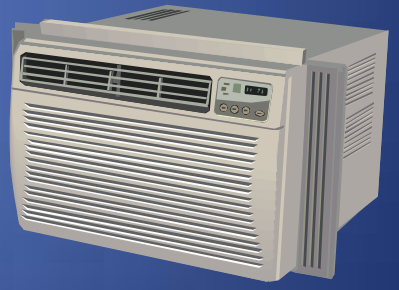
An Experimental Analysis of the Impact of Tree Shade on Electricity Consumption

David N. Laband
School of Forestry & Wildlife Sciences
Auburn University

John P. Sophocleus
Department of Economics
Auburn University



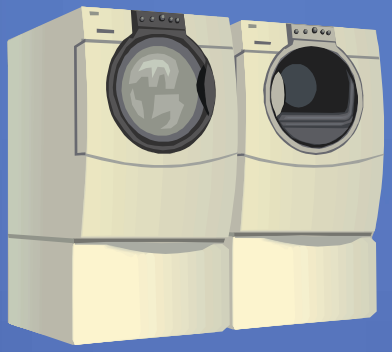
Motivation

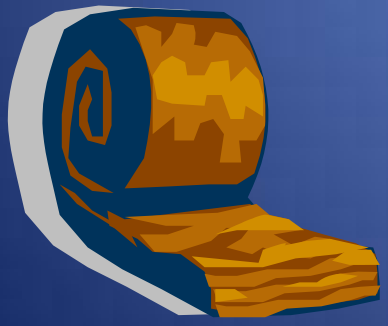
Almost all of the current public discussion regarding energy focuses on:

(1) Supply - - developing alternative (non carbon) sources of energy

Or….

(2) Demand - - conserving energy by improving the efficiency of appliances and structures that use electricity (e.g., heat pumps, refrigerators, washers, dryers, air conditioners, insulation for houses)

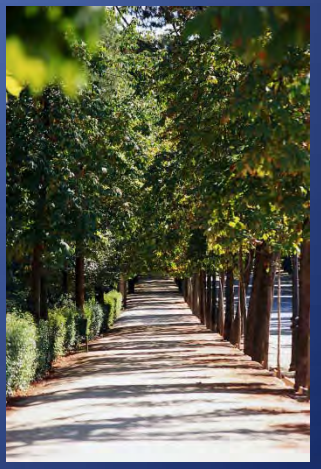




Man versus Nature

- Focus on improving what has been termed man's 'built environment', rather than on taking advantage of services provided by the natural environment that would permit us to conserve energy.

- One such service is the natural air conditioning provided by tree shade.



Tree Shade as Natural Air Conditioning

- Common sense tells us that tree shade keeps us cooler in the summer and thus lowers utility bills. But by how much?

- When you cut those mature trees near your house so the next hurricane (cyclone) does not blow them on your roof, what will this cost you in terms of higher electric bills?

Why is Valuing Tree Shade Important?

- Without knowing how valuable the natural air conditioning provided by tree shade is, individuals have little incentive to use trees strategically to reduce their electricity use during the hot summer months.

- To encourage individuals to adopt strategies that help conserve energy we must give them scientific data identifying the financial savings they personally can enjoy that result from management of tree shade on their residential lots.

The Problem: absence of scientific guidance

- mostly simulation work, almost no hard estimates using real data from households.

- large-sample studies of residential electricity consumption - - Rudie & Dewers (1984), Jensen et al. (2003); Donovan and Butry (2009) - - typically contain few controls for confounding effects - - family attributes, dwelling attributes, etc.

Objective

To develop empirical estimates of the energy savings provided by tree shade.

Methods - Theoretical Foundation

- A simple way of thinking about how to assign a monetary value to the cooling services provided by tree shade is to think in terms of replacement cost.

- In the absence of the natural air conditioning provided by tree shade, we artificially cool our dwellings and commercial buildings and we CAN identify the costs of doing so.

- Thus, we can estimate the value of natural air conditioning provided by tree shade by calculating homeowners' savings from not having to provide the equivalent level of mechanical cooling.

Methods - Implementation

Compare electricity consumption used to maintain a constant temperature in two otherwise identical buildings, situated in different shade conditions.

Getting going…..

- two 10’ x 16’ storage sheds with identical construction specifications.
- dark gray, shingled roof with ridge vent
- 6 windows
- Fully insulated with R-13 batting
- Linoleum plus 1/4 round molding over plywood floors
- Wired with electrical current
- Identical window Air Conditioners plugged into loggers that recorded electricity usage.
- Thermostats set to 72 degrees F.

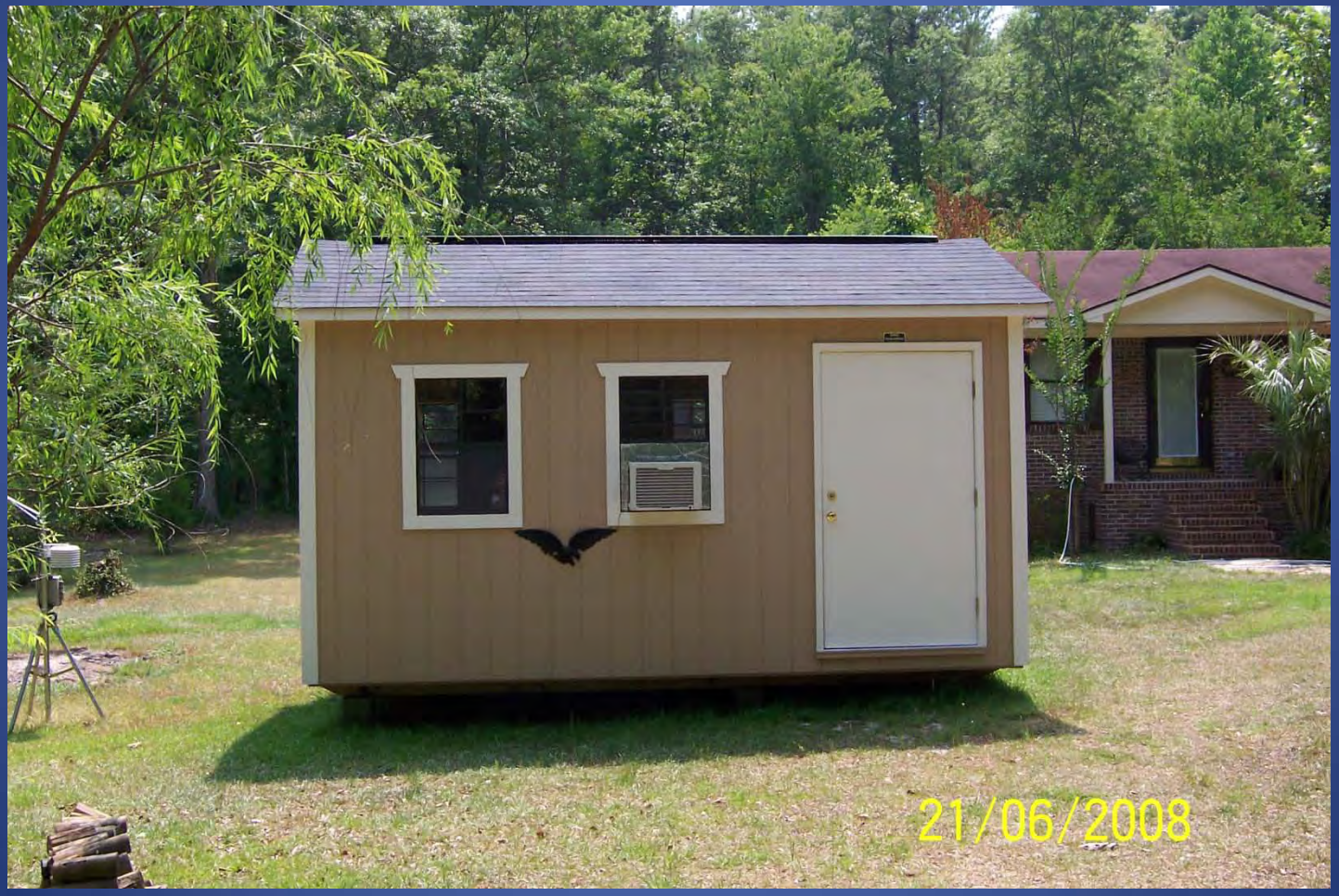
Apollo and Hades

- Buildings were physically located on a property in Beauregard, Alabama at 32.534283^0 N latitude and 85.356333^0 W longitude.

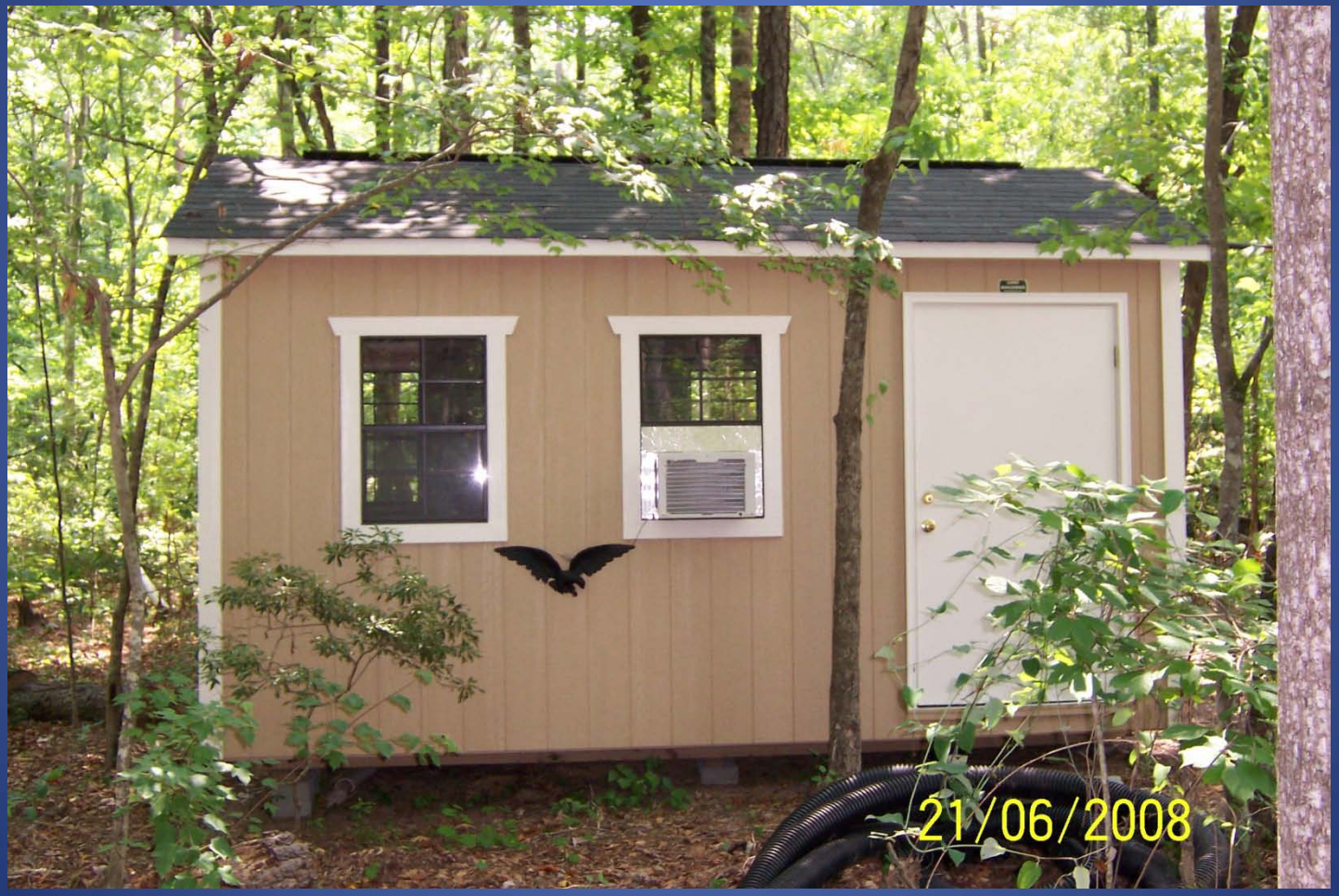
- One building was located in full sunshine (Apollo); the other was located approximately 130 feet away in dense shade (Hades).

- The two buildings were situated in the same spatial configuration relative to the arc of the sun.

Apollo



Hades



Air conditioning

- Identical window air conditioning units in each building - - only draw on the electrical current supplied to each building.
- The air conditioners were Sears - - Model number: 580.75051, Cooling capacity: 5,300 BTU, Watts: 490, EER: 10.8 BTU/hr, Volts: 115; 60Hz, Amps: 4.6(single phase).
- The thermostat on each was set to 72^{o} F.
- AC units were plugged directly into data loggers that recorded electricity use; readings were taken daily.

Measuring light conditions

- Hobo weather stations located 6 feet due south of each building collected information at 15-minute intervals on outside temperature, humidity, and light conditions.

- Photosynthetically Active Radiation (PAR) is the spectral range of solar light from 400 to 700 nanometers that is needed by plants for photosynthesis.

- Mean PAR at each building was calculated from the non-nighttime readings.

Comparison of Light Conditions (PAR) and Electricity Used for Cooling (Kwh) Between Apollo and Hades

	Mean PAR			Kwh/day		
Time Period	Apollo	Hades	t-statistic	Apollo	Hades	t-statistic
April 2008	609.24	153.07	12.12***	1.33	0.28	7.86***
May 2008	655.18	57.05	18.75***	2.56	0.65	7.87***
June 2008	684.71	50.11	22.92***	4.71	1.93	10.69***
July 2008	650.96	41.55	29.06***	4.40	1.80	15.18***
August 2008	543.44	50.12	14.89***	3.61	1.47	8.15***
Sept. 1-17 2008	506.87	47.89	14.07***	3.33	1.45	6.59**

*** t-value statistically significant at 0.01 level

Findings

- The mean power use for cooling Hades (Apollo) over the entire sample period was 1.25 (3.26) kwh/day.
- In percentage terms, Apollo required 2.6 times the electricity for cooling than did Hades.
- In our OLS regression analysis, external temperature and PAR, by themselves, explain 90% of the variation in daily cooling effort.

Discussion

- At the local rate of $0.13/kwh, it cost approximately $7.84 more per month to cool Apollo as compared to Hades, at the 72^{o} F thermostat setting.
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- This may not seem like much, but this is for a very small area (160 square feet).

- The additional cost of cooling a space 10 times this size, which closely approximates the size of many actual dwellings, would surely be several hundreds of dollars per year, even acknowledging the relative cost efficiency of central air conditioning over window units.

Caution

- It seems possible, if not likely, that the impact of tree shade on energy used for cooling is not equal in all circumstances.
- Specifically, the beneficial impact of tree shade may be sensitive to the intensity of the cooling effort, as reflected in:
- (1) the difference between the outside temperature and the desired thermostat setting, and
- (2) the efficiency of the existing structure with respect to preventing warm (cool) air from entering (leaving) the structure.

Future Research

- Explore whether impact of tree shade on electricity used for cooling is affected by:

- (1) changing the intensity of cooling effort - - by exploring a range of thermostat settings on the AC units

- (2) changing structural efficiency - - roof color, reflective blinds on the windows, high efficiency windows

Questions/Comments/Suggestions/Scorn…..