Shining a Light on Cancer Rates and Brownfield Development

INTRODUCTION

Since its discovery, light with the harnessing of fire has been a common partner in mans life. Humans have cooked with, heated themselves by, and illuminated their world during the night with fire. We began to break from this partnership with the invention of the incandescent bulb and the turning of the twentieth century. The use of this new light source rapidly became integrated into all aspects of the industrialized world and progress was coupled with increased amounts of night time light. Like its predecessor fire, the incandescent light bulb can have adverse health effects on humans, but unlike the damage from smoke inhalation or threat of fire the artificial light from incandescent has recently been acknowledge to increase the rate of cancer in humans.

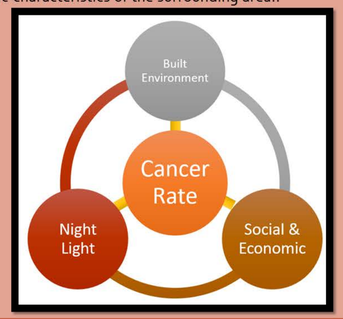
LITERATURE REVIEW

- Human produced night time light illumination has been in existence since before civilizations were created by way of fire. These fires most often were associated with cooking and heating. Smoke was produced and made the first carcinogen.
- The invention of the incandescent bulb made light abundant and reliable. Shift work became possible and allowed for added economic gains.
- Societies and especially cityscapes became lite with this new light source. Residential, industrial, and commercial areas all emit night time light.
- The capability to observe and quantify night time lights became possible in the 1960's with the Defense Meteorological Satellite Program (DMSP). For the first time global night time light illumination could be recorded and studied. The course resolution of the measurements allows for macro analysis.
- Research has found that prolonged artificial light exposure can lead to adverse health effects. This can include confusion, headaches, and even cancer if the conditions are extreme enough.
- Brownfields exists in almost all urban centers. These areas have recently become a target for redevelopment and with that will most likely be relite by the light of "progress".

- This study will pair remotely sensed DMSP observations and brownfield redevelopment with medically diagnosed cancer rates at the macro level.

CONCEPTUAL FRAMEWORK

As municipalities seek to redevelop brownfields within their jurisdictions to enhance their appeal and profitability they also increase the amount of nighttime light in and around the redevelopment area. Brownfields are typically located within the original core of a city and there has been a recent push to bring these properties back into economic operation. I believe that the proximity of the brownfield sites within urban cores will increase cancer rates among the local population because the redevelopment will increase night time light pollution as well as have an effect on the built environment itself and the social and economic characteristics of the surrounding area..

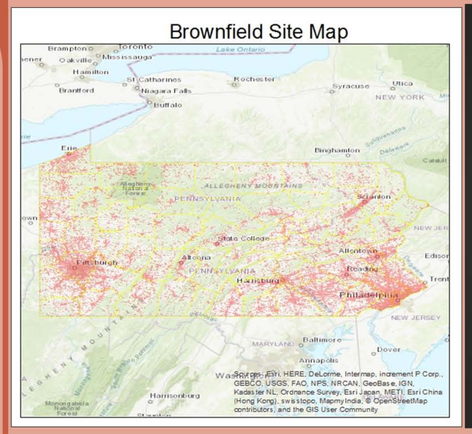


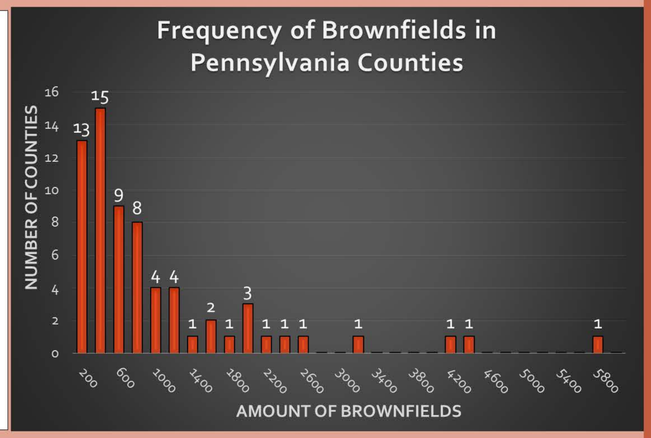
HYPOTHESES

- **HO_1** Night time light measurements from the DMSP can be used as an indicator for cancer rates among a population at the county level in the United States. The DMSP statistics can also improve prediction models when used with other known variables that predict cancer rates.
- **HO_n** Night time light measurements from the DMSP are not an indicator for cancer rates among a population at the county level in the United States and do not improve prediction models when used with other known cancer rate prediction variables.

STUDY AREA

The Commonwealth of Pennsylvania has a history of being a manufacturing and extractive resource economy. This has served the state well prior to globalization, but since the early 1990's many sectors of their economy have relocated. Pennsylvania is home to a dense amount of brownfields (59,474 sites) which are becoming a focal point for developers. For these reasons the Commonwealth will serve as the study area for this research at the county level (67 counties) from 1990 to 2015.





METHODOLOGY

This study will be conducted in 2 phases.

- First, 17 variables from within the 3 sectors of conceptualization and across the 25 year time period will be analyzed by way of linear regression to predict cancer rates within counties. These individual sector models will quantify the impacts the sector variables have on predicting cancer rates and serve as a baseline for comparison to one another and a full model of linear regression that contains all 17 variables. Variations in the effects that each variable has from their independent model and within the full model will be assessed.

DMSP		Social & Economic	Built Environment
Minimum	Sum	Education Rate	Brownfields
Maximum	Variety	Per Capital Income	Population Density
Range	Majority	Total Population	
Mean	Minority	White Population	
STD	Median	Minority Population	

- Secondly, a time series visual analysis will be conducted to asses whether the migration of DMSP variables have an effect on cancer rates. The migration direction will be computed using mean center weighted shifts in the sum of all light within the county at different time periods. Quantities of light and cancer rates will be expressed as a net gain or lose from the previous time period for analysis.

RESULTS

DMSP Light Model

```
lm(formula = TotalCancerCase ~ Minimum + Maximum + Range + Mean +
    StandardDeviation + Sum + Variety + Majority + Minority +
    Median)

                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        1.953e+03  6.571e+02   2.973  0.00323 **
Minimum           -8.865e+01  4.267e+01  -2.077  0.03875 *
Maximum            7.127e+01  4.349e+01   1.639  0.10249
Range                     NA         NA      NA       NA
Mean               1.215e+02  6.845e+01   1.775  0.07708 .
StandardDeviation -2.346e+01  6.298e+01  -0.372  0.70987
Sum                1.163e-03  5.440e-03   0.214  0.83085
Variety           -1.000e+02  4.696e+01  -2.130  0.03414 *
Majority          -2.160e+01  9.940e+00  -2.173  0.03071 *
Minority          -8.746e+00  4.832e+00  -1.810  0.07147 .
Median            -6.194e+01  5.029e+01  -1.232  0.21924
---
Residual standard error: 1470 on 258 degrees of freedom
Multiple R-squared:  0.1059,    Adjusted R-squared:  0.07474
```

Social & Economic Model

```
lm(formula = TotalCancerCase ~ EducationRate + PerCapitalIncome +
    TotalPopulation + WhitePopulation + MinorityPopulation)

                    Estimate Std. Error t value Pr(>|t|)
(Intercept)       -1.987e+02  7.337e+01  -2.708 0.007219 **
EducationRate      1.516e+02  1.563e+02   0.970 0.332999
PerCapitalIncome   1.025e-02  1.565e-03   6.553 2.97e-10 ***
TotalPopulation    5.117e-03  2.012e-04  25.435  < 2e-16 ***
WhitePopulation    8.125e-04  2.261e-04   3.593 0.000391 ***
MinorityPopulation -4.925e+02  2.828e+02  -1.741 0.082809 .
---
Residual standard error: 139.4 on 262 degrees of freedom
Multiple R-squared:  0.9918,    Adjusted R-squared:  0.9917
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

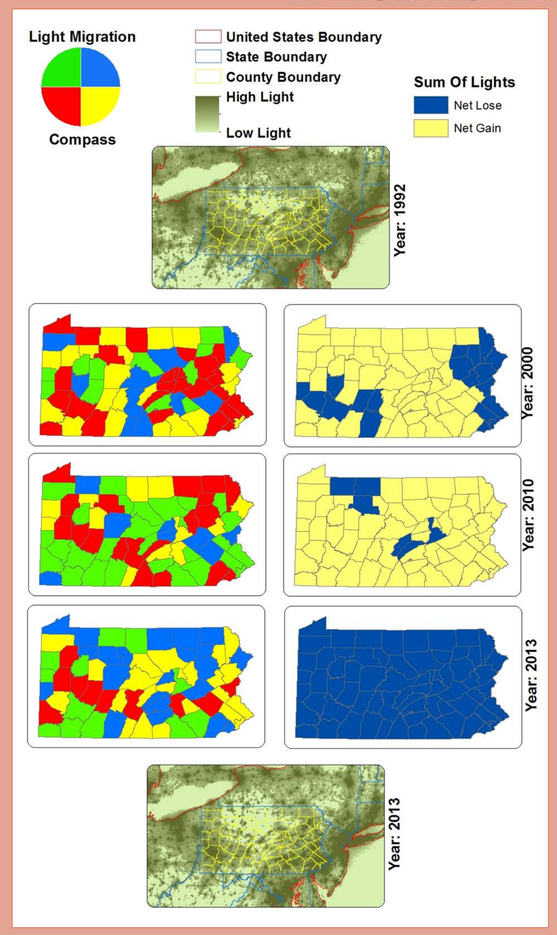
Built Environment Model

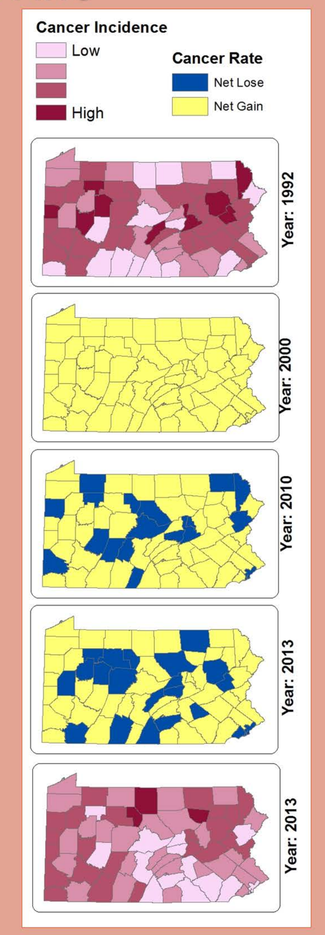
```
lm(formula = TotalCancerCase ~ Brownfield + PopulationDensity)

                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       -154.45492   39.31903  -3.928 0.000109 ***
Brownfield           1.37455    0.05190  26.484  < 2e-16 ***
PopulationDensity    0.00597    0.30500   0.020 0.984397
---
Residual standard error: 477 on 265 degrees of freedom
Multiple R-squared:  0.9033,    Adjusted R-squared:  0.9026
```

Full Model

```
lm(formula = TotalCancerCase ~ Brownfield + PopulationDensity +
    Minimum + Maximum + Range + Mean + StandardDeviation + Sum +
    Variety + Majority + Minority + Median + EducationRate +
    PerCapitalIncome + TotalPopulation + WhitePopulation +
    MinorityPopulation)

                    Estimate Std. Error t value Pr(>|t|)
(Intercept)       -2.361e+02  1.102e+02  -2.143   0.0331 *
Brownfield         9.756e-02  4.371e-02   2.232   0.0265 *
PopulationDensity  5.080e-01  1.980e-01   2.566   0.0109 *
Minimum           -3.872e+00  4.052e+00  -0.956   0.3402
Maximum           -2.293e+00  4.398e+00  -0.521   0.6026
Range                     NA         NA      NA       NA
Mean              -9.559e+00  6.907e+00  -1.384   0.1676
StandardDeviation -1.458e-01  5.973e+00  -0.024   0.9805
Sum                3.014e-04  6.323e-04   0.477   0.6340
Variety            3.469e+00  4.664e+00   0.744   0.4577
Majority           6.237e-01  9.278e-01   0.672   0.5021
Minority          -4.017e-01  4.569e-01  -0.879   0.3802
Median             9.522e+00  4.820e+00   1.975   0.0493 *
EducationRate      2.128e+02  1.667e+02   1.276   0.2030
PerCapitalIncome   9.310e-03  1.626e-03   5.725 2.94e-08 ***
TotalPopulation    4.942e-03  2.062e-04  23.966  < 2e-16 ***
WhitePopulation    2.036e-04  3.157e-04   0.645   0.5196
MinorityPopulation -4.018e+02  2.834e+02  -1.418   0.1575
---
Residual standard error: 134.4 on 251 degrees of freedom
Multiple R-squared:  0.9927,    Adjusted R-squared:  0.9923
```

TIME SERIES MAPPING





CONCLUSIONS

This study analyzed the relationship between DMSP night time light measurements, cancer rates, and known cancer rate predictors at the county level within the Commonwealth of Pennsylvania. The following list summarizes the findings of the study:

- The DMSP Light Model revealed that 3 of the 10 variables were highly significant in predicting a county's cancer rate. DMSP minimum, variety, and majority light values assisted the model in explaining 7 percent of all cancer rates. This establishes a small association between DMSP measurement values and cancer rates.
- The Social & Economic Model revealed that 3 of the 5 variables were highly significant in predicting a county's cancer rate. SES variables of per capital income, total population, and white (majority) population values assisted in explaining 99 percent of cancer rates. These relationships have been confirmed by other research.
- The Built Environment Model revealed that 1 of the 2 variables were highly significant in predicting a county's cancer rate. The quantity of brownfields within a county predicts 90 percent of cancer rates. These sites are known to have residual pollutants within them and are the focus of this study as they will be redeveloped and re-lite.
- The Full Model of linear regression revealed 5 of the 17 total variables were highly significant in predicting a county's cancer rate. The variables performed differently when combined into a full model as shown by the change in variable significance from the individual sector models. The amount of brownfields, population density, median DMSP light value, per capital income, and total population assisted the model in explaining 99 percent of all cancer rates. The fact that the median DMSP light value was significant in the Full Model supports the **HO_1** hypothesis.
- The Time Series visual analysis establishes 1992 baseline levels for DMSP sum of light and cancer rates as a starting point and progresses through 3 iterations of mapping. It is not clear from the visual analysis that the migration of light interacted on the cancer rate directly.

The correlation of night time light data gathered from the DMSP and a county's cancer rate determined in this study needs further research to affirm the correlation and its strengths. It is possible that the level of this study has caused aggregated results in the findings which could be cause for the weak correlation within the linear regression models. A future study done at the census statistical area level that utilizes census block data instead of county level data could shed new light on this research.

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