Bark Beetles, Dust on Snow, and Management under Uncertainty
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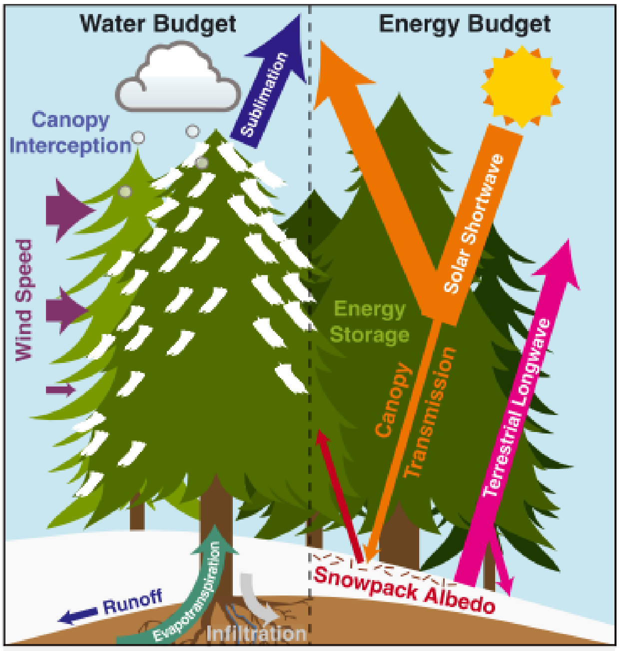
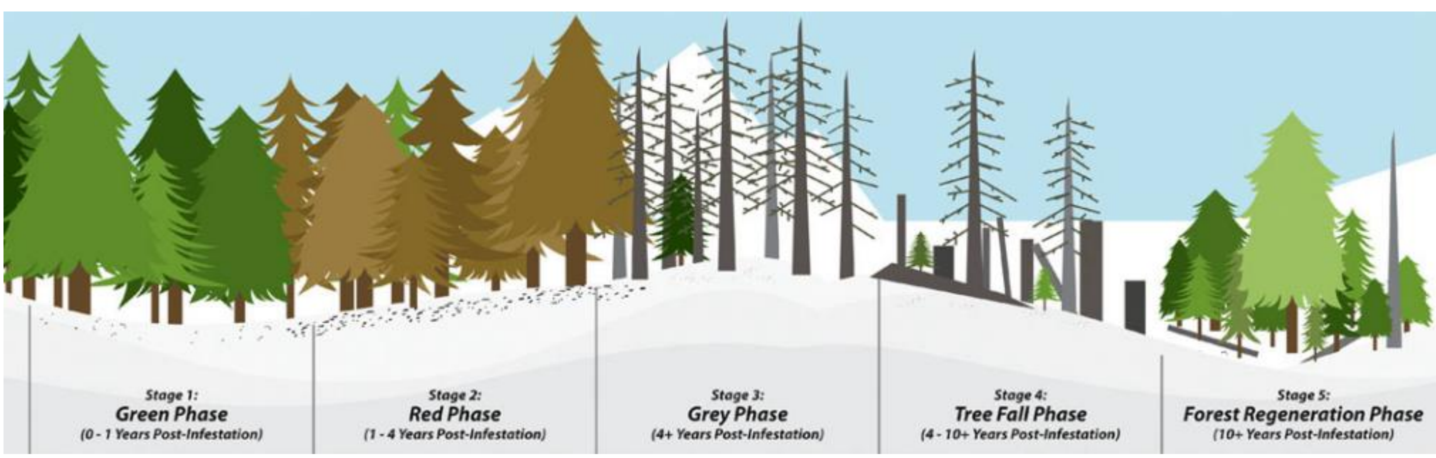
For more info about dust and beetles, Ben Livneh, Western Water Assessment



Relevant meteorologic and hydrologic processes for the energy-water balance in a snow-dominated forest system (Pugh, 2013)


Sublimation (snow converting to vapor due to dry, warm winds) on Mount Everest (Benjamin Oppenheimer, USGS)

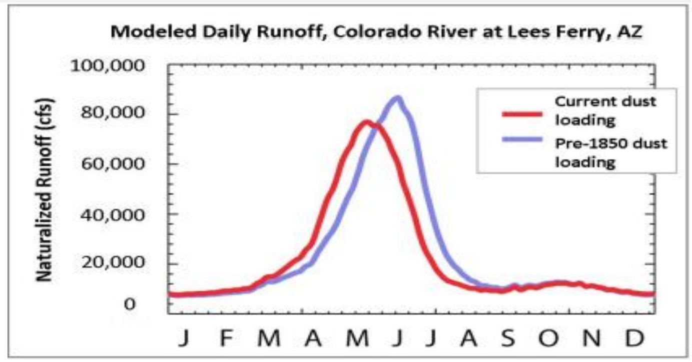

The Mountain Pine Beetle (MPB) is 5mm long and feeds on a variety of trees such as lodgepole pine, ponderosa pine, and limber pine. The current outbreak began in the mid 90s and has affected over 400,000 square miles of western North American forests.



Above is an illustration of the 5 stages of impacts resulting from bark beetle infestation. Modeling results show that Mountain Pine Beetle-related canopy degradation leads to greater snow accumulation as a result of less canopy interception and reduced sublimation. Combined with a loss in root-water-uptake during the warm season, the increased soil moisture availability can translate into an overall increase in water yield (i.e. streamflow) on the order of 3% - 15%, depending on MPB severity. The increased streamflow expected from beetle-kill may be moderated by accelerated growth in young, unaffected trees and patchiness of

San Juan Mountains (photo courtesy Jeff Deems). Colorado Plateau is a major source of dust.

Dust loading in the snowpack alters the energy balance of snowmelt by increasing the solar energy absorption of snow, which is usually very reflective. This enhances melt rates and advances the timing of spring runoff. Painter et al. (2010) concluded that the dust costs the river about 5% of its annual flow, on average— about 800,000 acre-feet, or more than the annual use of the river by Las Vegas, Denver, Phoenix, and Tucson combined.



Managing water resources given vast and often compounding uncertainties is challenging. With a seemingly infinite number of future scenarios and many different infrastructure and operational components to adjust to try to cope, new methods are emerging to assist in finding a practical, flexible, and defensible strategy. This is an area where multiobjective evolutionary algorithms (MOEAs) can help:

1. A representation of a water supply network (Simulation) is embedded in the search loop of an MOEA to automate the suggestion and evaluation of water management solutions while optimizing across many, potentially conflicting, performance objectives.
2. A collection of high-quality solutions are produced from which managers may choose for further evaluation.
3. Upon choosing several viable solutions or components of solutions, water utilities can create a robust and flexible Integrated Water Resources Plan (IWRP).

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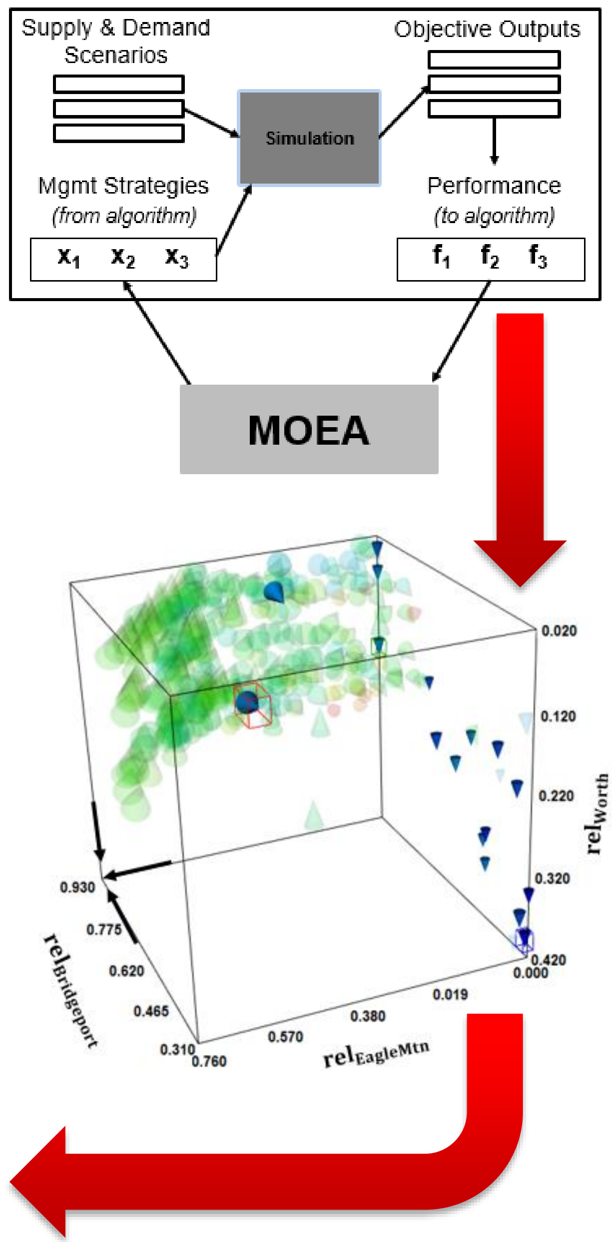

3