<u>FORESTS AND WATER: SOME PRINCIPLES OF MANAGEMENT</u>

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(1) What are your thoughts on the appropriate management strategies for DCR to put in place on the state forests and parks to ensure delivery of sufficient quantities of the ecosystem service that you are representing?

Volumes have been written on the appropriate management strategies to ensure delivery of sufficient quantities of drinking-quality water from forest-protected water supplies. Recent texts worth reviewing include <u>Land use effects on streamflow and water quality in the Northeastern United States</u> (de la Cretaz and Barten, 2007) and <u>A century of forest and wildland watershed lessons</u> (Ice and Stednick, eds. 2004) Some of the major findings from the past century of research can be bullet-summarized under the subheadings of water *yield* and water *quality*, as follows (specific references can be provided if needed):

<u>Water *yield* principles:</u>

- Water yields generally increase as the percentage of forest cover removed increases, although 25-30% of a fully-forested watershed must be cut to produce a measurable increase in yield.
- Complete removal of forest cover can result in first-year yield increases of 4-10 area-inches (total average annual streamflow from forested watersheds in the Northeast is approximately 20-25 area inches, or about 50% of total precipitation).
- Water yields decrease with reforestation of disturbed watersheds and growth of younger forests, with a linear relationship between the percentages of watershed reforested and water yield decrease.
- Water yield increases are greatest the first year after cutting and decline thereafter, usually returning to pre-cutting levels within 3-10 years, depending on the pace of regeneration. Changes in species composition can prolong the effect on yield.
- Water yield increases are generally larger on north versus south facing slopes, with yields up to 2.5 times greater for clearings on north facing slopes. There is also evidence that west-facing forests use more water than those on east-facing slopes.
- Water yield increases from cutting in the many studies in the northeast occurred chiefly during the growing season, and are not as prolonged as yield increases in areas of higher snowfall, deep soils, or conifer cover
- Deciduous forests yield more water than coniferous forests, as conifers respire longer and use more water annually than deciduous trees and because snow capture and evaporation/sublimation is greater from conifers. .
- Greatest yield increases are usually achieved through removal of riparian vegetation or lower elevation watershed vegetation. (e.g., cutting 33% of the stocking in riparian areas in Massachusetts increased yields by 20-22% for the 1st year following cutting.)
- Much of the increased flow generated by cutting is seen as increases in low flow periods, due to changes in evapotranspiration. Cutting does not significantly alter peak flows during winter or spring storm events.

- Cutting watershed forests in the Northeast generates lower yield increases of shorter duration than similar practices on watersheds in areas with deeper soils, longer growing seasons, and higher average evapotranspiration rates (e.g., the Southeast).
- Certain early successional hardwoods use measurably more water than late successional hardwoods, and changes in water yield due to shifts in species composition may last in excess of a decade.

Water *quality* principles;

- No other watershed cover exceeds the water quality protection provided by forests. Some covers (e.g. roofs, septic systems or oily parking lots) provide substantially poorer protection.
- Surface "runoff" almost never occurs in Northeastern forests due to the infiltration capacity provided by deep organic soils. Water flows through these forests as subsurface flow, resulting in very significant reduction in nutrients and sediments.
- Since forest canopies accumulate rain into larger drops, and because raindrops can regain terminal velocity in 25-30 feet, forest soils are protected from erosion more directly by the accumulation of litter on the forest floor than by an intact canopy.
- Clear cutting an entire watershed can result in a doubling of conductivity, a tenfold increase in nitrate, a tripling of calcium, and a doubling of sodium, magnesium, and potassium. These changes may return to reference levels within four years.
- While logging can increase sediment yield to streams, these effects can be reduced to insignificant levels by following Best Management Practices for the construction and maintenance of access roads and staging areas.
- Uncontrolled, "logger's choice" cutting can result in suspended sediment losses as high as 1.44 tons/acre, while logging controlled by BMPs remains well within the natural range of sediment yields, of less than 0.05 tons/acre.
- Increases in yield from a watershed are frequently correlated with increased movement of sediments and nutrients, but at least 25% of a watershed forest must be cut to create a measurable increase in yield.
- While research in nitrogen saturation shows that younger forests capture N additions from atmospheric inputs versus N losses from older forests, research in Chile (remote from atmospheric pollutants) indicates that old forests do not "leak" nitrogen.
- Clearcut size is less critical in determining water quality effects than the ability of advance regeneration and surrounding buffers to utilize mineralized nutrients. There are no simple rules for threshold opening sizes to protect against nutrient losses.
- Diversity in the forest cover provides better protection than homogeneity. Species and age diversity provide resilience. Homogenous watersheds melt their snow cover "all at once", increasing the magnitude of the hydrograph while diverse cover results in desynchronized snowmelt and a lower magnitude, less erosive hydrograph of longer duration.

In very simplified summary, any plan for property in Massachusetts being managed for the protection of drinking water supplies should include the following practices:

1. **Do everything possible to gain more and lose none of the forest cover presently protecting the water supply.** There simply is no better protection for drinking water than forest cover. Period.
2. **Create and manage according to zones of hydrologic sensitivity.** These are primarily based on distance from surface water sources, but should also reflect the hydrologic distance to the supply intakes for these sources. Close proximity suggests more conservative management practices.
3. **Delineate subwatershed boundaries and map and analyze** recently completed and proposed harvesting activities in order to verify that not more than 25-30% of the subwatershed forest cover is regenerated in any given 10 year period.
4. **Separate roads and staging areas from water resources**, either by careful placement or strict adherence to Best Management Practices, including the use of portable bridges for flowing streams, water bars, diversion, detention, and retention structures, etc.
5. **Maintain the forest's ability to regenerate itself,** primarily by controlling populations of browsing ungulates (deer, moose) and the influence of terrestrial invasive species.
6. **Work to diversify species composition and age structure** in order to build resistance and resilience in the forest cover to maintain its integrity through the range of disturbances that occur in the Massachusetts forest, and to desynchronize and reduce the magnitude of the hydrologic response to snowmelt and storm events.

(2) How should provision of this particular ecosystem service be balanced with competing demands, if any, from ecosystem services represented by the other panelists?

Generally, the management of forests to protect water supplies is compatible with a wide variety of other environmental services. The forest-filtered water supplies for Boston and New York also provide extensive recreation, a wide variety of common and unusual wildlife habitat, protection of rare species and cultural resources, and a source of timber. A few possible exceptions might include:

1. Recreational activities need to be well-controlled on drinking supply watersheds, to limit the potential for fires and improper handling of human waste.
2. Research has shown that the greatest increase in water yields would result from extensive cutting of riparian areas and the forests growing on wet soils, but heavy cutting in these areas is in direct conflict with their functions in protecting critical aquatic habitat conditions.
3. Watershed forests are capable of yielding large volumes of wood products while providing optimum protection of drinking water, but there may be conflicts between maximizing the production of timber and maximizing the protection of drinking water supplies. For instance, while red pine plantations can produce greater volumes of timber per acre than diverse natural stands, these plantations are prone to wind, snow, and ice damage as well as rapid spread of host-specific diseases such as the root-rotting fungus *Heterobasidion annosum.*