Climatic Change Implications for Hydrologic Systems in the Sierra Nevada

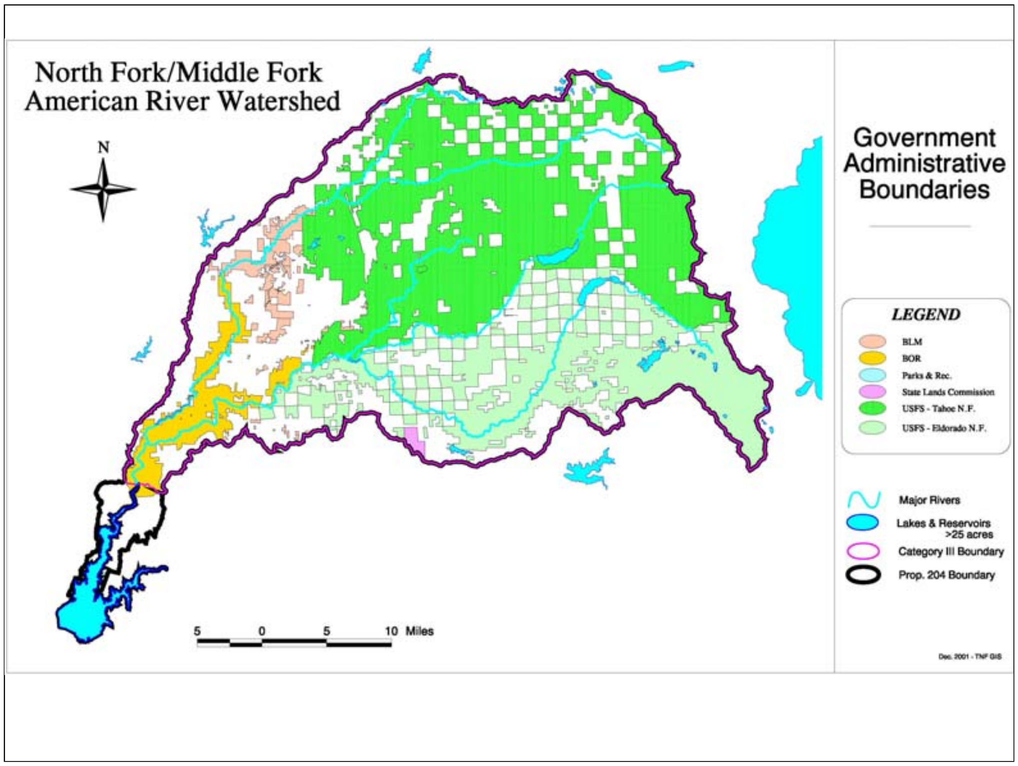
Part Six

Results from Calculator on Specific Example Watersheds

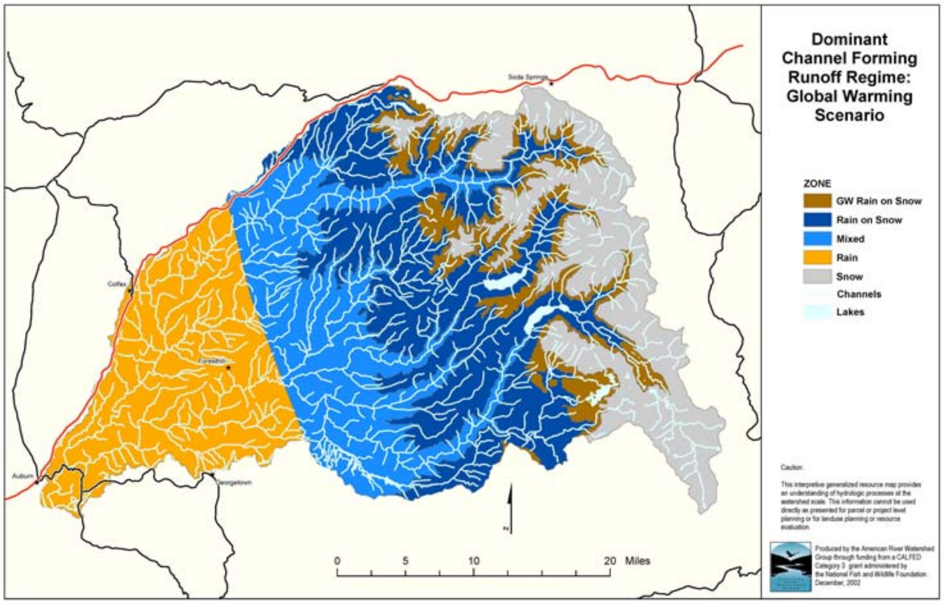
In this section, results from the calculator are applied to two example watersheds in the Northern Region– French Meadows and Pilot Creek.

John Humphreys, PhD, compiled the data for this section, using ESRI Spacial Analyst to define HRU acreage.

Otis Wollan generated the graphs from the calculator output.



The two example watersheds are located in the North Fork American River Watershed, which is east of Folsom Reservoir, and west of Lake Tahoe (partially shown at the far right of the map).



This is a non-modeled estimate of changed dominant runoff process regime, under the influence of global warming.

Channel segments within the Snow Zone (above 6500 ft) should see essentially no change in channel forming flow magnitudes and remain largely unchanged during global warming.

Channel segments within the Global Warming Rain on Snow Zone (6000-6500 ft) should have the greatest change in forming flow magnitudes as these segments will shift from snowmelt to rain on snow runoff regimes. These channel segments should undergo substantial channel enlargement and overall channel adjustments. This condition will be particularly evident in channel segments with bordering fluvial terraces and with channel margins otherwise subject to erosion, channel enlargement, and channel lateral migration. To the degree that channel changes entrain elevated levels of sediment production, these changes could be propagated downstream a cause secondary channel adjustment processes.

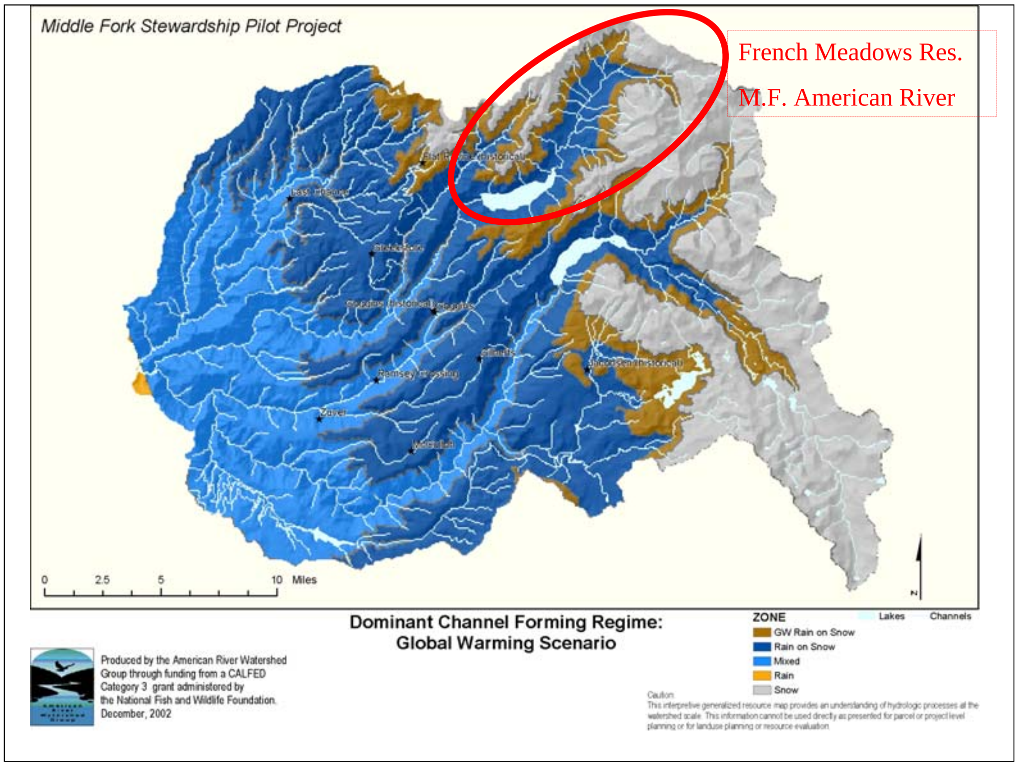
Channel segments within the Rain on Snow Zone (4500-6000 ft) should see little change in channel forming flow magnitudes and remain largely unchanged during global warming because this area is a rain on snow zone in both present and potential global warming scenario. To the degree that future rain on snow runoff events may be more severe in the futures, there could be some increase in channel sizes.

Channel segments within the Mixed Zone (3500-4500 ft) should see a reduction in channel forming flow magnitudes because this is a zone that changes from rain on snow to rainfall regimes which should result in a decrease in floodflow magnitudes. These segments should and remain largely unchanged during global warming but with some possibility for aggradation and narrowing.

Channel segments within the Rain Zone (below 4500 ft) should see increased rainfall intensities and increased floodflow frequencies and therefore leading to an enlarged channel network, increased floodflows, enlarged channels, and increased sediment production. These changes would be aggravated by land use development in this area with increased impervious cover and artificial channel density.

From: American River Integrated Watershed Plan and Stewardship Strategy (PCRCD, 2001)

Note the two major reservoirs, French Meadows and Hell Hole, in the middle of the watershed at the upper elevation. This reservoir area is seen in closer detail in the next slide.



Watersheds included on this map are: the North Fork of the Middle Fork of the American River, the upper Middle Fork of the American River, and the Rubicon River.

The first example watershed is within the circled area on the Middle Fork of the American River, with its lowest point at the dam of French Meadows Reservoir.

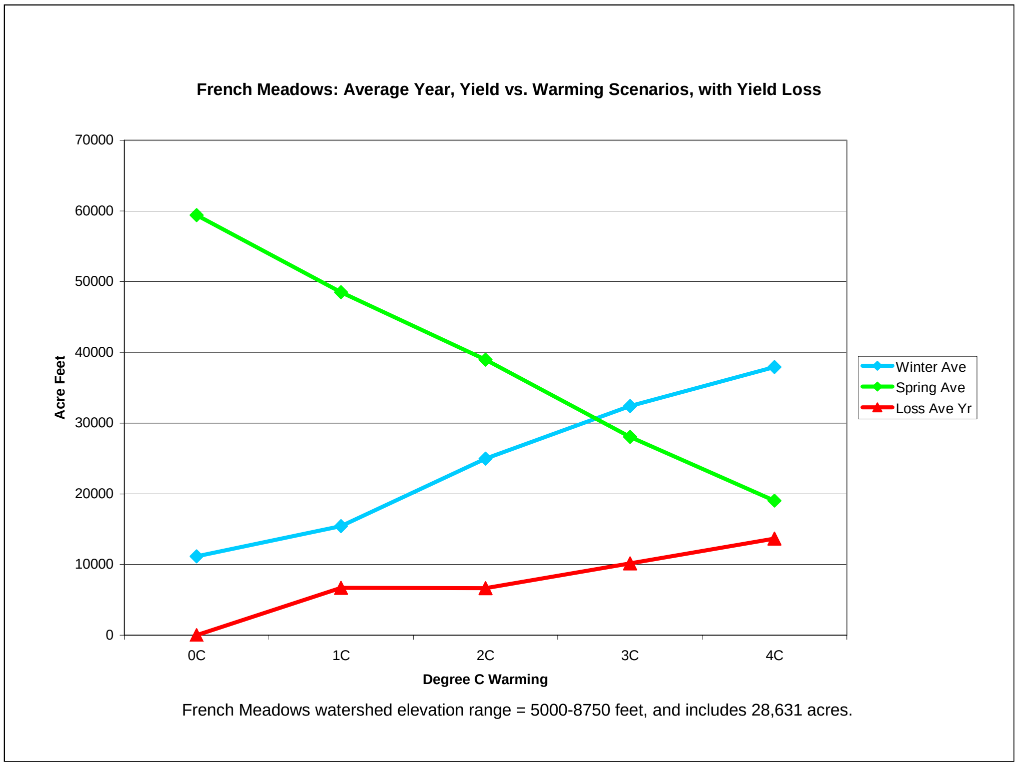
French Meadows Reservoir Watershed (28,630 acres)

Grey = snow   Blue = rain on snow

Gold = Global Warming induced rain-on-snow by one degree Centigrade

A closer view.

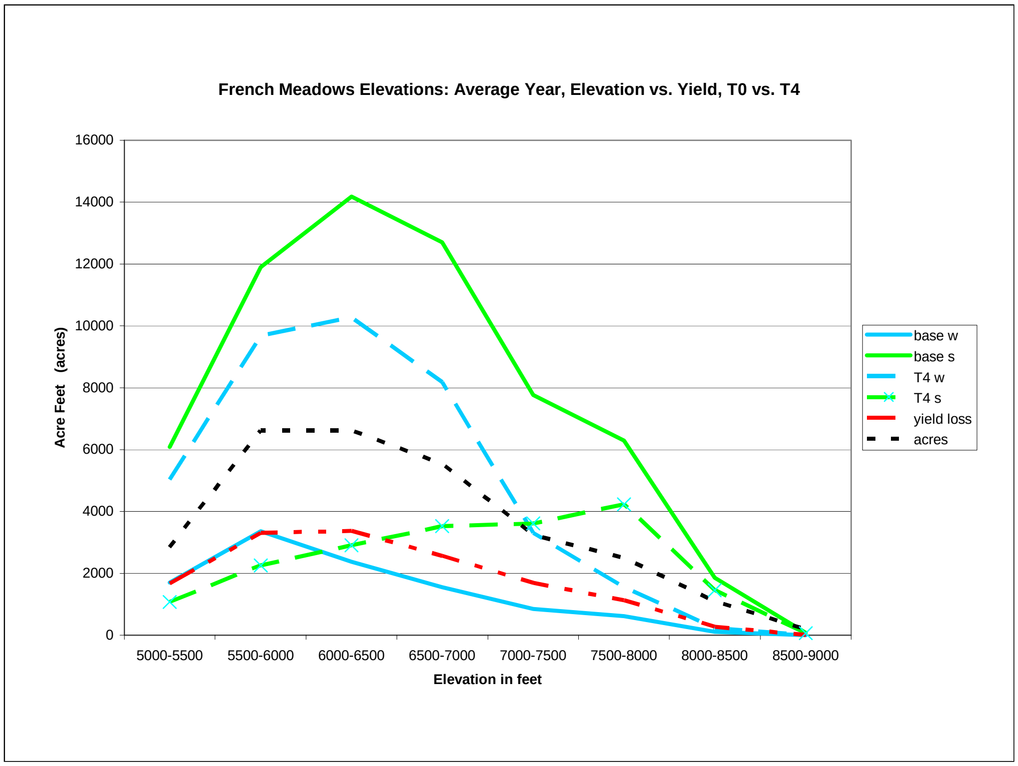
The new global warming induced rain-on-snow area indicated by the color gold, are shifts from snow melt channel forming processes to rain-on-snow channel forming processes. Thus, they have greater peak flood flows. The map indicates that these areas are moving up slope into areas of steeper stream gradient. Stream power increase plus steeper gradient implies aggravated consequences, e.g. generating greater sediment transport, stripping of channel beds with sediment, potentially greater degrees of bank erosion.



The graph shows watershed yield in acre-feet, under baseline conditions (0 degrees C) and all four temperature scenarios (1-4 degree C warming) on the horizontal axis. No precipitation changes were made to the warming scenarios.

Of note is the red line, which is the significant loss of volume due to higher evaporation losses, and transpiration.

The watershed becomes predominantly winter runoff at 4 degrees C warming. The watershed has lost 2/3 of its snowpack storage on April 1 for delayed seasonal runoff.



Yield by elevation band.

The dotted black line indicates acres in each elevation increment. This demonstrates how important watershed area is in using the calculator. Yield will necessarily track with watershed area; the runoff magnitudes are significantly influenced by the elevation distribution of watershed area.

The graph compares the 4 degree C warming scenario (T4) to the baseline T0.

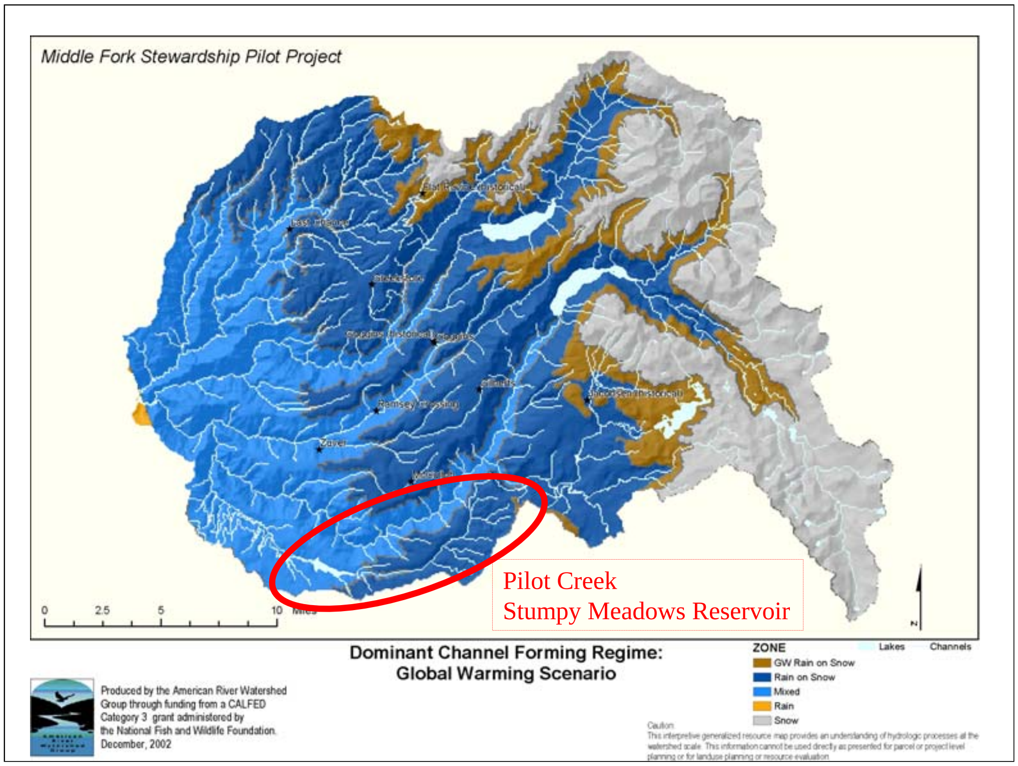
In this watershed, the greatest magnitude of runoff change occurs in the 5-7000 feet interval. This is due to the preponderance of area in this elevation interval (following the black dotted lines for acreage).

Note the top two curves: the solid green curve is baseline spring runoff--- spring snowmelt runoff dominates throughout the watershed under existing conditions.

In the T4 condition, winter rainfall (dotted blue curve) dominates up to approximately 7250 feet elevation. This is a dramatic shift in the timing of the watershed yield.

Yield losses due to evapo-transpiration are significant.

Without further analysis, it is difficult to conclude that the T4 condition exacerbates peak flood flows. While the condition indicates more rain in the winter season,



The second example watershed is Pilot Creek. This is at mid elevations, but entirely below the snow zone (grey).

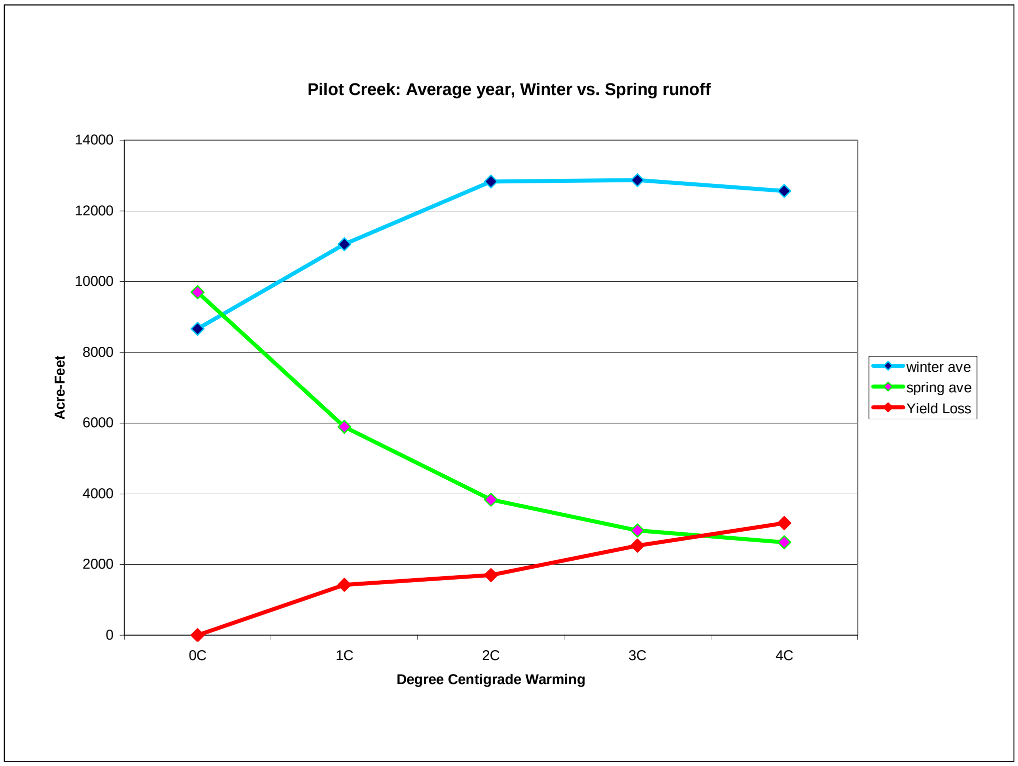
The bottom of the watershed is the dam at Stumpy Meadows Reservoir.

The dividing line between rainfall (light blue) and rain-on-snow runoff (dark blue) is shifted 500 higher in this map portraying global warming conditions of one degree C. The lower elevations, like the area around Stumpy Meadows Reservoir, have shifted from rain-on-snow dominated runoff to rain. These reaches should experience reduced peak flow, reduced stream power, and the possibility of net aggradation (sediment accumulation).

Pilot Creek and Stumpy Meadows Reservoir: (7670 acres)

Light blue = mixed rain and snow Dark blue = rain on snow

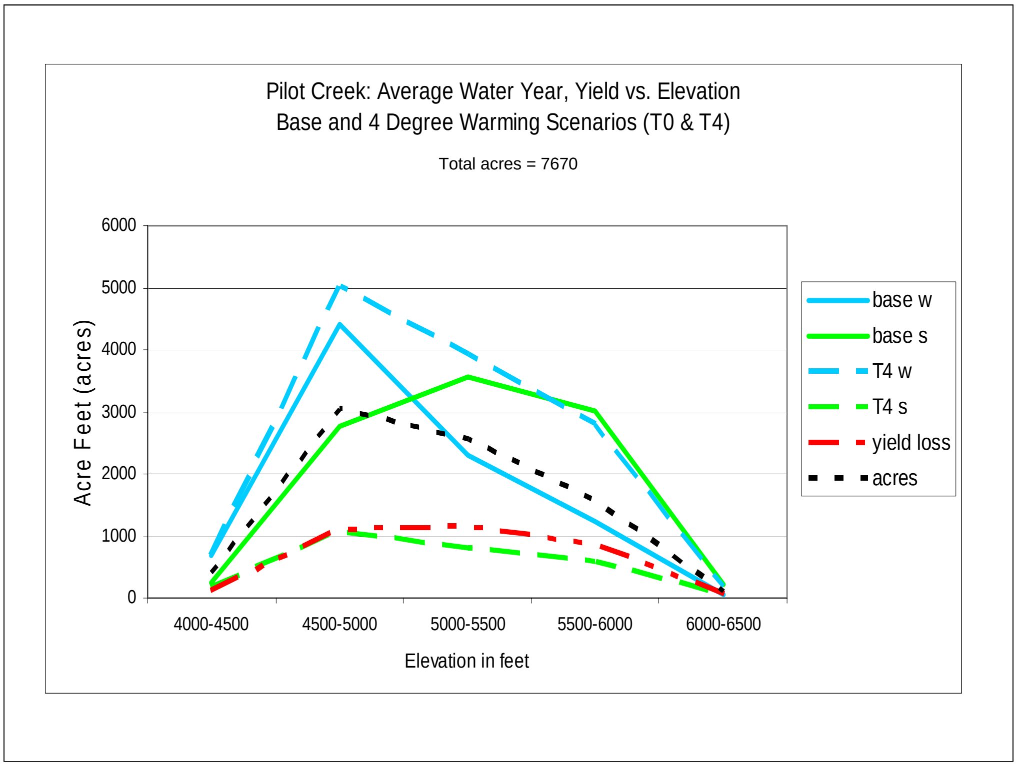
A closer view of Pilot Creek.



The baseline existing conditions show a watershed that is slightly dominated by spring runoff. Under the global warming scenarios, the watershed transforms dramatically to a winter runoff dominated watershed.

The majority of the change occurs in the first two degrees of global warming. The calculator can be used to identify the sensitivity of watershed yield at different elevations.

Also note that the yield loss is greater at lower elevations.



Yield by elevation increment.

The dotted black line indicates acres in each elevation increment. This demonstrates how important watershed area is in using the calculator. Yield will necessarily track with watershed area; the runoff magnitudes are significantly influenced by the elevation distribution of watershed area.

The graph compares the 4 degree C warming scenario (T4) to the baseline T0.

In this lower elevation example, the base condition spring runoff (solid green line) dominates the upper two thirds of the elevation range.

In the global warming condition (T4), spring runoff nearly disappears from the watershed, replaced by winter runoff and yield losses. The yield losses are significant throughout the watershed.