ESM 204, Homework #2
Simulating a Water Market

Agricultural water is managed by irrigation districts and is increasingly scarce. To conserve water and reduce costs, four irrigation districts are considering developing a water market, in which water rights would be traded across the districts. In this homework you will conduct data analysis, simulations, and policy analysis to help inform the development of the water market. The dataset for this assignment is available in the file "Water_Districts.csv", available on Gauchospace. The dataset contains estimates of the **marginal cost** of reducing water use in each of the four irrigation districts (Kern, Mojave, Antelope, and Ventura) for different levels of **reduction** (in Acre Feet). A few notes:

- Current (i.e. baseline) water use in these districts[1] is: Kern = 150 AF, Mojave = 140 AF, Antelope = 220 AF, and Ventura = 245 AF.
- Prices are in $/Acre Foot and quantities are in Acre Feet (AF).

Please write a concise report that addresses all of the points below.

1. For each irrigation district, plot the marginal abatement cost data (from the data provided) and estimate a linear regression model with zero intercept. These estimated linear regressions will be your estimates of the marginal abatement cost curve (one for each irrigation district), which you will use for the remainder of this analysis.
2. Using your estimated marginal abatement cost curves, derive each district's **demand curve** for water. In other words, how much would each district be willing to pay for the right to use the first AF of water, second AF, etc.? Plot each district's demand curve on a single graph. Which sector is willing to pay the most for the first AF of water?
3. Here you will analyze three alternative policies for reducing water use among these irrigation districts. In total, these irrigation districts will need to reduce water consumption from the current 755 AF down to 500 AF. For each intervention listed below, perform the following calculations: (1) calculate the stringency of the policy (defined below for each intervention) required to achieve the 500 AF target, (2) calculate the total cost of meeting the target using that approach, (3) calculate the cost to each district, and (4) calculate the tax revenue generated.
    a. **Cap without trade.** Reduce each district's water use by the same fraction (e.g., 1/3 of current baseline use), so the 500 AF target is met. Trade is not allowed. Stringency is defined as the magnitude of the fraction.
    b. **Tax on water use.** A single tax is implemented on all water use in each of the four districts, such that water use is reduced to the 500 AF target. Stringency is defined as the magnitude of the tax.
    c. **Cap and trade.** Cap water use as in part (a), but after those caps are set, allow trade across districts. How much water is used by each district after trade? Stringency is the same as in part (a).
4. A severe drought hits California, and it is necessary to reduce water use from 500 AF down to 300 AF. Your job is to estimate the cost of the drought (i.e., the cost of reducing water use from 500 AF to 300 AF) to each irrigation district under each policy. Considering the entire jump from status quo (755 AF) to the drought (300 AF), which policy is preferred by each irrigation district? How does your answer depend on how rights are allocated to each district (in policies (a) and (c))[2]?

[1] These numbers are stylized for the purposes of this homework.

[2] In Question 3, we assumed that rights were reduced by a common fraction. But other allocation rules are possible. For example, all rights could be given to Ventura and Antelope, and the other districts would have to buy rights from them in a cap and trade. Any given allocation rule will have distributional consequences.