

FACTORS RELATED TO LARGER BUT FEWER WILDFIRES AND FEWER DEER IN CALIFORNIA: A GOOGLE SITES KNOWLEDGE BASE

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ABSTRACT

Large wildfires have been a recent focus of public concern in California and other western states. To provide public access to relevant information, a website knowledge base was developed using the new Google sites tool. Information collection and data analysis were based on an ongoing internet search of the issues in the public discussion. Data analysis includes statistical tests of some common factors proposed in the public discussion related to climate change and forest density. Findings include that data from 1932 show acres burned in Cal Fire jurisdictions has been about constant. Data from 1987 show that total acres burned increased and were correlated to increased maximum temperature, and that that wildfires have become larger but less frequent. A decline in logging activity was strongly correlated to increased fire size and reduced deer. Drought was also correlated to increased fire size and fewer deer. A survey of students indicates that the public has conflicting perceptions about forest density. Many more reported having received information that reduced logging to increase forest density will reduce wildfire risk, contrary to what the data and public information indicate: that reduced logging has increased forest density and wildfire risk.

Keywords: Knowledge Base, Internet Search, Data Analytics, Decision Support, Forest Management

INTRODUCTION

This case example shows how internet search, data analytics, and Google sites can be used to design, populate, and implement a knowledge base related to California forest management. All of the data used in this article are stored in an easy to download spreadsheet format in a “New Google Sites” website, a public knowledge base created for this project located at <https://sites.google.com/sjsu.edu/california-deer-and-forest/home>, a google sites link, and at <http://www.deerfriendly.com/deer/california/forest-density-wildfire-and-deer>. Also included are links to related research, data analysis presented in this article, and charts illustrating the data. The new Google sites is specifically designed to support a knowledge base and is available for no or low cost as a way to share information.

As illustrated in this application, the new Google sites is easy to use, allows for useful integration of other related Google tools such as spreadsheets and drive (storage in the cloud), but is currently limited in features when compared to other tools such as WordPress. For researchers interested in sharing lots of information from an attractive website that requires minimal technical effort, it is a good choice. Because the tool is still in development, it may become much better in the future. Characteristically, Google has provided sketchy information on timelines and specific development goals.

Information and analysis included in the site was determined by using a daily internet search of news and other content related to the recent public debate about forest management in California as a result of several catastrophic wildfires. The objective is to provide other researchers and the public with easy access to data and information.

The Public Debate about California Wildfire and Forest Management

A representative summary of the issues was summarized on national television by then Governor Jerry Brown (2018) who talked about the impact of climate change and mentioned that forests are a lot denser than they were 200 years ago in California. While there is wide public awareness of the climate change issue, there is less public awareness of the forest density issue although it is often described in public forums. For example, a Sacramento paper reported that “there is little debate about what’s causing the problem: The forests are too dense (Hardee, 2018).” However, a survey of students reported in the results section shows that they were mostly aware of climate change as a problem, but more than twice as many thought that reduced timber removal to increase forest density would be more likely to reduce wildfire risk than increased timber removal to reduce density. Years of wildfire

suppression and the dramatic decline of timber removed from California as logging activity has moved to the southeast have been major factors contributing to increased forest density.

Computer simulations of the impacts of climate change have played a major role in the public debate. In his television interview Governor Brown referred to a study that may have been one of these with similar results: Abatzoglou and Williams from 2016; Fried, Torn, and Mills from 2004; or, Westerling and Bryant from 2008. These studies estimated how many additional acres have been burned in the western United States as a result of climate change. A review of research related to forest decision-making (Yousefpour, et al, 2012, p. 1) notes that most studies about changing risk “tend to build on existing approaches about changes in risk levels contingent on climate change scenarios.” Keane, Loehman, Clark, Smithwick, and Miller C. (2015) document a detailed simulation model in a book devoted to computer simulations of these issues. Schnase, J.L. et al (2017) discuss the big data issues in model building. Gu, Syeda, and Ai (2016) describe a simulation approach that relies on social media to augment temperature and other climate data. Kanga and Singh (2017) rely on remote sensing and GIS data to populate their wildfire simulation model. Sterman et al (2016) documents an interactive climate model available for public use on the internet.

Table 1 below lists questions discovered related to forest management and wildfire resulting from the daily, detailed internet search as described by Webb (2016a). The Table was copied from the home page of the website and reduced somewhat to address key questions. Data were collected and analyzed to address these questions. A summary of the results is included in the answer to the questions. On the website the “Details” after each answer in Table 1 links to a page on the site presenting the statistical analysis with supporting charts. These “Details” are presented in the results section of this paper. Deer data were included as a proxy for forest density and as a forest resource.

Table 1: Questions Raised in the Public Debate That Were Analyzed With Results Provided in the Knowledge Base. This information was copied from the front page of the Google site where “*Details*” links to a page providing the analysis.

Questions about California forests, wildfire, and deer. Results based on available data.

How has wildfire changed in California? Data from 1932 to 2016 for timberland under jurisdiction of the California Department of Forestry and Fire Protection (Cal Fire) show a wide variation in the number of acres burned each year, but no change in the average number of acres burned. There were a high number of acres burned in recent years of 2015 and 2016. Data for total wildfires in the state from 1987 to 2016 show an increasing number of total acres burned, fewer but larger fires. *Details*.

How has climate change related to wildfire? The average annual temperature in California rose by about 2 degrees Fahrenheit from 1932 to 2016, with most of the increase coming since the 1980's. Climate variables including annual temperature, precipitation, and drought were correlated somewhat to the number of acres burned each year for Cal Fire timberland from 1932 to 2016, and for total acres burned from 1987 to 2016, with maximum temperature most significant. *Details*

How has timber production in California related to wildfire? Timber removed from California lands has declined dramatically since the 1960's. This decline was strongly correlated with increased fire size and reduced number of fires using data available from 1987 to 2016. Drought was also correlated to increased fire size over this time period. *Details*

How has timber production related to California deer? Deer populations are generally lower when forests are denser, so they serve as an index of forest density. The decline in board feet of lumber removed from California lands was the most significant variable associated with the decline of deer harvests in California using data available from 1976 to 2016. Drought was also correlated to fewer deer. *Details*

Knowledge Management, Knowledge Base, Analytics, and Dashboards

A thorough listing of definitions for Knowledge Management was compiled by Girard and Girard (2015, p. 2) starting with one of the most often quoted from O'Dell and Grayson that it is a “strategy of getting the right

knowledge to the right people at the right time and helping people share and put information into action.” Pauleen and Wang (2017) propose that Knowledge Management research should integrate big data and analytics in order to support decision making. Xu (et al 2015) builds an urban emergency events knowledge base by crowdsourcing of social media and develops algorithms that effectively detects emergency events. The Botstiber Institute for Wildlife Fertility Control is building a web-based repository for related information. In the application described in this paper, factors that may be related to the changing wildfire environment and deer population were tested and are presented here as standard hypothesis tests.

Dashboards, a collection of charts and other displays, are widely popular as a way to convey complex information. Baumeister and Reutelschöfer (2011) discuss the use of dashboards as an effective visualization technique for use in the knowledge base. The following sections present some of the digital dashboards developed for this online knowledge base. The new Google sites is particularly good at creating this kind of dashboard.

The New Google Sites

Harris and Hodges (2016) describe experiments using Google sites as a learning management system, praising the low cost, ease of use, and positive student response. Google acquired the wiki collaboration company, JotSpot, in 2006, and offered it as a free tool or as part of the G-Suites. In 2016, Google announced plans to provide a new version, built from the ground up, with more features advising that “we’ll ensure that the new Sites includes several features necessary for team sites, portals, knowledge bases, and intranets (Google, 2017).” A major improvement over the previous version allows multiple users to work on a web page at the same time without conflict. As of this writing, features were still being added. Formatting options are limited and are being improved at a slow rate. For example, only a few fonts, limited page themes with no option to customize, no ability to create Tables directly on web pages. Tables must be created in Google docs and embedded in the website.

The free version of new Google sites does not allow the easy integration of Google drive, but the full version is included as part of G-Suite so would be available at no incremental costs to organizations using G-Suite as at the author’s university. The basic site with full drive integration is currently priced at \$5 per user month and includes 30GB of storage. The enterprise version with unlimited storage is currently priced at \$12 per month with unlimited storage. A google sites URL, as shown for this site in the first paragraph of this paper, is created for all sites with the option of purchasing a custom domain name from any of the standard providers such as GoDaddy or Google itself.

Charts, spreadsheets, and docs can easily be embedded from Google drive. Spreadsheets can be interactive. To illustrate for this article, Tables from docs embedded in the Google site were copied and pasted into the following results sections. Table titles here are added to provide formal hypotheses tests and conclusions. Charts from the site are omitted in some cases here to save space. Charts were created in Google Sheets, linked to appear in a Google Doc, which was then embedded in the web pages. Changes to data, charts, and docs are all updated automatically. This allows for different persons to work independently on the spreadsheets and docs without anyone having to log in to the site itself, so no need to worry about participants damaging the site. Users can easily download or copy the data. Charts are automatically updated as the data is updated. Trend lines showing underlying equations and the R-square statistic for linear, exponential, polynomial, logarithmic, power series, and moving averages are available with error bars. More information at gsuite.google.com.

DATA ANALYTICS – RESULTS

Data shared on the website were collected from a variety of public sources. Table 2 which provides data definitions, sources, and descriptive statistics was copied directly from the site. Although there are a relatively small number of variables, testing alternative combinations of variables and a variety of time lags proved to be somewhat unwieldy. A data mining approach generally relying on the step-wise regression tool in SPSS was used. A target variable is identified and “best” models are selected using specified significance levels, with statistics available for excluded variables allowing the researcher to get a sense of variable behavior. The results here are divided into sections representing questions from Table 1, each a separate web page on the site.

Table 2: Variables Explored, Definitions, Sources, Descriptive Statistics

Variables in 1932 to 2016 Data Set			
Wild Fire for California	Range	Average	Cal Fire has data back to 1932 for the number of acres burned each year.
Timberland Acres Burned Within Cal Fire Jurisdiction	281 to 147,103	19,010.9	
Climate for California			The National Oceanic and Atmospheric Administration (NOAA) makes monthly climate data dating back to 1895 for each state available in an easy to use online database allowing for quick graphing to visualize data. The average temperature in California has risen by about 2 degrees F. since 1932.
Average Annual Temperature	55.6 to 61.4	57.9	
Average Maximum Temperature	67.9 to 74.2	70.5	
Average Minimum Temperature	42.8 to 48.7	45.4	
Cooling Degree Days	507 to 1176	769.5	
Heating Degree Days	2092 to 3690	3117	
Palmer Drought Severity	-4.44 to 7.14	-0.3	
Palmer Z	-4.34 to 7.14	0.1	
Palmer Hydrological Drought Index	-0.44 to 7.14	-0.3	
Deer Hunt for California			States routinely use a two month moving average of the buck kill as a basis for estimating deer populations.
Total Deer Harvest	10,892 to 102,636	36,783.7	
Two Month Moving Average of Buck Harvest	11,520 to 74,225	35,192.6	
Data Sources			
Wildfire: http://cdfdata.fire.ca.gov/incidents/incidents_statsevents			
Climate: www.ncdc.noaa.gov/cag/statewide/time-series			
Deer: www.wildlife.ca.gov/hunting/deer#5477272-harvest-statistics			
Deer data prior to 1998 provided by California Department of Fish and Wildlife			
Variable Definitions			
Degree days are the difference between the daily temperature mean, (high temperature plus low temperature divided by two) and 65°F.			
Palmer Drought Severity uses temperature and precipitation data to estimate relative dryness. Range: -10 (dry) to +10 (wet). Quantifies long-term drought.			
Palmer Z quantifies short term drought.			
Palmer Hydrological Drought Index quantifies hydrological impacts of drought such as reservoir levels and groundwater levels			
Variables in 1978 to 2016 Data Set			
Includes all variables above in addition to those below			
Timber (MBF, million board feet)	Range	Average	The California Board of Equalization uses timber tax records to estimate the board feet of number removed from California land. The variables measuring harvest value per million board feet (MBF) are calculated using data from the data source.
Timber removed from California (not including tribal lands)	805 to 4670	2501.4	
Timber removed from local, state & federal government lands.	60 to 2048	698.7	
Timber removed from private lands	745 to 2766	1802.7	
Government Harvest Value per MBF	66.7 to 433.1	177.8	
Private Harvest Value per MBF	113.4 to 493.8	261.4	
Data Source: www.boe.ca.gov/proptaxes/pdf/harvyr2.pdf			
Variables in 1987 to 2016 Data Set			
Includes all variables above in addition to those below			
Wildfire	Range	Average	This data includes all wildfire for all jurisdictions, not just timberland wildfire in Cal Fire jurisdiction which is in the 1932 to 2016 data.
Total Acres Burned	44,200 to 1,593,690	557,324	
Number of Fires Reported	6,043 to 13,476	8782.6	
Acres per Fire	4.6 to 254.8	68.7	
Data Source: cdfdata.fire.ca.gov/incidents/incidents_statsevents			

How has wildfire changed in California?

Data from 1932 to 2016, analyzed in Table 3 for Acres Burned on California Timberland in California Department of Forestry and Fire Protection (Cal Fire), show no change in the number of acres burned, although there were a large number of acres burned in 2015 and 2016. Data from 1987 to 2016 analyzed in Table 4 show an increase in the Total Number of Acres Burned and a decrease in the number of fires reported, so the average fire size is becoming larger. This result suggests a need for further investigation. Why would fire under one jurisdiction, Cal Fire, remain constant while total acres burned increases?

Table 3: Results of Hypothesis Test H_1 that The Number of Timber Acres Burned In Cal Fire Jurisdiction from 1932 to 2016 Has Changed. Hypothesis Rejected. No Change.

Dependent Variable: Number of Acres Burned in California Timberland in Cal Fire Jurisdiction Has Been Constant from 1932 to 2016. Linear Regression.			R-square = 0.0014
Independent Variable	Estimated Coefficient	p-Value	
Intercept	17,092.8	0.009896	
Time t = 1 in 1932	44.608	0.733875	
Data from 1932 to 2016 for Acres Burned on California Timberland in California Department of Forestry and Fire Protection (Cal Fire) show no change in the number of acres burned, although there are a large number of acres burned in 2015 and 2016. A slight upward trend, not significant.			

Table 4: Results of Hypothesis Test H_2 that The Total Number of Timber Acres Burned from 1987 to 2016 Has Changed. Hypothesis Accepted. Change fits an exponential model.

Dependent Variable: Total Number of Acres Burned in California from 1987 to 2016 Exponential Model.			R-square = 0.135
Independent Variable	Estimated Coefficient	Model Summary Exponential	
Intercept	261,800	F = 4.353	
Time t = 1 in 1987	0.032	Significance 0.046	
Data from 1987 to 2016 for Total Acres Burned in California show a significant upward trend best summarized by an exponential model, indicating an accelerating trend. A linear model also shows an upward trend, but with less significance 0.072.			

Table 5 reports that average wildfire size increased from 1987 to 2016. An exponential model provide the best fit to the data.

Table 5: Results of Hypothesis Test H₃ That The Average Number Acres per Fire from 1987 to 2016 Has Changed. Hypothesis Accepted. Change Fits an Exponential Model.

Dependent Variable: Average Acres per Fire in California from 1987 to 2016 R-square = 0.292			
Independent Variable	Estimated Coefficient	Model Summary Exponential	
Intercept	22.84	F = 11.533	
Time t = 1 in 1987	0.051	Significance 0.002	
An exponential model fits the data with high reliability, but compound, growth, and logistic produced similar statistics. The model estimate is above the actuals after 2009, suggesting the exponential will overestimate into the future.			

Table 6 reports that the total number of wildfires declined significantly from 1987 to 2016, finishing the summary of how wildfire has changed in California. Among the alternative equation formats tested, the logarithmic equation provided the best fit to the data. Since 1987, total acres burned has increased, the average number of acres burned per year has increased, but the number of wildfires per year has declined. Charts appearing on the site are not displayed for some of the remaining Tables to conserve space here.

How has climate change related to wildfire?

Results of data mining for climate change factors related to wildfire begin with Table 7. Although timberland acres burned in California from 1932 to 2016 were constant, the best equation for predicting the number of acres burned in any one year relied on the maximum temperature for the state during the year. Other variables listed in Table 2 that were available from 1932 to 2016 were excluded in the step-wise regression process. The negative intercept in Table 7 suggests the number of acres burned would become negative if the temperature fell to zero, a condition far outside the range of the data used to build the model, but suggesting a more complex equation is in order. An equation similar to the one in Table 7 also comes out of the 1987 to 2016 data for total wildfire acres burned.

Table 6: H₄ That Number of Fires Has Declined. Hypothesis Accepted. Logarithmic.

Dependent Variable: Number of Wildfires per Year in California from 1987 to 2016 R-square = 0.702		
Independent Variable	Estimated Coefficient	Model Summary: Logarithmic
		F = 65.8
Intercept	13,569.5	Significance 0.000
Time t = 1 in 1987	-1934.5	

Table 7: H₅ That Temperature is Associated with Timber Acres Burned. Hypothesis Accepted.

Dependent Variable: Timberland Acres Burned in Cal Fire Jurisdiction 1932 to 2016 R-square = 0.122		
Independent Variable	Estimated Coefficient	p-Value
Intercept	- 589,785	0.002
Maximum Temperature	8,353.8	0.001

How has timber production in California related to wildfire?

Tables 8 and 9 contain analysis for the 1987 to 2016 data set. During that period total acres burned increased and board feet of timber removed fell by 66.6 percent. As Table 8 reports, the board feet of timber removed from California was the most significant variable explaining the decline in the average fire size while drought was also very significant. Wildfire size goes up as less timber is removed or in drought years. Board feet of timber removed was the only variable not excluded from the equation explaining the number of wildfires per year, with the number going down as less timber is removed.

Table 8: H₆ That Climate and Timber Removed Have Affected Increasing Average Fire Size. Accepted

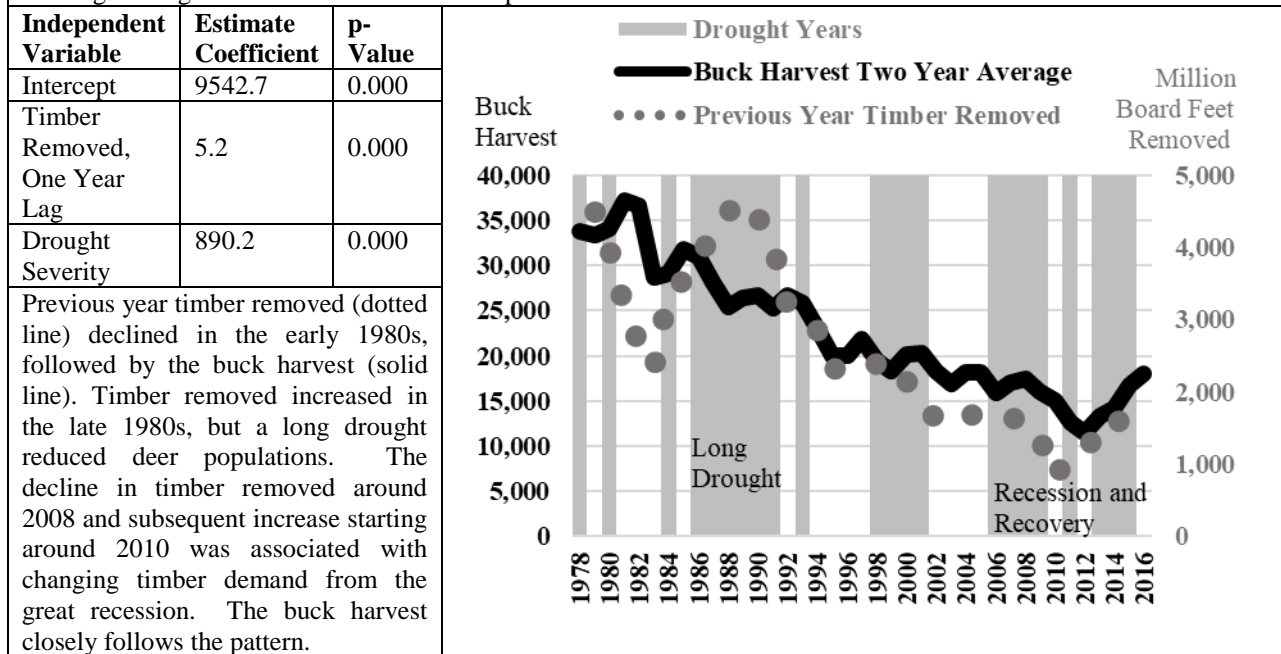
Dependent Variable: Average Fire Size per Year in California from 1987 to 2016 R-square = 0.306		
Independent Variable	Estimated Coefficient	p-Value
Intercept	116.5	0.000
Timber Removed	-0.026	0.011
Drought Severity	-10.1	0.019

Table 9: H₇ That Timber Remove Is Correlated to the Number of Fires. Accepted

Dependent Variable: Number of Wildfires per Year in California from 1987 to 2016. R-square = 0.664		
Independent Variable	Estimated Coefficient	p-Value
Intercept	5395.7	0.000
Timber Removed	1.541	0.000
All other variables were excluded using step-wise regression and a significance level of 0.05.		

How has climate timber production related to the California deer population?

Table 10: H₆ That Climate and Timber Removed Have Affected Deer Populations as Measured by a Two Year Moving Average of the Buck Harvest. Accepted



A two-year moving average of the buck harvest is typically used by states to estimate deer population trends (Webb, 2016b, 2018). The equation reported in Table 10 indicates that about 75 percent of the variation in the buck harvest moving average is explained by the two variables, timber removed lagged by one year and drought severity. The

one year lag is consistent with deer behavior since deer find a significant amount of food in a newly cut forested area where the sunlight is allowed to reach the ground and grow new plants for deer to browse on. By itself, timber removed explained 63.4 percent of the variation in the buck harvest.

In looking at the equation chart, it appears that a significant decline in the California deer harvest into 2010 and a resulting recovery may be explained by the great recession which reduced demand for timber and then increased in demand for timber as the economic recovered. Increased forest density is a common factor negatively affecting deer populations. This relationship supports the analysis that reduced logging (timber removal), allowing more fuel in denser forests, has increased the risk of larger wildfire. Fire suppression may have the same effect, but no relationship was uncovered in the data relating wildfire to deer.

Public Perceptions as Measured by a Student Survey

Students in the business school taking an introductory class in information systems were asked to report what information they had received about wildfire risk in California. Results of this convenience sample are reported in Table 11. Percentages don't add to 100 because students generally reported receiving information on more than one factor. Students also reported hearing contradictory information such as both that increased temperature and decreased temperature was a risk factor.

Although our internet search of public information regarding factors related to risk of wildfire did not find any that suggested too much logging or timber removal would increase wildfire risk, many students reported that they had received this information from some public source. More than twice as many reported they had learned that too much logging would increase wildfire risk than those who reported that reduced logging would increase wildfire risk. Years of information on the negative aspects of logging appear to have created an impression that logging is always bad. The risk factor that most students reported having learned about from public sources was climate change, with rising temperature playing a role. Somewhat a surprise, about 10 percent reported having heard that falling temperatures related to climate change increased wildfire risk. Drought was the second most learned factor, with about two-thirds reporting this risk factor. An outbreak of bark beetles has also received some public attention. The beetles have killed many trees in the past few years, putting a lot of dry fuel in the form of dead trees in the forest.

Table 11: Students Report Which Factors Related to Increased Wildfire Risk They Remember Learning About from Public Sources, N = 149

Factor That Would Increase Wildfire Risk	Number of Responses	Percent of Respondents
Climate change, rising temperatures	124	83.2 %
Climate change, falling temperatures	15	10.1 %
Too much logging (timber removal), reducing forest density	55	36.9 %
Reduced logging (timber removal), increasing forest density	24	16.1 %
Bark Beetles, Killing Trees	13	8.7 %
Drought	101	67.8 %

The public in California have strong negative perceptions about logging and the state has made an effort to reduce logging in order to capture more carbon dioxide in the atmosphere. This negative public perception about logging and the timber industry may be making students believe they have learned from public sources something which does not seem to appear in public sources.

CONCLUSIONS

The goal of this project has been to use information systems tools - a website, data collection and analytics - to provide information for the public and other researchers interested in this topic. The new Google sites provides a low-cost and easy to use platform for building a website knowledge base. Researchers spend so much time and money to collect data, sharing of data in this fashion may reduce this barrier to knowledge creation. However, the new Google sites tool is still in the development stage, so it is unclear what features will be added. As a result, it may not be a good choice for a major website effort. The tool has been in a slow development stage since it first

became available in 2006, and work on the new version is also proceeding at a slow pace. Features are limited, but the price is low for unlimited storage and ease of use.

Both of the risks to increased wildfire -- climate change and forest density -- that California Governor Jerry Brown mentioned in his television interview quoted at the beginning of this paper are supported by the data analysis. The governor spent much more time on climate change, but also mentioned that forests are denser than they were 200 years ago. To the extent that this mix of attention is reflective of the public information flow about this topic, it can be observed in the student survey results. A significant majority, 83.2 percent, reported having information that rising temperatures resulting from climate change increase wildfire risk. A majority, 67.8 percent, were also aware that drought, a climate issue, increased wildfire risk. Only 16.1 percent reported having information that reduced logging which increases forest density was a wildfire risk factor – a risk factor strongly supported by the data and which can be found in public information sources. Surprising, 36.9 percent had the view that they had learned that too much logging reduced forest density and so increased wildfire risk. No public sources for this view were discovered in the internet search done for this research, so it appears this view may be an artifact of a general public malaise related to the timber industry.

This exploratory data analysis suggests some possible further research efforts. Although the number of acres of timberland burned in California under Cal Fire jurisdiction since 1932 is correlated to maximum temperature, the average number of acres burned each year has remained about the same while the temperature has risen. The data showing increased total acres burned was only available back to 1987. Further searching of the internet may uncover more data that might explain why acres burned in on jurisdiction has remained constant while total acres burned has increased. The analysis showing that the deer population is trending lower as the board feet of timber removed is declining provides further evidence that reduced timber harvests are increasing forest density. Deer populations decline as forest density goes up.

How effective is the state's policy of discouraging timber harvests in order to capture carbon dioxide when denser forests increase risk of wildfire that releases carbon dioxide? No research was uncovered addressing this issue. The equations generated here form the beginnings of a more comprehensive computer model that could be used to provide decision support. It is hoped that the knowledge base created for this project will inform the public debate and support related research.

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