Prioritizing Land to Protect Drinking Water Supplies

Streams, rivers, lakes, reservoirs, and groundwater aquifers supply the drinking water which sustains people and communities. The character and condition of the landscape (watershed) through which this water flows has a direct influence – either favorable or undesirable – on the availability, quality, and healthfulness of drinking water. Hence the condition of the watershed influences the cost of water treatment. It may be modest if simple disinfection (*e.g.,* chlorine, ozone, or ultraviolet light) is sufficient. It can be substantial if complex physical, chemical, and engineering methods are required to remove contaminants and toxins. Of course the capital funds to build or upgrade plants and the annual operating funds required to treat water to acceptable standards are not available for education, health care, public safety, and other uses.

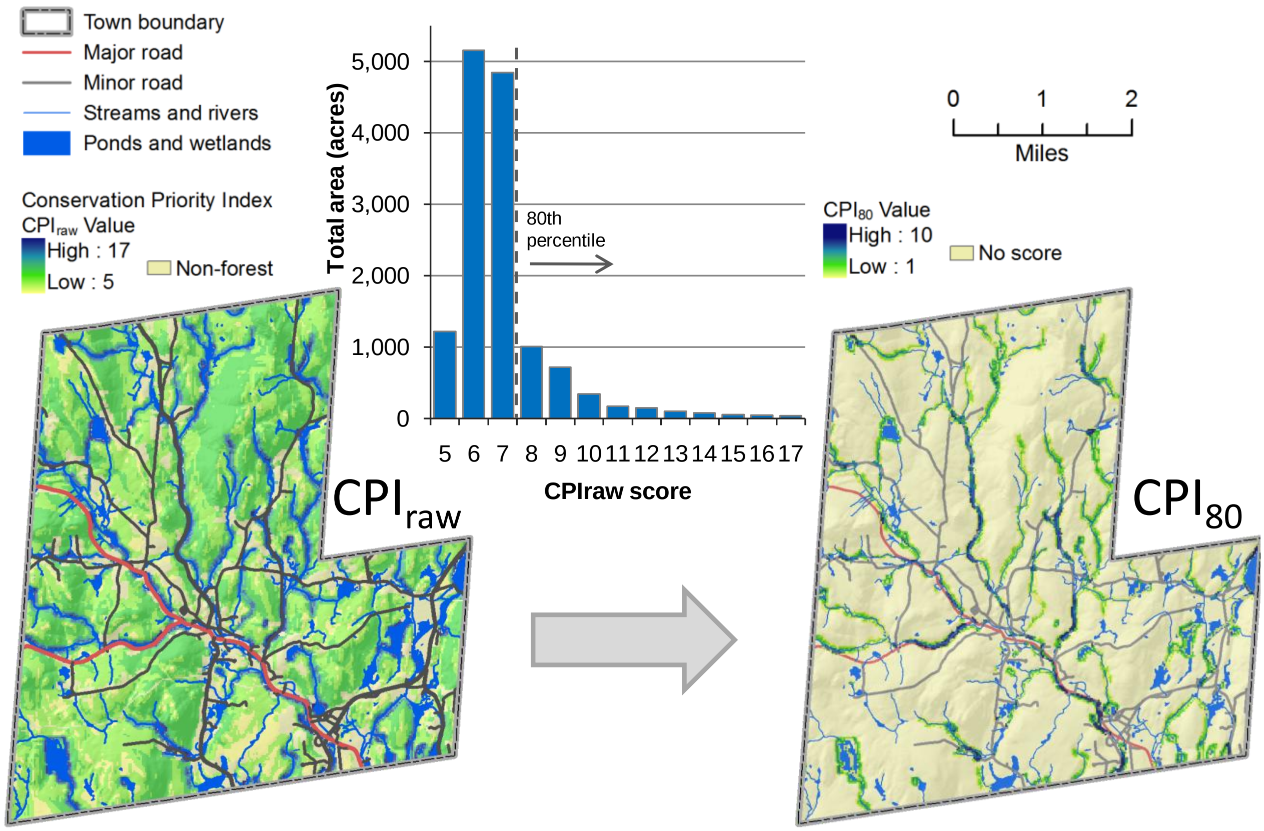
Effective water supply protection efforts rely on the time-tested multiple barrier approach, beginning far upstream in the Sebago Lake watershed. Forests are the critical first barrier – ***the solar-powered living filter*** – for reservoir systems here and in many other parts of the world. No other land cover or land use has a more favorable influence on quantity and timing of streamflow or chemical and biological water quality. Tree roots anchor soil and stabilize slopes and stream banks. Fallen leaves and other organic material protect the soil surface, enhance the permeability and water storage capacity at the surface and throughout the rooting zone, and help to foster subsurface flow and natural filtering. A growing forest – preferably with a diverse mix of tree species, sizes, and ages – uses nitrogen, phosphorus, potassium (and other minerals) and carbon dioxide (via photosynthesis) to grow, retain carbon, and release oxygen and water vapor back to the atmosphere. The forest also provides wildlife habitat, recreational opportunities, and many other ecological, social, and economic benefits and values.

The ***Conservation Priority Index*** (CPI, developed by Drs. Yanli Zhang and Paul Barten at UMassAmherst in cooperation with the US Forest Service, Trust for Public Land, and US EPA) is an intuitive, scientifically-based method for scoring and ranking the importance of land for water supply protection (Table 1). Any 30 x 30 meter (0.22 acre) grid cell of forest in the spatial database could receive a minimum score of 5: 3 points for forest, ½ point for a deep water table, ½ point for being well drained, and 1 point for a gentle slope (if it is more than 300 feet from a water feature, no points are allotted for “proximity”). In contrast, only a small number of grid cells will be forest land with steep slopes, immediately adjacent to streams, with silt or clay soils that are frequently saturated, and would yield a score of 18. As might be expected, there is a large amount of average forestland with low CPI scores (Figure 1). Using an analogy to the evaluation of standardized test scores for a group of students, the 80th percentile (top 20%) and higher are used for further analysis and ranking.

TABLE 1. Description of GIS data layers and scoring strategy for the *Conservation Priority Index*.

	Landscape characteristic	Why is it important?	Increasing importance ⟵ 3	2	⟶ 1	Decreasing importance 0
	Land use	Forests provides the best protection of water resources of any land cover.	Forest/wetland	—	—	All others
	Distance to streams (feet)	Forests provide shade, organic matter, and woody material while they absorb nutrients and trap sediment. The “riparian forest buffer” has a major influence on streamflow and water quality.	0 to 100	100 to 200	200 to 300	> 300
	Distance to ponds/wetlands (feet)		0 to 100	100 to 200	200 to 300	> 300
Soils (1/2 weight)	*Depth to water table*	If forests are removed more water enters the soil. If the shallow water table reaches the surface it can lead to overland flow and erosion.	shallow	intermediate	deep	—
Soils (1/2 weight)	*Permeability*	This is the rate at which water flows into *and* through soils. Poorly drained soils can lead to overland flow and erosion.	poorly drained	intermediate	well drained	—
	Slope	The rate of water flow is directly related to land slope. Steep slopes also may be less stable and more prone to erosion.	steep (> 15%)	intermediate (5 – 15%)	gentle (< 5%)	—
	Water – Forest – Roads	The narrow strips of forest between roads and streams are especially important for water quality protection.	yes	no	no	no

FIGURE 1. Development of the Conservation Priority Index (called CPI_{raw}); and CPI_{80} based on the top 20% of forestland identified by the CPI_{raw}.



Parcels are prioritized and ranked for conservation opportunities using a set of metrics. The above scores are used by a GIS to calculate two metrics at the parcel level: the sum of the raw CPI cells and the sum of the 80th percentile of cells falling within each parcel (ΣCPI_{raw} and ΣCPI_{80}, respectively). It is more efficient to work with the owners of fewer larger parcels rather than many small parcels, so another metric is size. Figure 2 shows the strong statistical relationship between the area of the parcel and total CPI score. The parcel scoring algorithm is shown in Figure 3. Parcels ranked in the top 20 for multiple metrics represent the best conservation opportunities and receive a score, (value) of 10. Parcels ranked in the top 20 for only one metric, but in the top 20-50 for multiple metrics receive a score of 8 – not quite the best, but close. Parcels ranked only in the top 20 for one metric are scored 7. Those parcels ranking in the top 20-50 for multiple metrics are scored 5, and those in raking in the top 20-50 for only one metric are scored 3. A parcel's overall rank is determined by the number of metrics it ranks in the top 20 and top 20-50, and its ΣCPI_{80}.

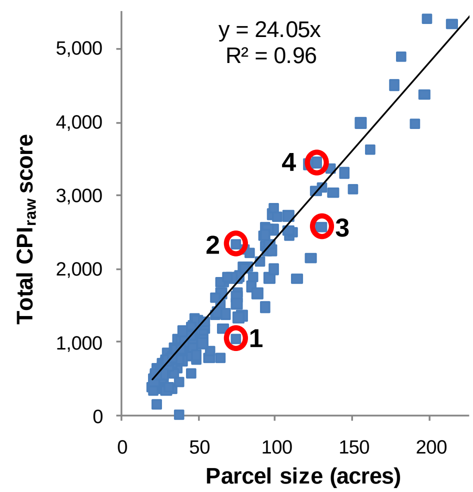
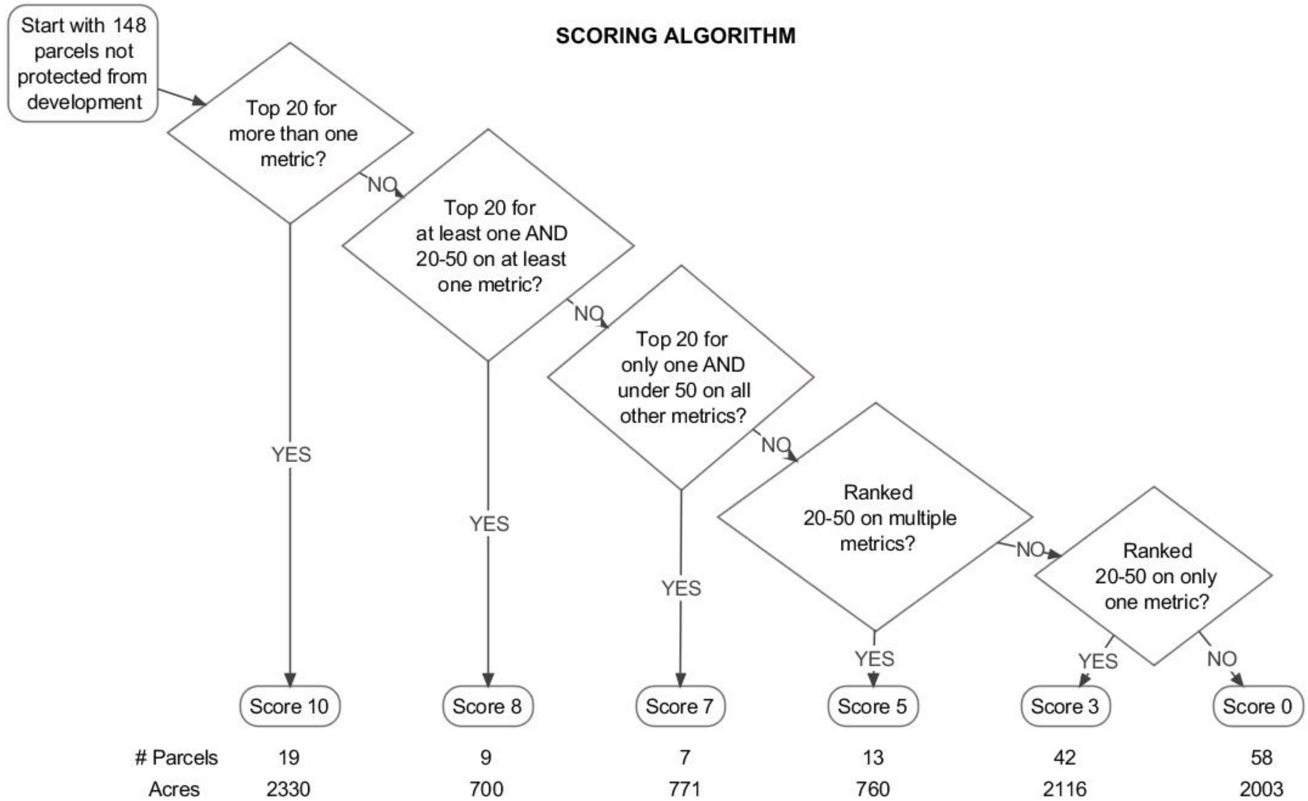


FIGURE **2.** Total ***Conservation Priority Index*** (ΣCPI_{raw}) score in relation to parcel size. Interpreting the results — Parcel 1 has about 40% of the conservation value of Parcel 2. Parcel 2 and 3 are comparable in conservation value, despite Parcel 2's smaller size, and have about have about 70% of the conservation value of Parcel 4.

The importance of using these multiple metrics is shown in Figure 4. Land trusts, watershed councils, municipalities, and government agencies have limited financial resources, and it takes time to develop and cultivate relationships with landowners. This method clearly identifies the top conservation opportunities in the watershed. Losing the forest land on these highest scoring parcels to inappropriate development would be the most damaging to streamflow and water quality. If for some reason the owners of those parcels aren't available for outreach, other high-value opportunities are identified that might otherwise be indistinguishable from below-average prospects. This ensures that scarce resources are focused on parcels with the greatest contribution to water supply protection.

FIGURE 3. Parcel prioritization algorithm and results for parcels larger than 20 acres.



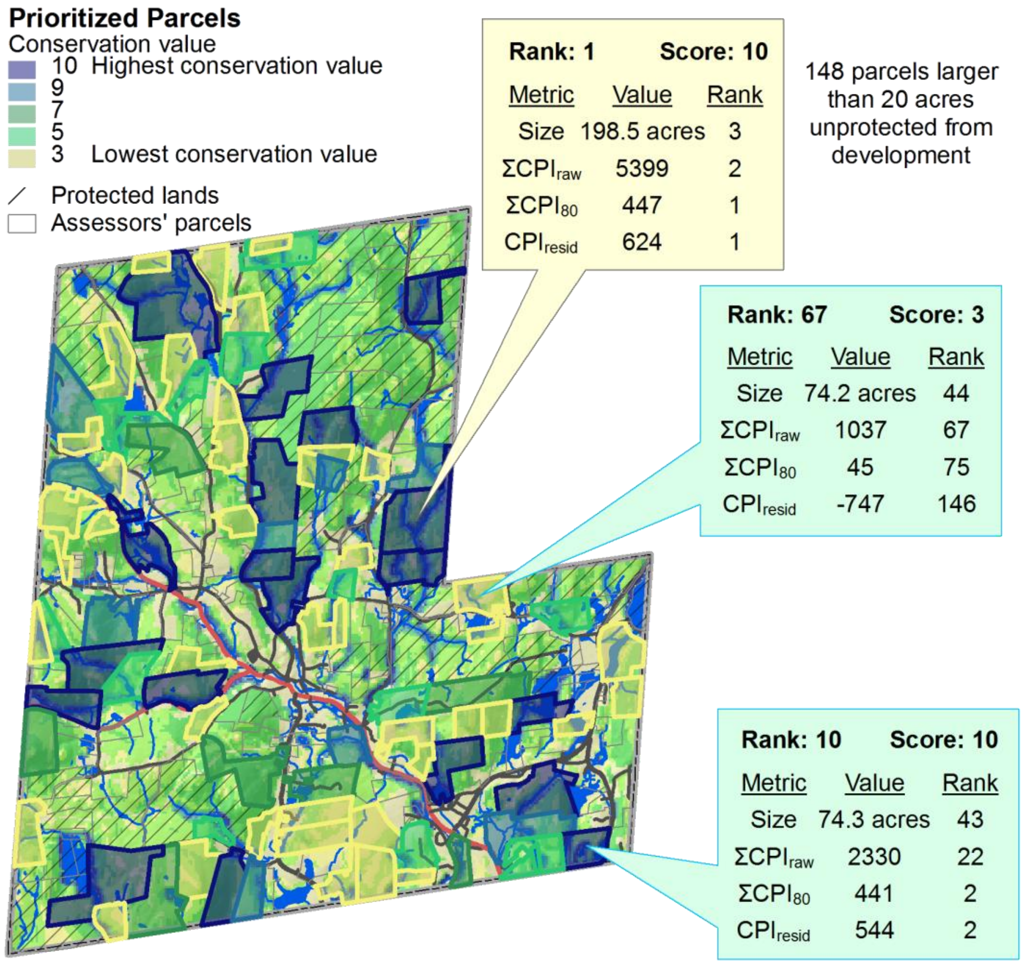


FIGURE 4. On the basis of size and ΣCPI_{raw}, the two parcels above seem to represent similar conservation opportunity. Using the additional metrics, it becomes clear that working with the owners of the left parcel represents a better value, investment of time and money, and a better conservation opportunity.