect. Run 1 relaxes the KNF PA ASQ constraint of 47.5 mmbf/year to establish a baseline for comparing other runs within this series (all of which do not use the ASQ constraint present in Run 00). Run 2 removes the operational limits on acres of uneven-aged management (UE). UE constraints are then re-applied in Run 3 and commercial thinning (CT) limits are removed. The next run (Run 4) removes both the UE limits and the CT limits to estimate their combined effect. For Run 5, watershed opening limits are removed (UE and CT limits are put back in place) and tested. In Run 6, with watershed limits re-applied, wildlife opening limits are remove and tested followed by Run 7 which evaluates the combined effect of removing both the watershed opening limits as well as the wildlife opening limits. The final run in the series (Run 8) removes all of the above constraints to estimate their combined effect.

In Series 2, the same process and sequence of runs is followed but without the budget constraint used in Series 1. As in Series 1, Series 2 uses the Max DFC attainment objective function.

Series 3 and Series 4 repeat the process described for Series 1 and 2, but under a different objective function. Series 3 and 4 use the Max Timber (maximizes first decade ASQ) objective function. Series 5 and 6 are Max Timber/Max DFC rollover runs used to calculate the DFC score of the Max Timber runs in Series 3 and 4.

Series 7, 8, and 9 evaluate the effects of implementing the KFSC vegetative guidelines within the KNF preferred alternative under the three different objective functions as well as both with and without the PA budget constraints. Additionally, runs with and without the UE operational limits are included to test the effect of this particular constraint individually. For example, Run 49 (Series 7) implements the KFSC guidelines with budget and UE limits constrained to the PA level. Run 50 removes the UE limit of 500 acres per year. Run 51 implements the KFSC guidelines without budget constraints and Run 52 implements them without budget or UE limits. Series 8 repeats this process using a Max Timber objective function and Series 9 calculates the DFC scores for Series 8 runs.

**Table 3. Summary of results from *Spectrum* sensitivity analysis.**

| Run ID# | Objective Function | Run Description | ASQ Decade 1 (MMBF/Yr) | Total Acres Treated/Yr Decade 1 | DFC Score | Budget Decade 1 (MM$/Yr) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | Baseline Run for Comparison | | | | |
| 00 | Max DFC Attainment | Fully constrained - Kootenai NF Preferred Alternative (PA) | 47.500 | 5,828 | 24,767,466 | $6.870 |
| | | | | | | |
| | | Series 1: Max DFC Sensitivity Analysis with Budget Constraints | | | | |
| 1 | " | No ASQ constraint | 36.857 | 6,351 | 23,910,682 | $6.870 |
| 2 | " | No ASQ constraint; no unevenaged harvest (UE) operational limits | 36.857 | 6,351 | 23,910,682 | $6.870 |
| 3 | " | No ASQ constraint; no commercial thinning (CT) operational limits | 37.825 | 8,371 | 23,885,478 | $6.870 |
| 4 | | No ASQ constraint; no UE and no CT operational limits | 37.825 | 8,371 | 23,885,478 | $6.870 |
| 5 | " | No ASQ constraint; no watershed opening limits | 36.857 | 6,351 | 23,910,682 | $6.870 |
| 6 | " | No ASQ constraint; no wildlife opening limits | 37.191 | 6,378 | 23,873,848 | $6.870 |
| 7 | " | No ASQ constraint; no watershed or wildlife opening limits | 37.191 | 6,378 | 23,873,848 | $6.870 |
| 8 | " | No ASQ constraint; no UE or CT operational limits; no watershed or wildlife opening limits | 37.845 | 8,408 | 23,846,168 | $6.870 |
| | | | | | | |
| | | Series 2: Max DFC Sensitivity Analysis without Budget Constraints | | | | |
| 9 | Max DFC Attainment | No ASQ constraint; no budget constraint | 80.218 | 9,480 | 19,809,192 | $14.197 |
| 10 | " | No ASQ constraint; no budget constraint; no UE operational limits | 85.500 | 10,637 | 19,619,160 | $15.040 |
| 11 | | No ASQ constraint; no budget constraint; no CT operational limits | 80.622 | 12,053 | 19,709,524 | $14.086 |
| 12 | " | No ASQ constraint; no budget constraint; no UE or CT operational limits | 84.753 | 12,769 | 19,584,614 | $14.800 |
| 13 | | No ASQ constraint; no budget constraint; no watershed opening limits | 94.625 | 9163 | 19,020,158 | $15.879 |
| 14 | | No ASQ constraint; no budget constraint; no wildlife opening limits | 83.644 | 10239 | 19,405,618 | $15.026 |
| 15 | " | No ASQ constraint; no budget constraint; no watershed or wildlife opening limits | 96.124 | 9954 | 18,548,382 | $16.421 |
| 16 | " | No ASQ constraint; no budget constraint; no UE or CT operational limits; no watershed or wildlife opening limits | 95.238 | 11295 | 18,500,422 | $16.191 |
| | | | | | | |
| | | Series 3: Max Timber Sensitivity Analysis with Budget Constraints | | | | |
| 17 | Max Timber Decade 1 | No ASQ constraint | 50.531 | 4,509 | N/A | $6.870 |
| 18 | " | No ASQ constraint; no UE operational limits | 51.433 | 4,596 | N/A | $6.870 |
| 19 | " | No ASQ constraint; no CT operational limits | 50.531 | 3,917 | N/A | $6.870 |
| 20 | " | No ASQ constraint; no UE and no CT operational limits | 51.434 | 4,601 | N/A | $6.870 |
| 21 | " | No ASQ constraint; no watershed opening limits | 50.531 | 6,115 | N/A | $6.870 |
| 22 | " | No ASQ constraint; no wildlife opening limits | 50.562 | 6,115 | N/A | $6.870 |
| 23 | " | No ASQ constraint; no watershed or wildlife opening limits | 50.562 | 4,378 | N/A | $6.870 |
| 24 | " | No ASQ constraint; no UE or CT operational limits; no watershed or wildlife opening limits | 51.469 | 4,447 | N/A | $6.870 |
| | | | | | | |
| | | Series 4: Max Timber Sensitivity Analysis without Budget Constraints | | | | |
| 25 | Max Timber Decade 1 | No ASQ constraint; no budget constraint | 91.649 | 6,132 | N/A | $15.166 |
| 26 | " | No ASQ constraint; no budget constraint; no UE operational limits | 98.703 | 5,798 | N/A | $15.656 |
| 27 | " | No ASQ constraint; no budget constraint; no CT operational limits | 96.072 | 6,371 | N/A | $15.815 |
| 28 | " | No ASQ constraint; no budget constraint; no UE or CT operational limits | 100.768 | 6,081 | N/A | $16.035 |
| 29 | " | No ASQ constraint; no budget constraint; no watershed opening limits | 106.554 | 5,734 | N/A | $17.328 |
| 30 | " | No ASQ constraint; no budget constraint; no wildlife opening limits | 93.108 | 5,857 | N/A | $14.877 |
| 31 | " | No ASQ constraint; no budget constraint; no watershed or wildlife opening limits | 108.598 | 5,470 | N/A | $17.566 |
| 32 | " | No ASQ constraint; no budget constraint; no UE or CT operational limits; no watershed or wildlife opening limits | 109.065 | 5,681 | N/A | $16.983 |
| | | | | | | |

| Run ID# | Objective Function | Run Description | ASQ Decade 1 (MMBF/Yr) | Total Acres Treated/Yr Decade 1 | DFC Score | Budget Decade 1 (MM$/Yr) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | Series 5: Max Timber/Max DFC Rollover Sensitivity Analysis with Budget Constraints | | | | |
| 33 | Max Tim/Max DFC Rollover | ASQ constraint = 50.531 mmbf (from Run 17) | 50.531 | 5,599 | 27,910,516 | $6.870 |
| 34 | " | ASQ constraint = 51.433 mmbf (from Run 18); no unevenaged harvest (UE) operational limits | 51.433 | 4,535 | 32,216,478 | $6.870 |
| 35 | " | ASQ constraint = 50.531 mmbf (from Run 19); no commercial thinning (CT) operational limits | 50.531 | 5,599 | 27,910,516 | $6.870 |
| 36 | " | ASQ constraint = 51.434 mmbf (from Run 20); no UE and no CT operational limits | 51.434 | 4,465 | 31,666,442 | $6.870 |
| 37 | " | ASQ constraint = 50.531 mmbf (from Run 21); no watershed opening limits | 50.531 | 5,599 | 27,910,516 | $6.870 |
| 38 | " | ASQ constraint = 50.562 mmbf (from Run 22); no wildlife opening limits | 50.562 | 6,115 | 27,749,474 | $6.870 |
| 39 | " | ASQ constraint = 50.562 mmbf (from Run 23); no watershed or wildlife opening limits | 50.562 | 6,115 | 27,749,474 | $6.870 |
| 40 | " | ASQ constraint = 50.469 mmbf (from Run 24); no UE or CT operational limits; no watershed or wildlife opening limits | 51.469 | 4,455 | 32,158,342 | $6.870 |
| | | | | | | |
| | | Series 6: Max Timber/Max DFC Rollover Sensitivity Analysis without Budget Constraints | | | | |
| 41 | Max Tim/Max DFC Rollover | ASQ constraint = 91.649 mmbf (from Run 25); no budget constraint | 91.649 | 6,132 | 23,893,346 | $15.967 |
| 42 | " | ASQ constraint = 98.703 mmbf (from Run 26); no budget constraint; no UE operational limits | 98.703 | 5,798 | 22,552,604 | $16.533 |
| 43 | " | ASQ constraint = 96.072 mmbf (from Run 27); no budget constraint; no CT operational limits | 96.072 | 6,374 | 23,306,260 | $16.637 |
| 44 | " | ASQ constraint = 100.768 mmbf (from Run 28); no budget constraint; no UE or CT operational limits | 100.768 | 6,092 | 22,347,588 | $16.887 |
| 45 | " | ASQ constraint = 106.554 mmbf (from Run 29); no budget constraint; no watershed opening limits | 106.554 | 5,771 | 21,533,034 | $17.476 |
| 46 | " | ASQ constraint = 93.108 mmbf (from Run 30); no budget constraint; no wildlife opening limits | 93.108 | 5,857 | 24,317,216 | $15.787 |
| 47 | " | ASQ constraint = 108.598 mmbf (from Run 31); no budget constraint; no watershed or wildlife opening limits | 108.598 | 6,938 | 19,732,670 | $18.168 |
| 48 | " | ASQ constraint = 109.065 mmbf (from Run 32); no budget constraint; no UE or CT operational limits; no watershed or wildlife opening limits | 109.065 | 6,442 | 19,747,100 | $17.931 |
| | | | | | | |
| | | Series 7: Max DFC Analysis of KFSC Guidelines | | | | |
| 49 | Max DFC Attainment | No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 37.239 | 7,270 | 21,722,818 | $6.870 |
| 50 | " | No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 37.239 | 7,270 | 21,722,818 | $6.870 |
| 51 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 75.965 | 10,583 | 18,712,540 | $13.494 |
| 52 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 80.415 | 11,514 | 18,643,208 | $14.178 |
| | | | | | | |
| | | Series 8: Max Timber Analysis of KFSC Guidelines | | | | |
| 53 | Max Timber Decade 1 | No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 50.524 | 6,653 | N/A | $6.870 |
| 54 | " | No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 51.686 | 4,940 | N/A | $6.870 |
| 55 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 87.426 | 7,778 | N/A | $14.590 |
| 56 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 96.423 | 7,725 | N/A | $15.620 |
| | | | | | | |
| | | Series 9: Max Timber/Max DFC Rollover Analysis of KFSC Guidelines | | | | |
| 57 | Max Tim/Max DFC Rollover | ASQ constraint = 50.524 mmbf (from Run 53); budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 50.524 | 5,970 | 26,592,038 | $6.870 |
| 58 | " | ASQ constraint = 51.686 mmbf (from Run 54); budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 51.686 | 4,940 | 31,241,038 | $6.870 |
| 59 | " | ASQ constraint = 87.426 mmbf (from Run 55); no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25% | 87.426 | 7,778 | 21,707,116 | $15.440 |
| 60 | " | ASQ constraint = 96.423 mmbf (from Run 56); no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 96.423 | 7,728 | 21,448,122 | $16.327 |
| | | | | | | |
| | | Series 10: Max DFC Budget Sensitivity Analysis with KFSC Guidelines | | | | |
| 50 | Max DFC Attainment | Baseline Run--No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 37.239 | 7,270 | 21,722,818 | $6.870 |
| 61 | " | No ASQ constraint; PA level +10% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 40.102 | 7,436 | 20,969,200 | $7.557 |
| 62 | " | No ASQ constraint; PA level +20% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 45.613 | 7,464 | 20,357,210 | $8.244 |
| 63 | " | No ASQ constraint; PA level +30% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 50.790 | 7,666 | 19,890,706 | $8.931 |
| 64 | " | No ASQ constraint; PA level +40% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 55.136 | 8,015 | 19,515,090 | $9.618 |
| 65 | " | No ASQ constraint; PA level +50% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 59.699 | 8,423 | 19,215,072 | $10.305 |
| 52 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 80.415 | 11,514 | 18,643,208 | $14.178 |
| | | | | | | |
| | | Series 11: Max Timber Budget Sensitivity Analysis with KFSC Guidelines | | | | |
| 54 | Max Timber Decade 1 | Baseline Run--No ASQ constraint; budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 51.686 | 4,940 | N/A | $6.870 |
| 66 | " | No ASQ constraint; PA level +10% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 56.757 | 5,367 | N/A | $7.557 |
| 67 | " | No ASQ constraint; PA level +20% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 61.811 | 5,779 | N/A | $8.244 |
| 68 | " | No ASQ constraint; PA level +30% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 66.850 | 6,175 | N/A | $8.931 |
| 69 | " | No ASQ constraint; PA level +40% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 71.872 | 6,563 | N/A | $9.618 |
| 70 | " | No ASQ constraint; PA level +50% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 76.639 | 6,745 | N/A | $10.305 |
| 56 | " | No ASQ constraint; no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 96.423 | 7,725 | N/A | $15.620 |
| | | | | | | |
| | | Series 12: Max Timber/Max DFC Rollover Budget Sensitivity Analysis with KFSC Guidelines | | | | |
| 58 | Max Tim/Max DFC Rollover | Baseline Run--ASQ constraint = 51.686 mmbf (from Run 54); budget constrained @ PA level; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 51.686 | 4,940 | 31,241,038 | $6.870 |
| 71 | " | ASQ constraint = 56.757 mmbf (from Run 66); PA level +10% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 56.757 | 5,366 | 30,479,344 | $7.557 |
| 72 | " | ASQ constraint = 61.811 mmbf (from Run 67); PA level +20% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 61.811 | 5,779 | 30,159,682 | $8.244 |
| 73 | " | ASQ constraint = 66.850 mmbf (from Run 68); PA level +30% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 66.850 | 6,180 | 29,119,208 | $8.931 |
| 74 | " | ASQ constraint = 71.872 mmbf (from Run 69); PA level +40% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 71.872 | 6,563 | 28,153,022 | $9.618 |
| 75 | " | ASQ constraint = 76.639 mmbf (from Run 70); PA level +50% budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 76.639 | 6,744 | 27,229,800 | $10.305 |
| 60 | " | ASQ constraint = 96.423 mmbf (from Run 56); no budget constraint; evenaged yields, watershed & wildlife openings, and reforestation costs reduced 25%; no UE operational limits | 96.423 | 7,728 | 21,448,122 | $16.327 |
| | | | | | | |

Lastly, Series 10 through Series 12 are a budgetary sensitivity analysis with the KFSC guidelines in place under the three different objective functions. The purpose of these runs is to demonstrate how ASQ, acres treated, and DFC scores respond to incremental increases in available budget and to identify the budget necessary to produce an ASQ in the range of 70-90 mmbf/year (question 2). A baseline run for each series is shown first for comparison purposes and then the budget constraint of $6,870,000 per year is increased in 10% increments up to a 50% increase in budget. The final run displayed in the series has no budget constraint and is provided for purposes of comparison as well.

## *Some Assumptions and Limitations of this Analysis*

1. The KFSC guidelines don't change the transitional pathways of vegetation over time in response to management compared to KNF forest plan S&Gs.

As stated earlier, the KNF PA employed a Max DFC attainment objective function. Transitional pathways that show how vegetation will change over time as a result of management are a fundamental element of the KNF *Spectrum* model. An assumption of the present analysis is that using the KFSC guidelines instead of KNF forest plan S&Gs doesn't alter these transitional pathways. In other words, an acre of even-aged management under either set of vegetation management guidelines will have the same effect in terms of vegetative change through time even though more vegetation is left on-site after treatment and reduced openings are created under the KFSC guidelines.

2. Implementing the KFSC guidelines doesn't affect any costs other than reforestation costs.

It was assumed that leaving 25% more volume on-site following evenaged harvest under the KFSC guidelines would reduce reforestation costs by 25% since 25% less of the site would require planting. This analysis does not consider whether the KFSC guidelines might result in increased timber sale costs, for example.

3. No alternate approaches to modeling the KFSC guidelines were evaluated.

Our review of the KFSC guidelines suggested that they might represent a 25% reduction in volume harvested per acre, a 25% reduction in created openings per acre treated for watershed and wildlife considerations, and a 25% reduction in reforestation costs following even-aged regeneration harvest. No alternatives to this interpretation were formulated and tested. For example, what would be the difference in outcomes if harvest volumes and created openings were reduced by 20% or 30% instead of 25%?

## *Results and Discussion*

Before looking at any specific runs and outcomes a number of general observations can be made by examining the results found in **Table 3**.

- Series 1 runs demonstrate that when budget is constrained at the PA level ($6,870,000 per year), releasing individual constraints one at a time, releasing them in combination, or even releasing all of the constraints at once (Run 8) has very little effect in terms of increasing ASQ or improving

the DFC score. The PA budget level is the single most limiting factor relative to increasing ASQ or improving DFC attainment. Run 74, using a Max Timber objective function, indicates it would take at least a 40% increase in PA budget level to derive an ASQ minimally within the desired 70 – 90 mmbf range. Under a Max DFC objective function, an even greater increase in budget would be required (see Run 65).

- When budget is not constrained, limits on watershed openings have the greatest individual effect on ASQ levels and DFC attainment (see Run 13 and Run 45).

- The objective function in use influences the magnitude of outcomes. When Series 1 runs (Max DFC) are compared to Series 5 runs (Max Timber/Max DFC rollover), ASQs are about 35% higher when timber harvest is maximized (Series 5) and DFC scores are about 25% better when DFC attainment is maximized (Series 1).

- Within the model, interactions between constraints, treatment choices, and the objective function are complex and do not always seem to yield intuitive results. Total acres harvested in decade 1 is a good example. Treating more acres does not always result in a higher ASQ or a better DFC score. For instance, within Series 6, compare Run 41 to Run 42. Run 41 shows 6,132 acres treated per year in decade 1 resulting in an ASQ of 91.649 mmbf. Run 42 removes the operational limit of 500 acres per year on uneven-aged management. However, the result is that fewer acres are treated in decade 1 (5,798 per year) but they provide a higher ASQ (98.703 mmbf) and a better DFC score. Digging a little deeper into the solution, the mix of treatments beyond the first decade also matters since short-term ASQ is linked to long-term ASQ through the non-declining harvest flow constraints and DFC score is a cumulative measure over all decades. Runs 9 and 11 are another example. The two runs have similar ASQs and DFC scores but Run 11 treats significantly more acres in decade 1 for slightly less budget.

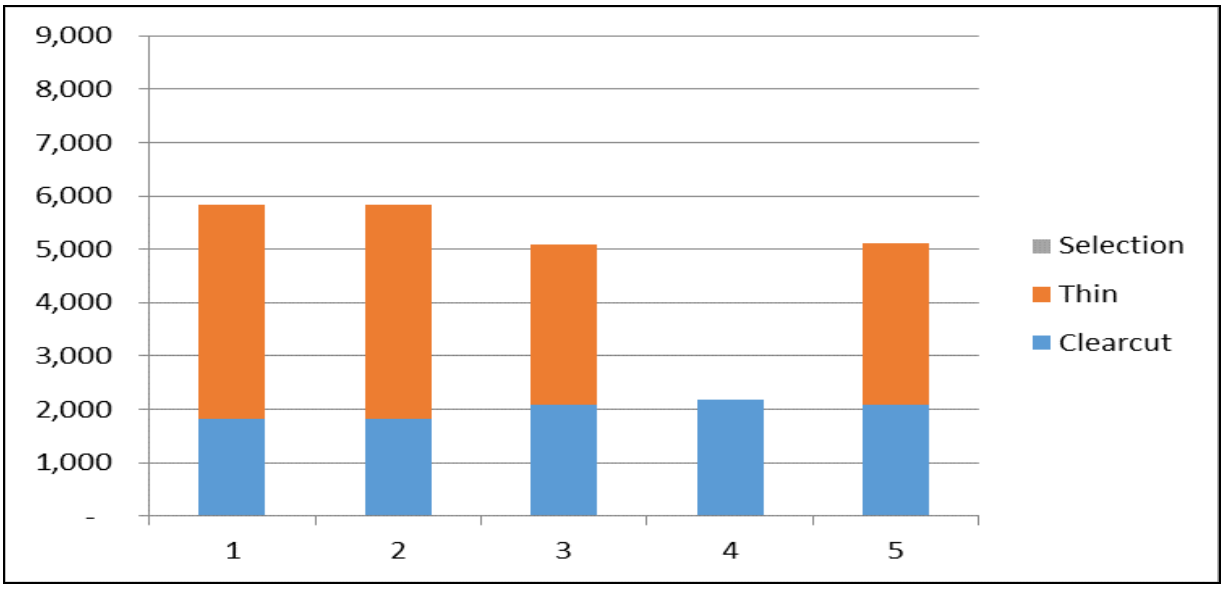
For more detailed solution information for each of the Spectrum runs displayed in **Table 3**, please refer to the Excel workbook *Spectrum_Runs.xlsx*. There, for each run in the sensitivity analysis, acres treated and volume harvested by treatment type (clearcut, commercial thin, and selection) are reported by decade as well as costs by category, and small diameter harvest (3”-7” dbh). The *Read Me* tab in the workbook explains each output contained in the run summary tabs. A chart showing acres harvested by treatment type for the first five decades is also included in each tab.

Several of the individual runs summarized in **Table 3** provide useful information in terms of answering questions 2 and 3 from page one of this document. The first is **Run 00**, the Kootenai N.F. Preferred Alternative. It has an ASQ of 47.5 mmbf; a DFC score of 24,767,466; and treats 5,828 acres per year via timber harvest in the first decade. **Chart 1** below is taken from *Spectrum_Runs.xlsx* and shows the distribution of treated acres per year by treatment type for the first 5 decades of the *Spectrum* solution. Note that clearcut and commercial thinning are the only harvest treatments in the solution. No acres of uneven-aged management (selection) get scheduled in the PA. Selection harvest tends to show up only when there is no budget constraint and/or when Max Timber is the objective function.

**Run 1** is essentially the same as Run 00 except the first decade ASQ constraint requiring 47.5 mmbf is removed. Without that constraint, ASQ falls to 36.857 mmbf in the first decade—a 22% reduction

compared to Run 00. It is important to understand that the Forest Service designed their preferred alternative to harvest significantly above what the ASQ would have otherwise been if maximizing DFC attainment were their only objective.

**Chart 1. Acres treated per year by treatment type for the first 5 decades of the KNF Preferred Alternative (Run 00).**




**Run 9** is the equivalent of the KNF PA without the ASQ constraint and without the budget constraint. It has an ASQ of 80.218 mmbf; a DFC score of 19,809,192; and treats 9,480 acres per year via timber harvest in the first decade. **Chart 2** shows the distribution of treated acres per year by treatment type for the first 5 decades of the *Spectrum* solution. Note that there is some selection harvest, but it is constrained in Run 9 to be within the operational limit of 500 acres per year.

Run 9 serves as a baseline for comparing KNF plan S&Gs to KFSC guidelines. **Run 52** substitutes KFSC guidelines for KNF PA S&Gs **and serves as the best representation of modeling KFSC guidelines in this study**. It has no budget constraint, no ASQ constraint, and it removes the operational limit of 500 acres per year on selection harvest, consistent with KFSC guidelines. Run 52 has an ASQ of 80.415 mmbf; a DFC score of 18,643,208; and treats 11,514 acres per year via timber harvest in the first decade. **Chart 3** shows the distribution of treated acres per year by treatment type for the first 5 decades of the *Spectrum* solution.

Compared to Run 9, Run 52 treats more acres, has a better DFC score, and results in a comparable ASQ that is within the desired range of 70 – 90 mmbf. The budget required in decade 1 for both runs is very nearly the same even though Run 52 treats over 2,000 acres more per year.

**Chart 2. Acres treated per year by treatment type for the first 5 decades for Run 9.**

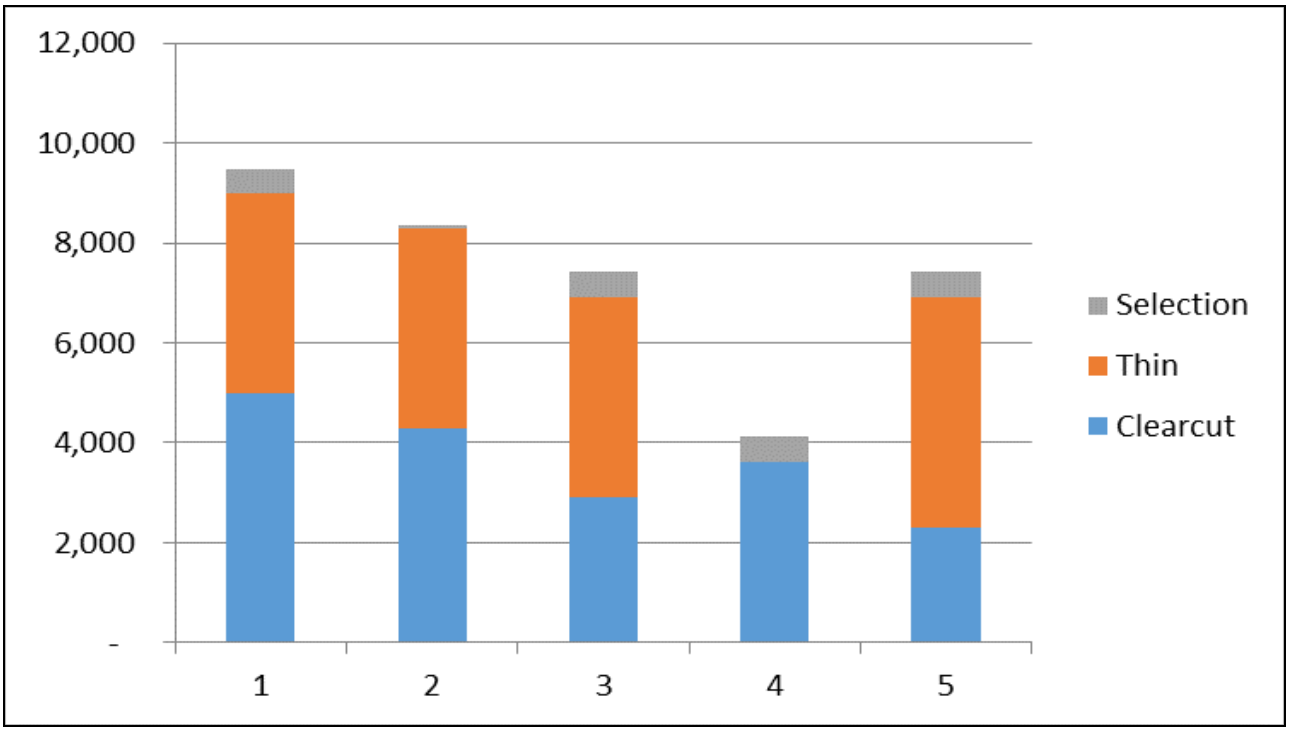
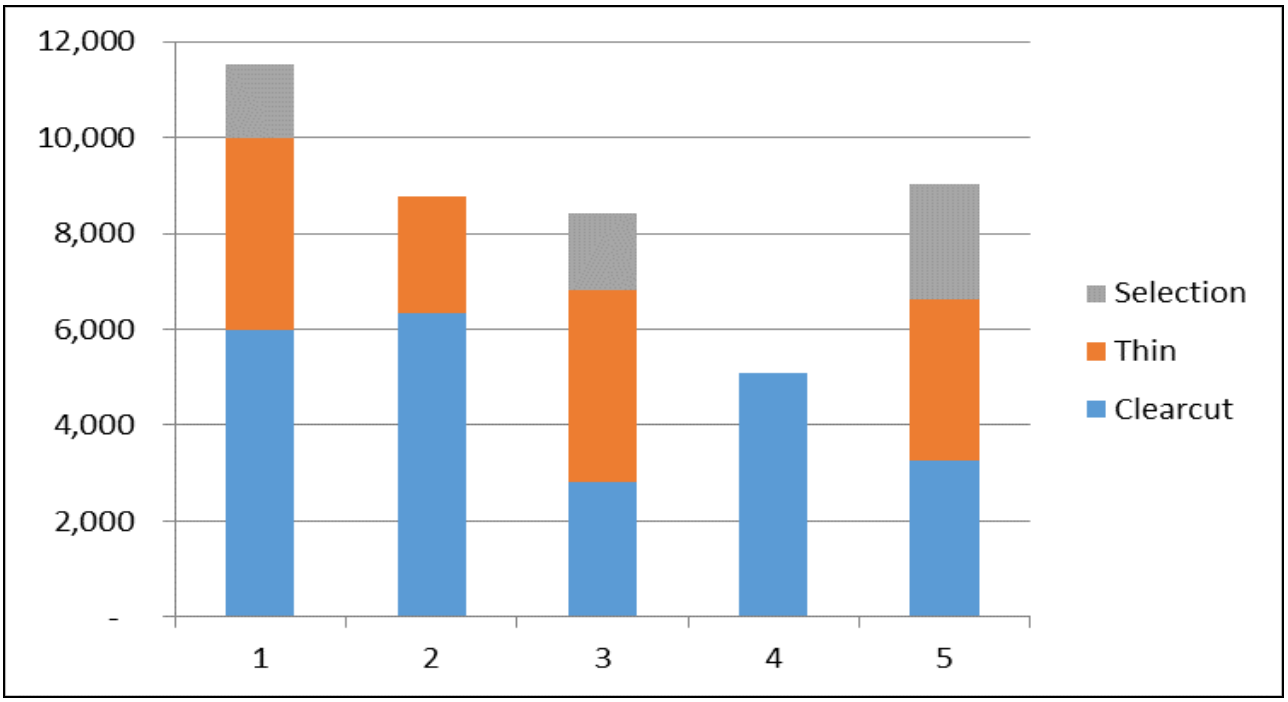



**Chart 3. Acres treated per year by treatment type for the first 5 decades for Run 52.**



To be fair, it could be argued that **Run 10** would be a better baseline for comparison to Run 52. Run 10 relaxes the operational limit on uneven-aged harvest as does Run 52. The counter-argument is that the KFSC guidelines recommend increased use of uneven-aged management. Run 10 has an ASQ of 85.5 mmbf; a DFC score of 19,619,160; and treats 10,637 acres per year via timber harvest in the first decade. Compared to Run 52, Run 10 has a higher ASQ by 5 mmbf; a poorer DFC score; and treats less acres in the first decade.

An interesting final point to note in comparing Run 10 to Run 52. As stated previously, KFSC guidelines essentially remove less volume per acre but harvest more acres. The 5 mmbf lower ASQ observed in Run 52 compared to Run 10 indicates that the reduction in volume per acre harvested is not being offset in total by the increase in acres being treated. However, when relaxation of the operational limit on uneven-aged management is included as a component of modeling KFSC guidelines, then Run 9 becomes the basis for comparison and the picture changes.