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

***G. Kent Webb, San Jose State University, g.webb@sjsu.edu***

## 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 starting from 1932 show annual acres burned in Cal Fire jurisdictions have 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 populations. 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 large 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 sites.google.com/sjsu.edu/california-deer-and-forest/home, a Google sites URL, and at 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.

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 discussion 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 presented 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 increased timber removal to reduce forest density would increase large wildfire risk than thought that reduced timber removal to increase forest density would increase risk. 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 "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 done as described by Webb (2016a). Table 1 was copied from the home page of the website and reduced somewhat to address key questions. Relevant data were collected and analyzed. A summary of the results appears below as an answer to each question. 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. Data for total wildfires in the state from 1987 to 2016 show an increase in 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 timber 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 detect 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 Reutelshoefer (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 for 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, there are only a few fonts, limited page themes with no option to customize, and 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 per month and includes 30GB of storage. The enterprise version with unlimited storage is currently priced at $12 per user 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 – the second URL in the first paragraph.

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. Annual wildfire data came from the California Department of Forestry and Fire Protection, commonly known as Cal Fire. Data for timber removed from California lands came from the California Board of Equalization which relies on tax records to make estimates. All of the climate data came from The National Oceanic and Atmospheric Administration (NOAA) which has an easy to use website supplying data for all states back to 1895. Table 2 which provides data definitions, sources, and descriptive statistics was copied directly from the website developed for this project.

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 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** (All URL's were active at the time of writing)<br>Wildfire: http://cdfdata.fire.ca.gov/incidents/incidents_statsevents<br>Climate: www.ncdc.noaa.gov/cag/statewide/time-series<br>Deer: www.wildlife.ca.gov/hunting/deer#5477272-harvest-statistics<br>Deer data prior to 1998 provided by California Department of Fish and Wildlife | | | |
| **Variable Definitions**<br>Degree days are the difference between the daily temperature mean, (high temperature plus low temperature divided by two) and 65°F.<br>Palmer Drought Severity uses temperature and precipitation data to estimate relative dryness. Range: -10 (dry) to +10 (wet). Quantifies long-term drought.<br>Palmer Z quantifies short term drought.<br>Palmer Hydrological Drought Index quantifies hydrological impacts of drought such as reservoir levels and groundwater levels | | | |
| **Variables in 1978 to 2016 Data Set**<br>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. |
| 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**<br>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 the1932 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<br>All data are available at: sites.google.com/sjsu.edu/california-deer-and-forest/data-for-2019-report | | | |

Data from 1932 to 2016, analyzed in Table 3 for annual acres burned on timberland in California Department of Forestry and Fire Protection (Cal Fire) jurisdiction, show no significant increase over time. Data from 1987 to 2016 analyzed in Table 4 show an increase in the total number of acres burned by wildfire throughout California. This result suggests a need for further investigation. Why would fire under one jurisdiction, Cal Fire, remain constant while total acres burned increased?

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

| Dependent Variable: Annual Number of Acres Burned in California Timberland in Cal Fire Jurisdiction 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 Cal Fire jurisdiction show no change in the annual number of acres burned, although there were a large number of acres burned in 2015 and 2016. A slight upward trend, not significant. | | |

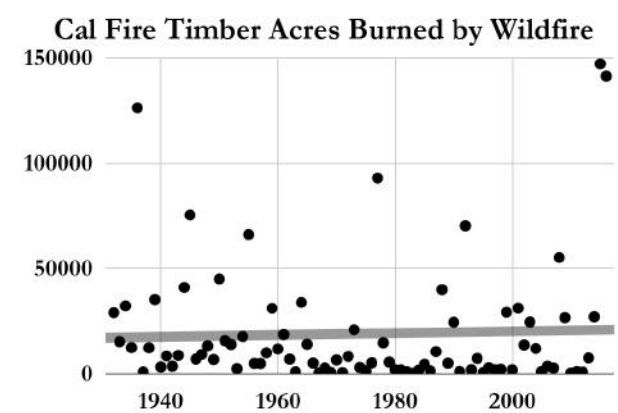
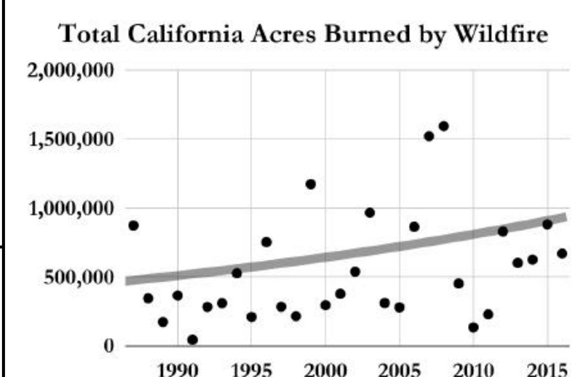



**Table 4.** Results of Hypothesis Test $H_2$ that the Total Annual Number of Acres Burned by Wildfire in California from 1987 to 2016 Has Changed. Hypothesis Accepted. Change Fits an Exponential Model.

| Dependent Variable: Total Annual Number of Acres Burned by Wildfire 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. | | |



In the worst wildfire year on record, 2018, a total of 1.9 million acres burned although this and related data were not available in time to be included in the analysis. Table 5 reports that the average wildfire size increased from 1987 to 2016. An exponential model provides the best fit to the data.

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 per wildfire has increased, but the number of wildfires per year has declined. Charts appearing on the website are not displayed for some of the remaining tables to conserve space here.

**Table 5.** $H_3$ That the Total Annual Number Acres Burned per Wildfire from 1987 to 2016 Has Changed. Hypothesis Accepted. Change Fits an Exponential Model.

| | | |
|---|---|---|
| Dependent Variable: Annual Acres Burned per Wildfire in California from 1987 to 2016<br>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 | | |

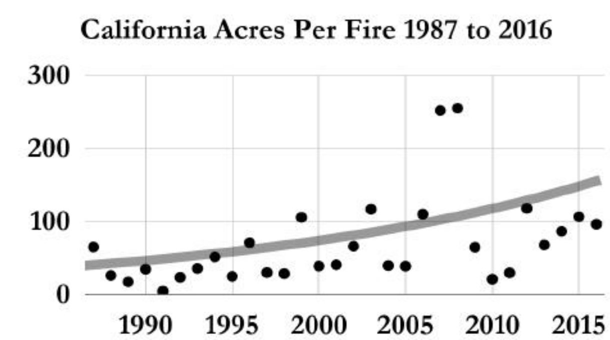



**Table 6.** $H_4$ That The Number of Fires Has Declined. Hypothesis Accepted. Logarithmic.

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

**Table 7.** $H_5$ That Temperature is Associated with Timber Acres Burned. Hypothesis Accepted.

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

**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 approximately 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.

**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 increase in the average fire size while drought was also very significant. Wildfire size goes up as less timber is removed and in drought years. As reported in Table 9, 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. The relationship is so highly significant that no non-zero values appear even three decimal places to the right of the decimal. While both values are trending down, there and up and down years for both. Perhaps activity related to timber removal has caused small wildfires.

**Table 8.** $H_6$ That Timber Removed and Drought Is Correlated to Average Fire Size. Accepted.

| Dependent Variable: Average Fire Size per Year in California from 1987 to 2016<br>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 |

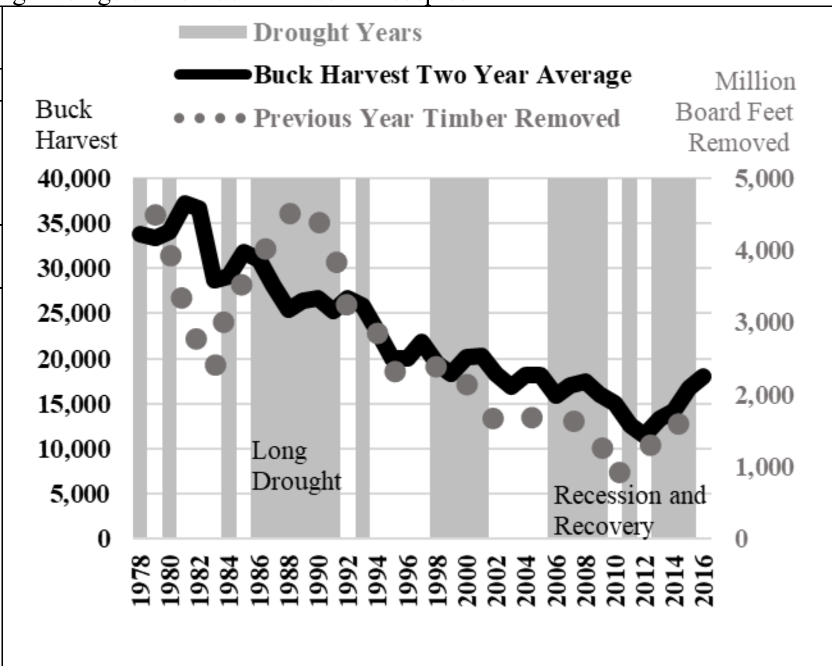
**Table 9.** $H_7$ That Timber Removed Is Correlated to the Number of Fires. Accepted.

| Dependent Variable: Number of Wildfires per Year in California from 1987 to 2016.<br>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 and Timber Production Related to the California Deer Population?**
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 more food in a forested area where timber removed allows more sunlight 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.

**Table 10.** $H_8$ That Drought and Timber Removed Have Affected Deer Populations as Measured by a Two Year Moving Average of the Buck Harvest. Accepted

| **Independent Variable** | **Estimate Coefficient** | **p-Value** |
|---|---|---|
| Intercept | 9542.7 | 0.000 |
| Timber Removed, One Year Lag | 5.2 | 0.000 |
| Drought Severity | 890.2 | 0.000 |
| Previous year timber removed (dotted line) declined in the early 1980s, followed by the buck harvest (solid line). Timber removed increased in the late 1980s, but a long drought reduced deer populations. The decline in timber removed around 2008 and subsequent increase starting around 2010 was associated with changing timber demand from the great recession and recovery. The buck harvest closely follows the pattern. | | |



In looking at the Table 10 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 demand for timber as the economy recovered. Increased forest density is a common factor negatively affecting deer populations. This relationship supports the analysis that reduced logging (timber removed), 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.

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

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

Although our internet search of public information regarding factors related to risk of wildfire did not find any that suggested increased logging (timber removed) would increase large 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 increased 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 learned 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.

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 data 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 increased 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 in each year 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 and other research efforts may uncover more data that might explain why acres burned in one 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 large 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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