Woodstock Technical Bulletin

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# Adding Spatial Resolution to Woodstock

The most recent versions of Stanley and Woodstock incorporate a number of new features and processes that can significantly improve the blocked harvest schedules produced by Stanley. Previously, users would first generate a number of non-spatial strategic harvest schedules with Woodstock. Next, stand level spatial resolution would be included in the analysis by using Stanley to schedule individual stands for harvest that simultaneously satisfy several spatial constraints. This process of running the two models sequentially produced very good results in many forests but the process performed less well when the forest was greatly fragmented and/or heavily cut over. In these latter cases, the spatially feasible harvest flows were much lower than the Woodstock analysis indicated. Because the Woodstock analysis did not recognize the fact that harvests in one area of the forest prevent harvests in adjacent areas, the harvest schedule included stands that were ineligible due to green-up delays. In turn, the scores used by Stanley to rate solutions were artificially low: regardless of the spatial arrangement used, there was no way to harvest all the stands without deviating significantly from the Woodstock harvest schedule or violating spatial constraints.

The situation just described is common if the forest has undergone intense management in the past. Stands adjacent to a recent cutover are not eligible for harvest until the prescribed green-up period has elapsed. When there are many of these “virtual buffers” in the forest, the result is a fragmented landscape that may pose significant difficulties to the Stanley blocking algorithms if they are included in the Woodstock harvest schedule. The scores used by Stanley to rate solutions will include significant penalties for not harvesting in the green-up zones. Obviously, it would be better to have these areas identified as ineligible to harvest before generating a harvest schedule with Woodstock. A new Woodstock schedule that recognizes these areas as ineligible will probably have a lower harvest level than before. Conversely, the spatial harvest schedules coming from Stanley will likely have much higher scores because the algorithms are no longer assessing penalties for not harvesting ineligible areas.

Version 3.0 of Stanley features the ability to locate all stands that are adjacent or proximal to existing cutovers and create Woodstock area files in which these stands are identified as having accessibility restrictions placed on them. Woodstock recognizes that these areas are ineligible for harvesting for a prescribed period and thus creates a strategic schedule that is more suitable for blocking by Stanley. This capability allows forest managers to better represent operating restrictions like green-up delays within the strategic planning process. In so doing, the tactical planning process is facilitated and overall there is less disparity between the spatial and non-spatial harvest schedules.

## An Example

The forest is approximately 45,000 hectares in size and has been intensely managed for pulpwood and sawlogs. Regulations require a 5-period green-up interval before harvesting adjacent areas, such that 4,461 hectares of cutovers are initially ineligible for harvest, and, in many cases, the stands in these areas would have been scheduled for harvest in the first periods of the planning horizon. However, these areas were readily identified using routines in Stanley to create a Woodstock area file that labeled all stands adjacent to recent cutovers as temporarily ineligible for harvest.[1]

To demonstrate the influence of locking out the areas before running a strategic analysis, we set up three scenarios. In the first scenario, a standard Woodstock analysis was performed, without explicitly recognizing any areas adjacent to existing cutovers. In the subsequent scenarios, we tested the effect of increasingly larger restriction zones around existing cutovers. All stands with a boundary within a given distance of an existing cutover were identified as part of a temporary restriction zone; these distances were 100m, 290m and 620m for scenarios 2 through 4, respectively.

We expected that the strategic harvest levels would drop in each subsequent scenario because more of the forest was ineligible for harvest in the early planning periods. Moreover, we expected the scores assigned to the best tactical harvest schedules in scenarios 2 through 4 to better than the score assigned to the best solution in scenario 1. Overall, we expected that the differences between strategic and tactical harvest levels would be smaller by explicitly recognizing restriction zones due to green-up intervals.

The relationship between the proximal distance used to identify stands within the restriction zone and the area within the restriction zone is not linear. An entire polygon is assigned an access lock, even if a single point along the polygon's boundary lies within the proximal distance specified. In general, as the proximal distance increases so does the area locked out but the actual area in the restriction zone will be significantly affected by the spatial arrangement of stands and cutovers. See Table 1.

| Scenario | Proximal Distance used to establish restriction zones | Area within restriction zone |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 100m | 8143 ha |
| 3 | 290m | 11947 ha |
| 4 | 620m | 17743 ha |

Table 1. Restriction zones associated with each scenario.

As expected, larger restriction zones resulted in lower objective function values in the Woodstock harvest schedules due to the reductions in land available for harvesting (see Table 2). However, the more interesting result comes out of scenario 3 where the tactical objective function value appears to be a local maximum.

[1] This procedure was done using the "Build Woodstock Input Files" utility, but you must first identify polygons in cutovers as pre-blocks (see Stanley User's Guide Chapter 8).

| Scenario | Strategic Objective Function Value | Δ% | Tactical Objective Function Value | % of Strategic |
|---|---|---|---|---|
| 1 | 100,000 | - | 63,500 | 63.5% |
| 2 | 98,800 | -1.2% | 78,546 | 79.5% |
| 3 | 97,100 | -2.9% | 82,631 | 85.1% |
| 4 | 85,300 | 14.7% | 74,978 | 87.9% |

Table 2.

In the first scenario, Stanley only blocked out 63.5 % of the strategic objective. Not all of the area scheduled for harvest by Woodstock in the strategic plan could be scheduled by Stanley because it included areas adjacent to pre-existing cutovers. These areas are not eligible for harvesting until the green-up interval has elapsed.

In the second scenario, stands within the minimum 100m distance of a cutover boundary were identified as ineligible for the prescribed green-up interval using the _LOCK feature of Woodstock. The new harvest schedule must delay the harvest of locked areas and consider alternatives that were not previously chosen. This results in a slightly decreased objective function value, but a more spatially relevant strategic schedule.

In the third scenario, stands within 290m of the cutover boundary were included in the restriction zone. You may ask the reasonable question, why would anyone want to tie up stands almost 3 times the minimum distance from a cutover boundary? The answer lies in the substantial improvement in the tactical objective function value relative to the strategic solution. Although the proximal distance used to identify neighboring stands was nearly tripled, the area within the restriction zone increased by less than 50%, resulting in a minor reduction in strategic objective function value. Yet, the tactical objective function value rose by more than 15% compared to scenario 1.

A corridor 100m wide does not lend itself to the creation of large blocks within the buffer because there simply is not sufficient room. Moreover, in a forest like the one used in this analysis, the close proximity of cutovers causes numerous small *islands* of eligible area surrounded by ineligible restriction zones. Taken together, these effects limit the ability of Stanley to create feasible harvest blocks anywhere in the neighborhood of existing cutovers. However by increasing the width of the

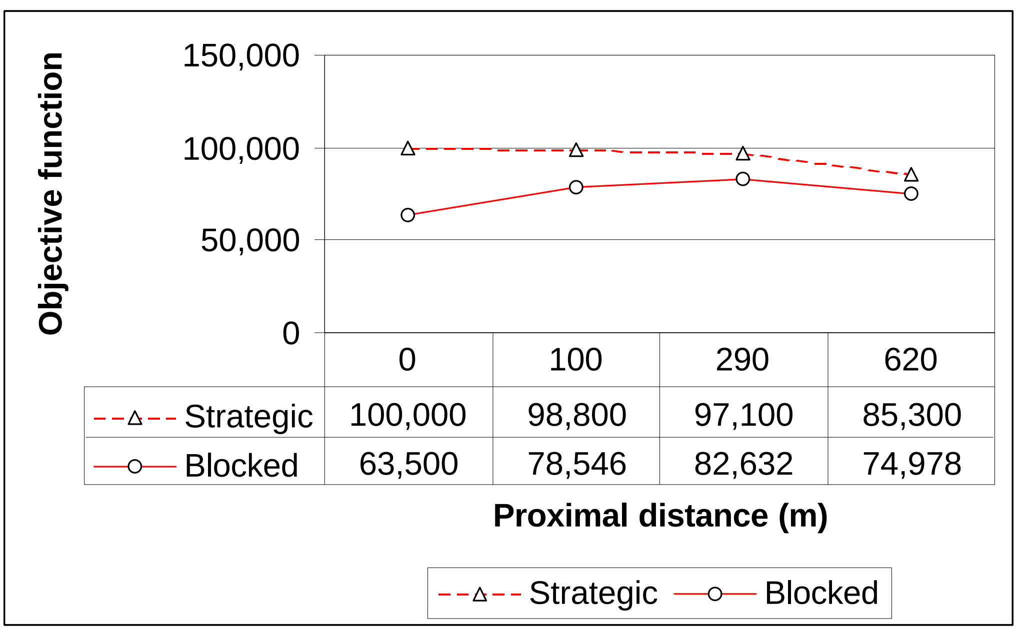


Figure 1. Effect of recognizing restriction zones around existing cutovers.

restriction zones, not only is there more room for blocks within the restriction zones after the green-up interval has elapsed, but more of the islands are eliminated through incorporation within the restriction zone.

The fourth scenario clearly demonstrates the effects of increasing the exclusion zones too far. Although the tactical harvest schedule yielded the highest proportion of the strategic objective function on a percentage basis, both the actual strategic and tactical objective function values were significantly less than scenarios 2 and 3. Using a proximal distance of 620m locked out significant portions of the forest in the first three periods resulting in a large reduction in strategic objective function value. Since the adjacency effects of existing cutovers were largely eliminated, Stanley was able to block a significant portion of the scheduled area, but yielded a lower objective function value than scenario 3.

## Conclusions

Although the specific results of this analysis cannot be expected to hold elsewhere, there are some general conclusions that apply to any forest planning problem where spatial constraints are applied. Unless regulations only apply to future activities, past practices may severely limit where you can and cannot conduct forest management activities.

1. Failure to recognize the green-up intervals for previously existing cutovers can result in significant overestimates of allowable harvest. In many cases, the losses attributed to spatial constraints are overestimated simply because the non-spatial strategic model included areas for harvest that are not eligible. Had these areas been recognized in the first place, the strategic harvest levels would have been lower and the difference between strategic and tactical output levels would not have been so large.
2. The area that should be included in restriction zones around cutover areas is dependent on several factors including the minimum and maximum sizes of harvest blocks, the relative size of stands (polygons) to harvest blocks and the spatial arrangement of stands in the forest. As the analysis here indicated, the minimum buffer distance called for in your operating guidelines may be insufficient to guarantee a good spatial solution from Stanley. Instead, you may need to try a range of values to determine the best buffer distance for your situation.
3. Recognize the fact that the sequential planning process used in Woodstock-Stanley is limited by the inability of Woodstock to schedule all harvest periods with knowledge about where harvest blocks are located. Even if you recognize the existing cutovers in your Woodstock analysis, the harvest schedule for all periods after the initial planning period will include areas that are not eligible for harvest because of adjacency to blocks cut in previous periods. Admittedly, the errors are small initially and can be safely ignored for a few periods, but the magnitude of the errors increases with longer tactical planning horizons. Through periodic re-planning, these negative effects can be mitigated but cannot be completely eliminated. One could perform a series of roll-over analyses[2] with Woodstock and Stanley to account for all the restriction zones over time but the effort is probably not worth the small increase in modeling precision.

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[2] A roll-over analysis involves an initial Woodstock analysis followed by a Stanley blocking procedure. The first period of the Stanley solution is assumed to be implemented and the forest database is updated to reflect the new conditions, including the restriction zones associated with the Stanley harvest blocks. This process is repeated for all subsequent periods until the desired number of planning periods have been successfully blocked out.