Forest Planning
Sustainability and Optimization of Harvest Levels
Forest Projection and Planning System (FPS)

The underlying assumption here is that the objective is to achieve the highest level of sustainable harvest that may be obtained from a given block of forest land. Realization of obtaining this level may be constrained by State regulations regarding riparian buffers, wildlife zones, limitation of some silvicultural methods (even-aged management using clearcutting), size or proximity of harvest units in a given period of time. It may also be constrained by owner-specific goals of standing forest attributes (species and age distributions), or by other goals regarding watershed, wildlife or visual aesthetics.

Sustainability

The term "*Sustainable*" does not have a well specified definition in its forest management or natural resource management usages. Using this term implies and begs for a statement of the "*time frame*" under consideration. However, a time frame is almost never provided in public usage of sustainability for forest practices, regulations or goals.

The time frame must be defined in order to determine "*repeatability*" of growth, harvest, investment, cash flow and/or revenue in subsequent time frames into the future. If these practices are repeatable in future time frames, then these practices are sustainable.

Sustainability may be fully defined, if both the time frame and repeatability in future time frames are considered.

Interestingly, it should be noted that this definition is complete and sufficient for forestry usage. However, it does *not* imply or require a constant level of growth, harvest, investment or revenue within the time frame being considered. Consider the following discussion of alternative and equally sustainable harvest plans.

In this discussion, it is appropriate to introduce the concept of a "planning horizon" for determining sustainability of harvest on a given block of forest land. The Planning Horizon is the "time frame" within which the harvest level is being determined. The Planning Horizon should be sufficiently long enough for the forest land base to cycle through all growth phases (regeneration to harvest) on each and every acre. Inclusion of these growth phases is necessary to define the sustainable capacity of this ownership. In the West, this Planning Horizon should be specified as being at least sixty to one hundred years in length.

Case I

A 100,000-acre block of forest may have a sustainable harvest plan when 2,000 acres are harvested and replanted annually with a cycle of fifty years across the ownership. This practice is sustainable in future and contains no variability from year to year within the planning horizon. This is the common default assumption for the public perception of sustainability, when no time frame or condition of repeatability is stated. Every year is the same as any other year with regard to the level of activity on the forest ownership.

Case II

A 100,000-acre block of forest may have a sustainable harvest plan when 100,000 acres are harvested and replanted once every fifty years across the ownership. This practice is sustainable in future and contains near the maximum variability of activity from year to year within the planning horizon. *This practice meets the same definition of sustainability as Case I.* However, it is far from the common default pubic perception of sustainability because of the variation of activity within the planning horizon. The undefined public perception of sustainability would argue that this plan is not sustainable; when, in fact, it is sustainable in every regard of the definition of sustainability!

Conclusion A: *Fluctuation* of harvest level within a Planning Horizon *is a potential constraint* to achieving the maximum sustainable capacity of a block of forest land. The current age/size distribution of the forest inventory across the 100,000-acre block will determine the exposure to this constraint. Extreme examples are three tracts of a) all fifty year-old forest, b) all bare ground, or c) all previously planted at one-year intervals over the past fifty years. All three examples are snapshots in time looking at potentially equally sustainable harvest plans.

Case III

A 100,000-acre block of forest *will not* have a sustainable harvest plan when all acres are managed on an individual-tree, all-aged selection harvest method as opposed to even-aged harvest methods (clear-cut, seed tree, shelterwood regimes). This practice not only limits the fluctuations of harvest level from year to year, but also from acre to acre. The common default public perception of sustainability appears to be best achieved when this practice is applied across an ownership. No single acre or aggregation of acres departs in visual perception from one year to the next. The landscape mosaic appears to remain intact over time. However, why is this harvest plan not sustainable?

Conclusion B: Fully regulated and exclusive harvest scheduling limited to individual-tree, all-aged selection harvest methods across all acres causes a transition to a different forest type (tree species, vegetation species, wildlife species) and forest health (tree vigor, disease and insects) than was there in the past. Maintenance of a harvest plan using these silvicultural methods throughout a planning horizon will result in a plan that is not repeatable in future (if not sooner).

The justification of the previous conclusion is due to the history of development of almost every forested block of land in North America. Changes have not occurred without fluctuation from year to year or from acre to acre. Changes in forest type and character have been mostly influenced by catastrophic perturbations at irregular intervals in time. This has resulted in existing forests mostly composed of shade-intolerant species such as Douglas-fir, various pines and larch. Wildfire and human induced fire have constrained distributions of disease and insects. Vegetation and wildlife existing in these forests have evolved to their current diversity and abundance as a result of this history.

If a forest harvest plan were developed over a planning horizon of sixty years or more with the objective of being sustainable (in the public view), then an individual-tree, all-aged selection harvest regime will begin an immediate transition to more shade tolerant species over time. With this trend will also be a transition to a different composition of vegetation and wildlife species than previously existing on these lands. Since there is a value separation by tree species available for harvest, then there will be a transition in revenue not anticipated by the composition of the previous forest. Also, the size and frequency of mechanical harvesting equipment operating within each acre will promote the distribution of damage and disease to regeneration attempting to take hold and grow on those acres. To achieve harvest levels near those of even-aged regimes over time will require entering significantly greater numbers of acres each year than required by even-aged methods. This results in a greater dependence on an active road network across the entire ownership. These effects of transitions in harvesting methods, road access, species management and disease control change the level and type of cash flows relative to other silvicultural systems to attempt to achieve the same sustainable revenue stream.

Since any attempt to manage all acres exclusively with a selection harvest regime causes a transition of the forest composition to conditions not previously observed, it is not an option if sustainability is an objective in either biological or economic terms.

If every acre in the forest land base has the opportunity to transition from regeneration to maturity to harvest and back to regeneration, then that period in years is a sufficient Planning Horizon for determining sustainability. This may be a land base with an aggressive even-aged plantation to harvest regime of thirty years. This may also require a time period of eight hundred years or more in the case of a National Forest with no active management and dependence on insects, disease and wildfire to cause cycling of the growth phases on all acres. Both of these time frames are sufficient to define sustainability in their respective cases. However, the public perception of sustainability is more in conflict with the current practices on National Forests than it is with industrial forest lands. The practice of "closing" Federal forest lands to any type of harvest creates a situation where large perturbations (wildfire) in the forest condition from year to year become the primary means for the forest to re-cycle itself. The owners of every forest land base should be aware of the complete definition of sustainability and the associated tradeoffs (periodic fluctuations and long-term transitions) of the current Forest Management Plan being invoked on that land base. These owners may be family groups (family-owned forest), Board of Directors (corporate forest) or the general public (Federal forests).

It is the responsibility of the forest management staff on each land base to determine the current forest condition, types of constraints (biological, economical, regulatory), silvicultural systems which apply, and to determine the resulting sustainable capacity. To achieve these responsibilities, the staff must understand the full definition of sustainability and the implications of alternative silvicultural systems or fluctuations within the Planning Horizon. Further, it is the responsibility of the staff to pass this information on to the owners in order for them to make informed decisions as to the future of this forest land base.

It should be noted that most Forest Plans produced by planning teams on Federal lands do not provide sufficient information to determine sustainability. This may be due to the situation where most of these teams do not understand what constitutes sustainability. It may also be due to the fact that most SAF-certified forestry schools do not provide graduates with sufficient understanding of sustainability and the means to determine it on a given block of forest land.

Optimization of Harvest Levels

In the previous discussion the usage of a Planning Horizon was described and applied in the determination of sustainability. The Planning Horizon is best defined when it provides sufficient time for each acre to transition from regeneration to maturity to harvest and back to regeneration (as previously stated). The *optimization* of harvest levels requires knowledge of two major components of forest planning:

a) Silvicultural regimes which are acceptable (biological, regulatory, economic); and
b) The forest composition and time necessary to transition to this optimal level.

Due to various constraints (economic, regulatory, public observation) it is usually not possible to immediately convert an entire forest land base to a fully implemented set of optimal silvicultural regimes invoking target tree species, densities and distributions. Therefore, forest planning activities are consumed with determining the current forest condition (species composition, density, size, growth capacities and geographic location) and with determining the target kinds of silvicultural regimes that will eventually define the forest. The planning activity (analysis) then becomes a series of evaluations of alternative silvicultural regimes which will transition the current forest composition into the target forest composition in the shortest time or at least cost or with least perturbation (ecological, economic, aesthetic). These evaluations are intensely intertwined with the level and type of constraints placed on the forest land base. These include:

a) Maximum size of harvest openings;
b) Proximity to other openings, riparian zones and wildlife corridors;
c) Type, intensity and frequency of silvicultural treatments specified within wildlife buffers, corridors and riparian zones;
d) Types of green-tree retention and minimum residual density levels imposed by regulatory agencies;
e) Economic and regulatory accessibility to each stand in the forest regarding roads and harvesting systems;
f) Range of approved silvicultural regimes (clearcut, seed-tree, shelterwood, selection) and their unique thresholds and time schedules (e.g., California rules);
g) Economic flexibility and investment strategy to convert non-stocked forest lands;
h) Economic management indices chosen to determine achievement of goals, such as, cash flow, net present value, internal rate of return or soil expectation value.
i) Range of economic values assigned by species, dimension, quality or weight; and,

j) Range of silvicultural methods available for evaluation and implementation of the final forest plan, such as herbicides, pesticides, fertilizers, planting stock quality, and genetic gain R&D investment in the current and in the target forest.

Suppose that we have a 100,000-acre block of forest land upon which a forest harvest plan is to be developed with the objective of obtaining the highest possible sustainable harvest level over the foreseeable future.

A complete and current forest inventory is required with a spatially-explicit stand-based list of forest vegetation types (species, size, density, growth capacities). This inventory must be made up of a list of GIS-based polygons which explicitly define each vegetation type both spatially and numerically. These requirements are necessary to individually evaluate spatial proximity to riparian buffers and wildlife corridors and to determine the range of flexibility regarding harvest opening sizes and proximity to other openings relative to their individual green-up timetables.

Suppose this forest land base is currently occupied with a range of tree species, stocking levels and size classes as a result of many different management objectives that were applied to various tracts within the total ownership in the past.

Development of the Forest Plan begins by considering the owner's objectives, local market opportunities, native growth capacity of the forest land base, available labor and equipment, and operational accessibility (topography and roads). The development of a Plan then proceeds with definition of a series of optimal silvicultural regimes which are to be implemented. This series will define the tree species, density, silviculture and harvest timing for each level of growth capacity of the forest land base. This is usually accomplished by stratifying the forest land base by native productivity levels and then determining the silvicultural system that closest achieves the owner's objectives.

At this point, the current forest condition (inventory) is defined and the target forest composition (silviculture) is defined. What remains is the *schedule* by which the current forest will transition from its current state to the target state.

The makeup of this schedule is determined by:

a) The magnitude of the departure between the current and target state of the forest land base; and,
b) The range and complexity of constraints imposed upon this land base.

Optimization of the management objectives for a forest land base is not about the target forest. Optimization is about the schedule applied to the existing forest to achieve the target forest.

For example, if the 100,000-acre land base presented earlier has a target composed of fifty-year rotations using clearcut and plantation regimes, then approximately 2,000 acres will be scheduled for harvest each year when the target forest is achieved. Given the current forest condition (inventory), how long will it take, what silvicultural methods will be applied and how many acres will be harvested each year to transition to the target state? If the first target plantation regime is established this year, then it will be fifty years (or more) into the future before we achieve the target state of the forest. Therefore the Planning Horizon should be established to be at least fifty years in length for this Harvest Planning Analysis. This duration ("time frame") is necessary to determine the full range and schedule of activities necessary to achieve the target state of the forest.

If a Planning Horizon is used for determining the highest sustainable harvest level for any period of length *less than* a full rotation of the target forest, then it is defined for simply computing a liquidation harvest level by year until all available forest products are exhausted. This is not a sustainable schedule because it is not repeatable in the next time frame.

As discussed, development of a sustainable forest harvest plan is primarily about optimizing the schedule for the transition of the existing forest to the target forest. To accomplish the optimization of the transition schedule implies evaluation of alternatives. It is an easy task for any experienced forester to walk into a forested stand and identify the most effective strategies (silvicultural treatments including harvest) to apply to that stand to achieve the owner's objectives.

It is extremely difficult, if not impossible, for anyone to look at a 100,000-acre existing forest and identify the most effective strategies (timing and treatments) to apply to that forest to achieve the target forest condition (i.e., owner's objectives). Therefore, a spatially-specific, stand-based harvest scheduling package of tools (software and databases) must be utilized to absorb, evaluate and schedule the transition from current state to target state of the forest.

To enhance the functionality and range of opportunities to optimize the transition requires that the Planning Forester provide a broad range of alternative silvicultural regimes (schedules of treatments over time) to the harvest scheduling analyses. These regimes must incorporate alternative timing of events and intensities of treatments to fully enable the harvest scheduling analyses to find optimal arrays of activities over the transition. To enhance the transition in wood and/or value flow, some stands will be harvested earlier than optimum or later than optimum for that specific stand. However, it will be closer to optimum for the forest objectives as a whole. This can only occur if the Planning Forester had provided those silvicultural regimes as part of the initial input the harvest planning analysis process. As a guideline, every stand polygon in the inventory should have at least three to six alternative regimes defined to achieve an optimum Harvest Schedule Plan (transition to target state) as the output from the harvest planning analyses.