Cutting Consumption of Paper on Campus

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Southern Oregon University

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I.   Introduction

This capstone is an audit of Southern Oregon University's printer use. The

printing data for how many pages and who printed them has already been gathered

automatically, but the data is either very crude or oversimplified with the current

software output. The goal is to analyze this data to come up with and implement effective solutions in order to reducing the amount of printing at SOU.

Currently SOU purchases 6000 reams of paper every year, which is about 120,000 pounds. Only 26,000 pounds makes its way into recycling bins here on SOU's campus, making up over 50% of our recycled materials by weight. Even if the paper does make its way into the recycling bins it's is still an energy intensive process to reprocess the paper into pulp and then paper again taking up to 6 kilowatt hours to produce 1 pound of copier paper (Allwood 2011).

Just over this past academic year SOU has printed 2,618,862 pages and only 496,342 were duplexed. According to values derived from the Papercut network printer management system's environmental impact reports, our printing resulted in the consumption of 34.6 trees and the production of 12,518 kilograms of CO_2. The amount of printers and copiers on campus is also unsustainable with over 400 printers showing up on the network, not counting personal printers. By comparison, a similar sized institution Oregon tech, has only 32 copiers and 50 network printers.

Table 1. Environmental Impact from SOU's printing, values are calculated sums from, every user's printing impacts output from papercut.

Academic Year	Number of Trees Consumed	CO2 Produced in KG	KW hours
2011-2012	31.6818	14,919.031	56,365.764
2012-2013	30.0223	10,865.547	41,056.674
2013-2014	30.4987	11,030.102	41,679.228
2014-2015	31.6588	11,456.735	43,292.652

2015-2016	34.584	12,517.945	47,291.82
SUMS	158.4456	60,789.36	229,686.138

Table 2. Yearly Environmental Impact of SOU's total printing on the Ashland campus by academic year.

Academic Year	Number of Trees Consumed	CO2 Produced in Kilograms	KW hours of energy for production
2011-2012	31.6818	14,919.031	56,365.764
2012-2013	30.0223	10,865.547	41,056.674
2013-2014	30.4987	11,030.102	41,679.228
2014-2015	31.6588	1,1456.735	43,292.652
2015-2016	34.584	12,517.945	47,291.82
SUMS	158.4456	60,789.36	229,686.138

Paper waste is an important area to focus on as 50% of our trash volume is made up by paper products in the USA (Rathje 1991). Sustainability and efficient conservation of resources are key tenets of environmental science. The current logging practices in the United states are unsustainable as we have lost three hundred million acres of forest land (Forest 2012) since logging began by european settlers.

Reducing printer waste is one small step toward reducing all paper waste in the form of media, sanitation, and packaging. Eventually finding an alternative sustainable means of meeting our demands for these products. Which will grow with increased populations and socioeconomic status of people. As was said earlier not only are trees the only utilized resource, but an immense amount of energy goes into producing paper

products. Up to 13 kilowatts hours per kilogram of virgin paper (Villanueva 2007). Reducing consumption would also mean less energy demand which can have a direct impact on fossil fuels consumed, and rising CO_2 levels in the atmosphere. The best way to accommodate a planet with seven plus billion people is to reduce the individual impacts that they all have.

In this project I hope to identify key areas of printer waste and formulate a strategy to reduce paper waste by 20%, or a reduction of 1200 reams of paper. I think this a good goal to aim for since SOU's printing has increased on average of about 12% every year, so a 20% reduction would mean a 10% decrease in usage from last year (Christ 2016). This would not only save the University a considerable sum of money in supplies and maintenance costs, but also to quantify this in environmental terms of trees, energy and water saved.

The financial impact of printing on the campus is about 2.5 cents per black and white page and about 34 cents per color page when taking into account the material and maintenance costs. Cutting printing on campus by 20% for black and white would mean a total savings of $55,101 for the 2015-2016 year (Christ, B. Southern Oregon 2016). This project should also highlight areas of campus that are especially wasteful in printing.

Realistically a reduction of printing on Southern Oregon University's campus will not net a relatively large environmental benefit as the end result would only save 7 trees, and 95 Megawatts of power from being used process new paper (Kinsella 2015, Christ, B. Southern Oregon 2016). Although we can use it as an example of sustainable

policy to be followed by other college campuses and agencies, as a way to not only meet sustainability goals, but also help with the financial bottom line.

There has not been much peer reviewed research on the subject of stopping paper consumption. The last study done specifically to changing printing habits was in 1975 by Virginia Polytechnic Institute and State University (Geller 1975). The study mostly pertains to improving student recycling and waste reduction through a positive reinforcement raffel reward system. There are plenty of contemporary studies centered around the reduction of waste through recycling, but none focus on the reduction of paper waste by stopping their consumption of in the first place.

II.   Methodology

Currently every page printed is tied to a department, a user and the Papercut system. Papercut is a network based printer management system that automatically collects data and manages its users. This data will be used to identify key outliers in departments to help cull overzealous printing habits. I will first be formatting and analyzing this data to identify key areas of waste in SOU's printing. Then using the trends I have identified I can see if I can find methods for culling SOU's printer waste. As seen in the results section the increase in printing is mostly attributed to the top 100 users at SOU. Therefore my hypothesis testing is as follows.

H0: The printing habits of the top 100 users at SOU are not a statistically significant cause to SOU's increase in printing.
Ha: The printing habits of the top 100 users at SOU are a statistically significant cause to SOU's increase in printing.

The main goal would be to see if educating faculty to deliver content to students and other faculty by other means would yield a loss in paper usage on campus. Education would be done by providing faculty with reminders at their communal copiers letting them know the alternative means of providing syllabi and additional readings through moodle or owncloud/class folder. I would also have materials present to educate faculty of their printing impacts on a couple of different scales, as a print job, user, and a department. This would hopefully help to persuade faculty to switch to alternative means of delivering information.

We can also use the data to find peak printing times during the terms and find ways to reduce them. One peak printing time is right before the term when many professors are printing out syllabi. A five page syllabus with twenty students in the class would mean one hundred pages printed for just that one class. Noticing this we would urge professors to instead make their class syllabi available over an electronic means, such as moodle or the network folders. A similar method could be used for identifying professors that routinely print out readings for students which could otherwise be delivered electronically.

III.   Results and Discussion

When analyzing the Papercut systems one thing noticed was that the average amount of printed pages by department printers has been increasing since the 2011-2012 academic year. It has gone in total from 1,655,383 to 2,618,862 pages printed per year, while our enrollment has gone down to a low of 6,097 students in 2013-2014 from a peak of 6,745, this juxtaposition is shown in Figure 1. Further data analysis showed

that there was a weak negative correlation between the enrollment and pages printed, with a correlation coefficient of -0.499 in Figure 2.
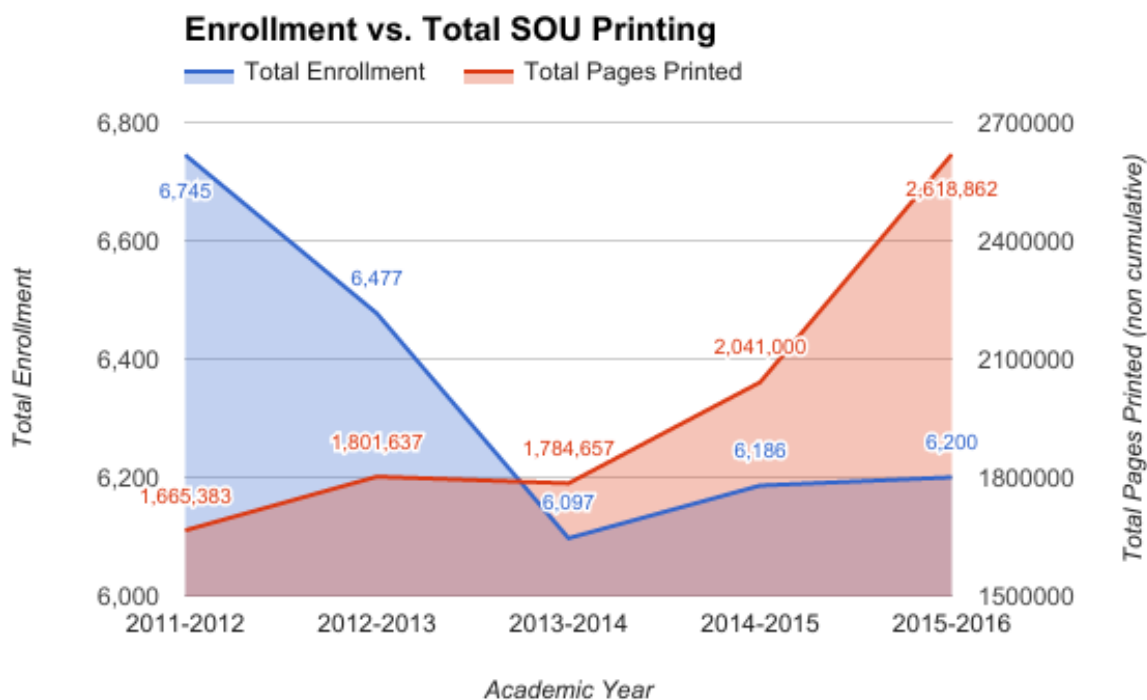

Figure 1. Graph showing growth of paper usage on SOU's campus despite lower Enrollment numbers.

Table 3. Total enrollment and pages printed with percent change over previous years.

Academic Year	Total Enrollment	Percent Change	Total Pages Printed	Percent Change
2011-2012	6,745	NA	1,665,383	NA
2012-2013	6,477	▼ -3.97%	1,801,637	▲ 8.18%
2013-2014	6,097	▼ -5.87%	1,784,657	▼ -0.94%

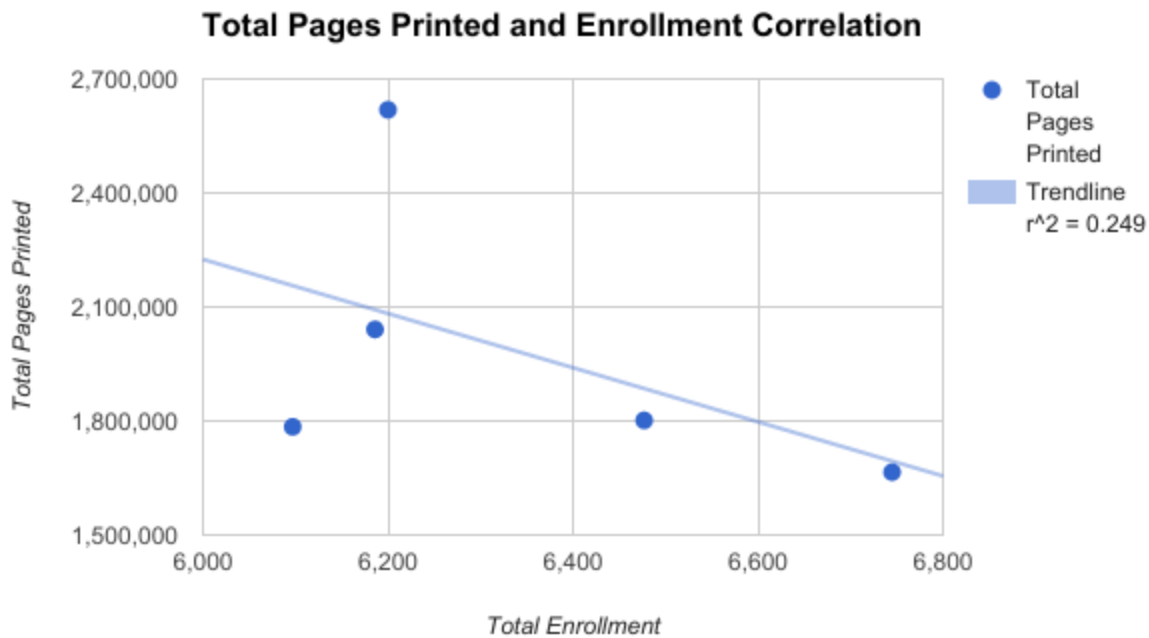|				
2014-2015	6,186	▲ 1.46%	2,041,000	▲ 14.36%
2015-2016	6,200	▲ 0.23%	2,618,862	▲ 28.31%
	AVG % Δ	▼ -2.04%	**AVG % Δ**	▲ 12.48%

Figure 2. Correlation scatter plot showing overall weak negative correlation between enrollment numbers and pages printed. Note: Data points do not appear in left to right chronological order.

Since there is no logical connection between the number of students enrolled and the amount of pages printed every year I ran a simple projection of what would happen if printing increased at the average 12.48% over the next 5 years with enrollment being stagnant. It came out to be more than double at 4.7 million pages. Although unlikely, the amount of printing SOU does as an institution is still far too much and we had to find a way to cull down the waste.
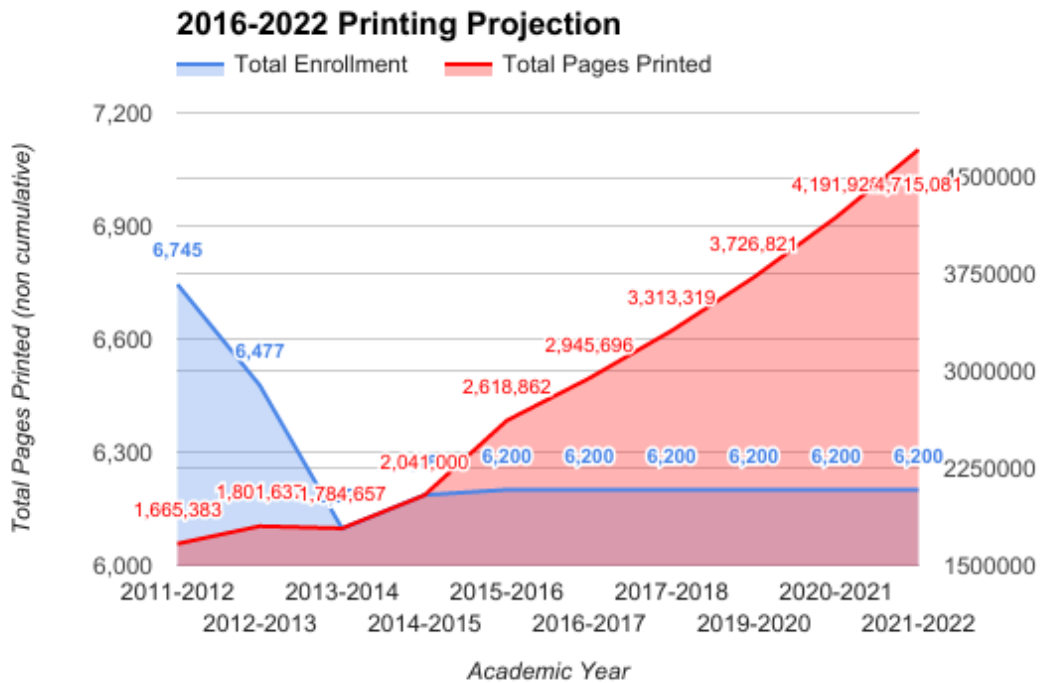
Figure 3. Projection of paper use if SOU continues at same rate of 12.48% more pages consumed every year.

Looking deeper into the data it was found that with every department printing a bit more, there were some departments printing a lot more than others. In 2011-2012 year the average amount of pages printed between department copiers was 1643 pages with a standard deviation of 2665. In the 2015-2016 year the average went up to 2813 sheets, but the standard deviation more than doubled at 5747. This confirms that most of the printing increases hasn't been from the campus as a whole, but rather specific departments and people.

Table 4. Total Department Printing averages and Standard Deviation over 5 academic years with change from previous years.

Academic Year	Average	Percent Change		Percent Change

			Standard Deviation	
2011-2012	1,643	NA	2,665	NA
2012-2013	1,837	▲ 11.79%	3,511	▲ 31.74%
2013-2014	1,833	▼ -0.22%	2,587	▼ -26.30%
2014-2015	2,135	▲ 16.49%	4,005	▲ 54.80%
2015-2016	2,813	▲ 31.77%	5,992	▲ 49.60%
	AVG % Δ	▲ 14.96%	AVG % Δ	▲ 27.46%

Based off figure four we can see that the student and Auxiliary departments are unlikely to cause as significant deviation from the mean. Therefore I looked closer at departmental data breaking it down to printing by user.
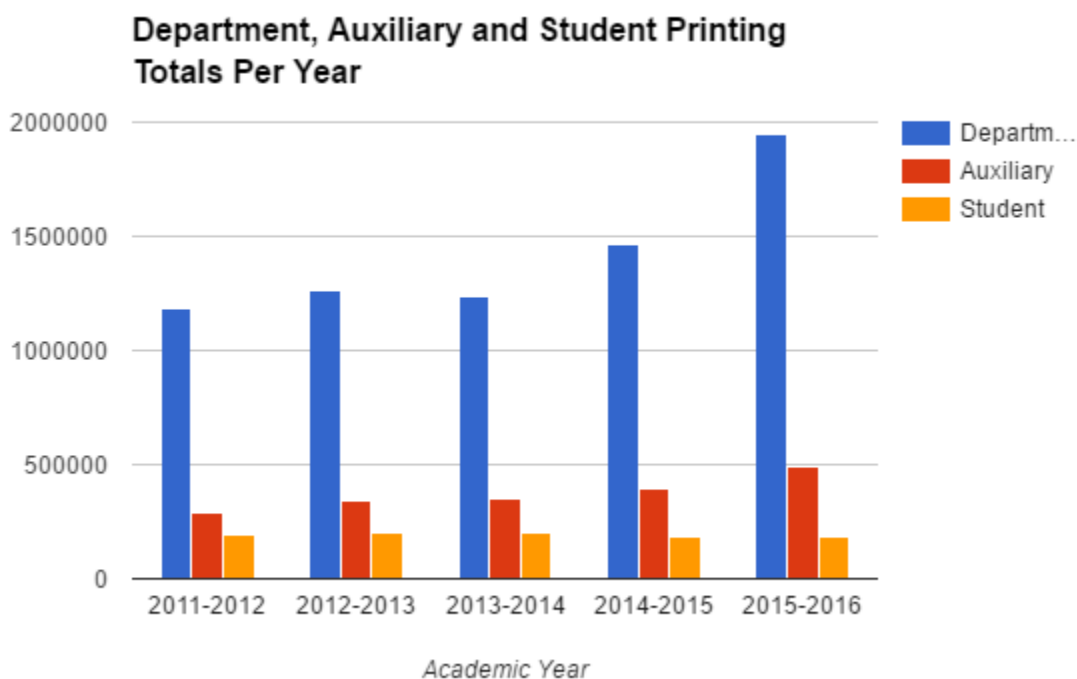

Figure 4. Printing by academic year for main Departments, Auxiliary, and Students.

Sorting to the top 100 users out of a 1000 faculty and staff by pages printed (duplex and non duplex), I found that combined they make up over half of the the total printing at SOU during 3 out of the 5 academic years observed (Table 4, Figure 5).

Running a linear correlation analysis I got a Pearson correlation of 89.2% showing the

data is not related due to random chance (Figure 6).

Table 5. Sum of the top 100 users compared against the total pages printed for that

academic year.

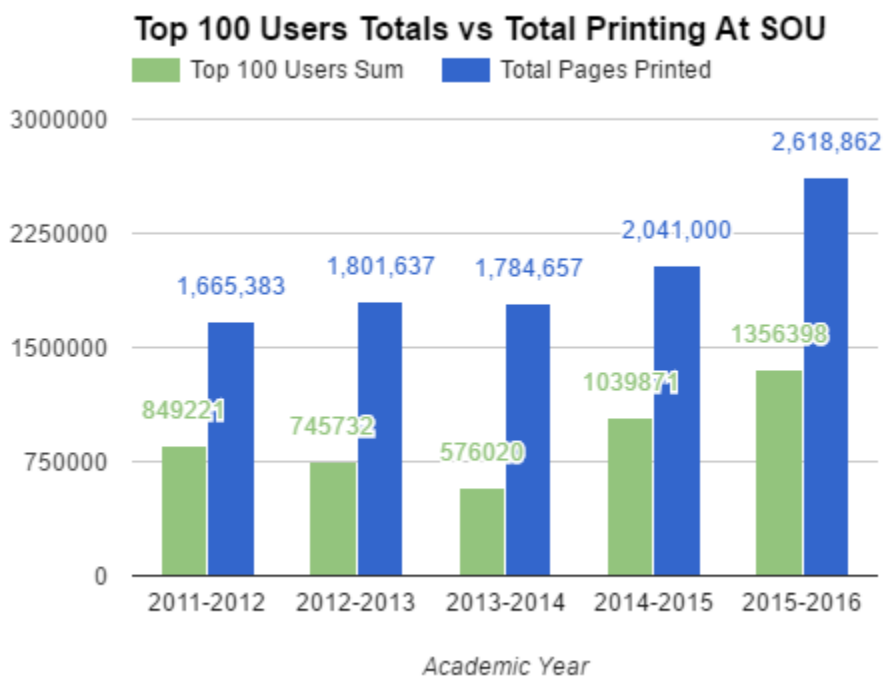| Academic Year	Top 100 Users Sum	Total Pages Printed	Percent of Total Print by top 100
2011-2012	849,221	1,665,383	51
2012-2013	745,732	1,801,637	41
2013-2014	576,020	1,784,657	32
2014-2015	1039,871	2,041,000	51
2015-2016	1356,398	2,618,862	52

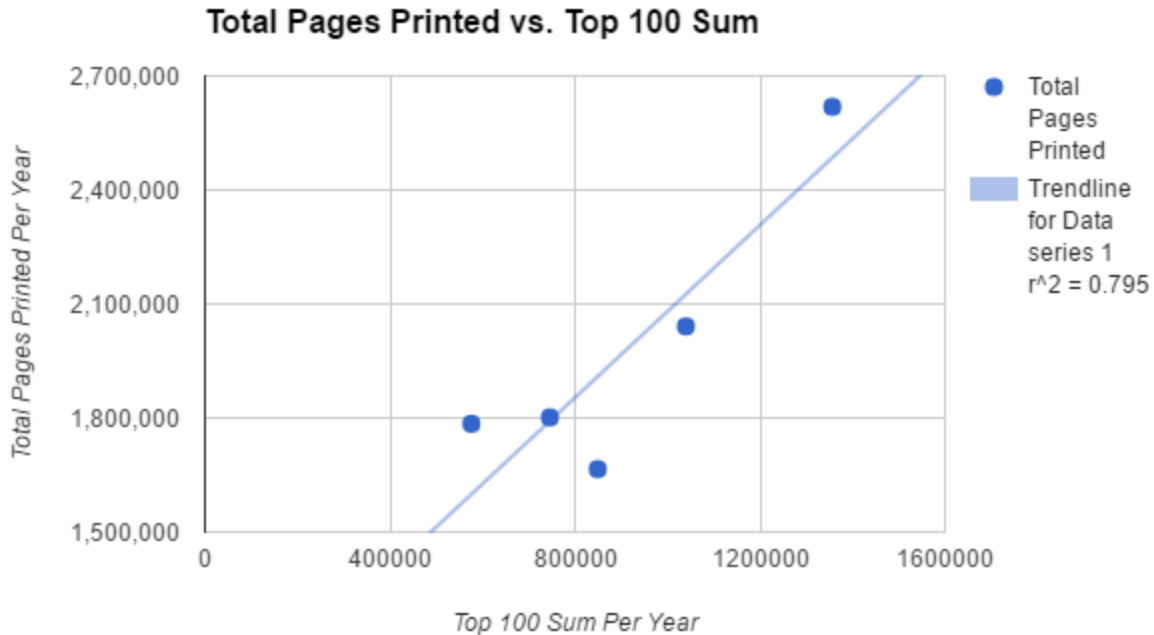Figure 5. Visual representation of how much the top 100 users print.

Figure 6. Linear Correlation analysis of average printing between top 100 users and total printing on SOU's campus.

Running a linear regression analysis I also got an R squared value of 79.5%. Running a regression line on a scatterplot shows same R squared value (table 5). This shows that there 79.5% of the variation in the top 100 users printing can explain the the total printing that occurs on SOU's campus. When running a one way anova the f statistic is at 11.63 and its significance level is at .042 showing little variance in means between the data. This statistically shows that there is overwhelming correlation between the mean changes in printing by the top 100 users and the overall increase in printing at SOU.This value is also below .05 showing that the data meets a 95% level of confidence, this means that we can reject the null and accept the alternative hypothesis.

SS	MS	F	Significance F		P(T<=t) one-tail	0
8483405715	284834054715	11.631	0.042		t Critical one-tail	2.131
7346484082	2448280694				P(T<=t) two-tail	0
58298896797					t Critical two-tail	2.77

andard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
413013.907	-1.149	0.333	-1789157.445	839631.722	-1789157.445	839631.722
0.205	3.41	0.042	0.0468	1.353	0.046	1.353

Reducing the printing habits of the top 100 users is where the project is focused as we will have implemented Technological, Cognitive, and Structural Changes to influence better printing habits among SOU staff and faculty.

Brad Christ has devised a technical change of uniforming our printer fleet to cut down on overall maintenance costs, and loss of paper resources to personal office printers. This is not only cost effective, but in reducing the amount of printers they are more effectively able to be serviced, limiting the amount of e-waste leaving our university. A structural fix also being worked on is giving the departments a set amount of free printing at the average amount of pages printed per department. Where all extra printing will be covered by the department itself. So only the outliers will be heavily penalised for their behavior.

The cognitive fix is a set of department specific email newsletters that have been mocked up which will be sent out to departments and their heads. They provide information of that department's specific environmental and monetary impact on the school. There is also a quick tip section showcasing alternatives delivery methods to paper copies for things like syllabi and readings. Department heads will also have access to all this information in real time with information about specific users. This will help them in applying internal pressure on certain users who print more than the department can afford.

Table 7.Projected environmental savings, if top 100 users printing was reduced by 50%

Environmental Savings, if top 100 users printing was reduced by 50%			
Academic Year	Trees Consumed	CO2 Produced in KG	KW hours
2011-2012	8.237	3878.948	14655.098
2012-2013	6.004	2173.109	8211.334
2013-2014	4.879	1764.816	6668.676
2014-2015	8.231	2978.751	11256.089
2015-2016	8.991	3254.665	12295.873
SUMS	36.344	14050.290	53087.072
AVG	7.268	2810.058	10617.414

In table 7 we can see that if the top 100 users reduce their printing by just 50% not down to the average, then we will see substantial gains in terms of saving trees consumed, Co2 not released in the atmosphere, and KW hours of energy retained.

Conclusion

Printing on SOU's campus has gotten out of hand causing great financial and environmental strain on this institution. Despite best efforts to divert paper waste from the landfill into recycling, this still utilizes water and energy as a means of reprocessing the paper. The solution came up with is to financially disenfranchise the departments and individuals who overzealously print, as well as provide educational materials the impacts they may have on the campus and environment. This proposal is scheduled to be brought in front of the student, sustainability, and tech council early next term in hopes of gaining comments and endorsements. The next step is to present to business advisory council and the board of trustees before the policy is signed off by the president and put into effect. Through these means we hope to see the rising trend of

paper consumption among the small number of faculty/staff stop, with goals to even reduce it back to historic lows.

Sources:

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