

# Sustainability for plastics

*LCA, MFA, TEA &  
systems thinking*

**VeeAnder Mealing, PhD candidate**  
**Amy E. Landis, PhD**

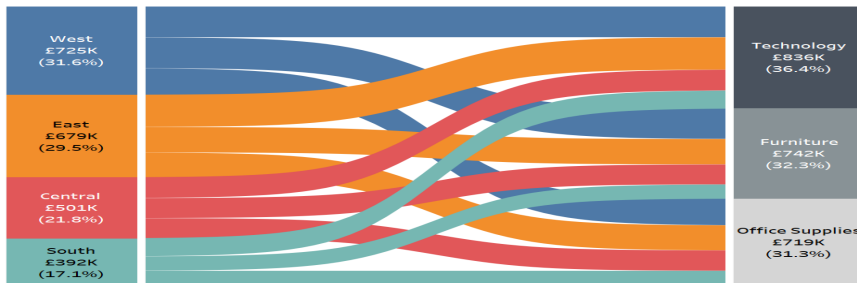
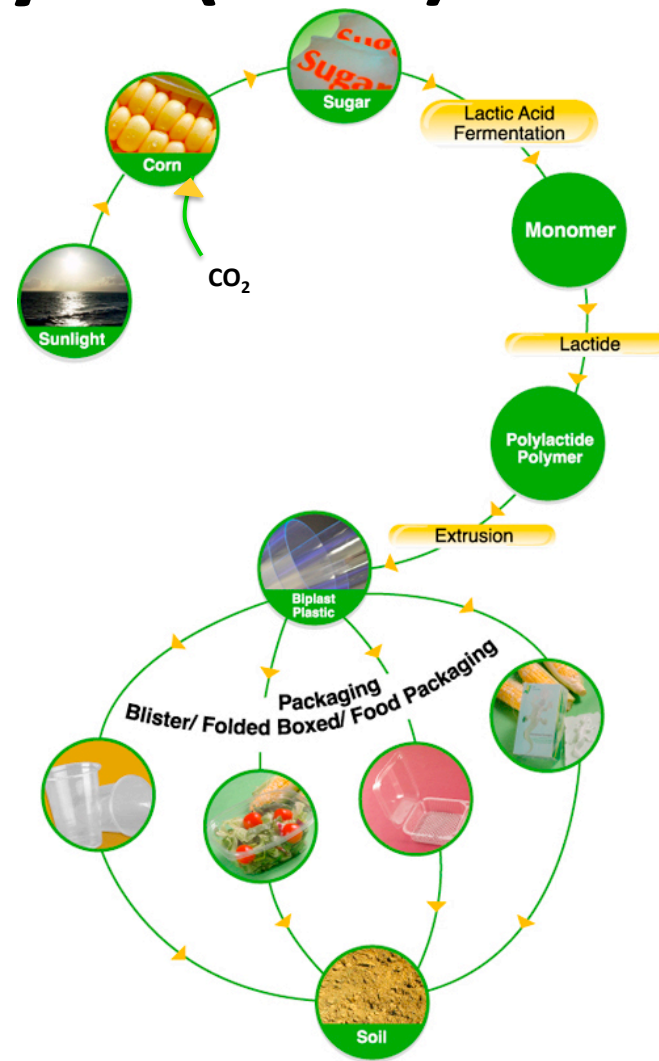
Email: [amylandis@mines.edu](mailto:amylandis@mines.edu)

# Life Cycle Assessment (LCA) and Material Flow Analysis (MFA)

## Life Cycle Assessment (LCA)

quantifies the environmental impact including *materials*, *energy* and *emissions* from raw materials extraction to end of life.

Material Flow Analysis (MFA) quantify stocks and flows of materials or substances in a system (it's perfect for Circular Economy)

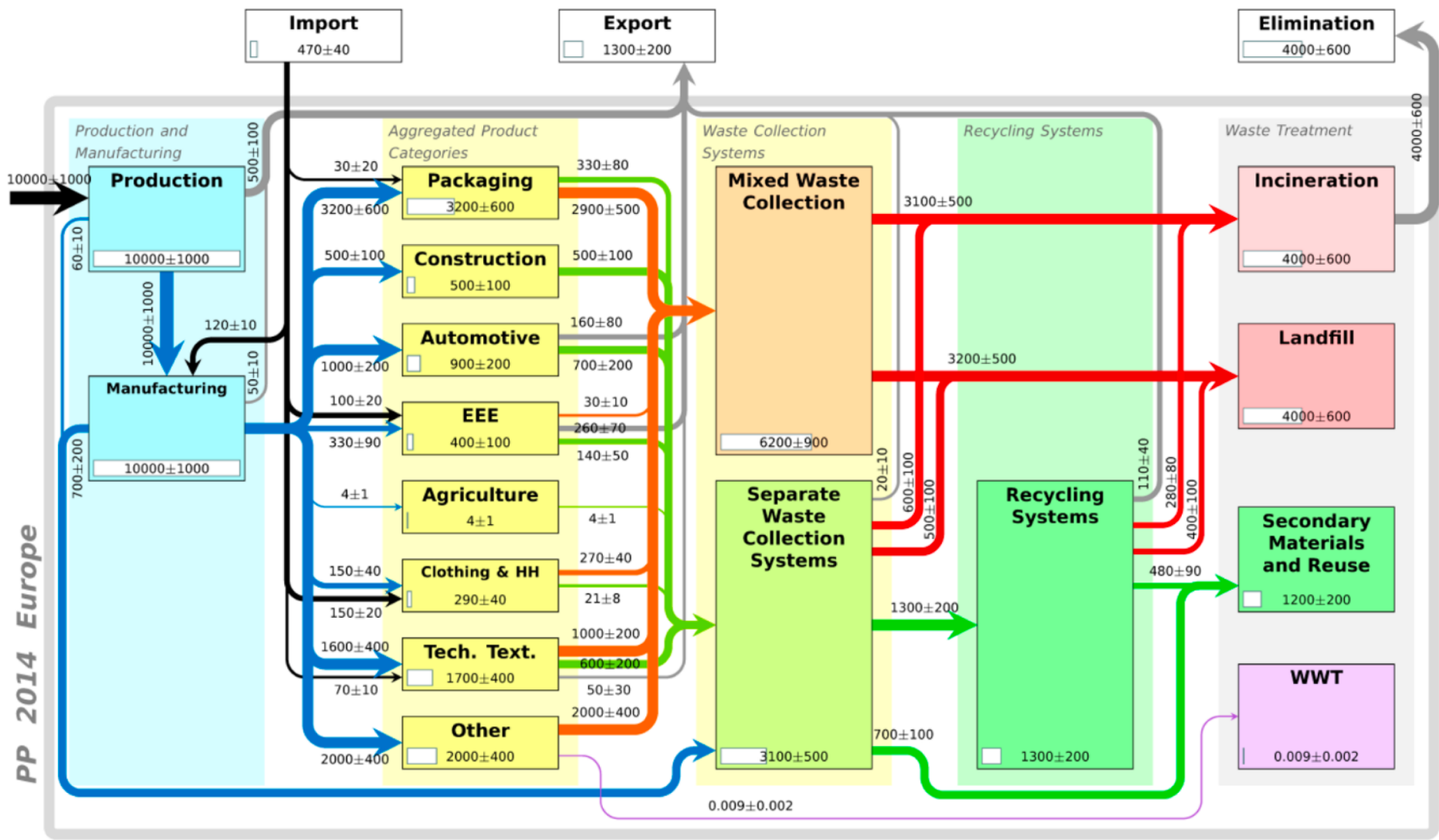


<https://www.theinformationlab.co.uk/2018/03/09/build-sankey-diagram-tableau-without-data-prep-beforehand/>

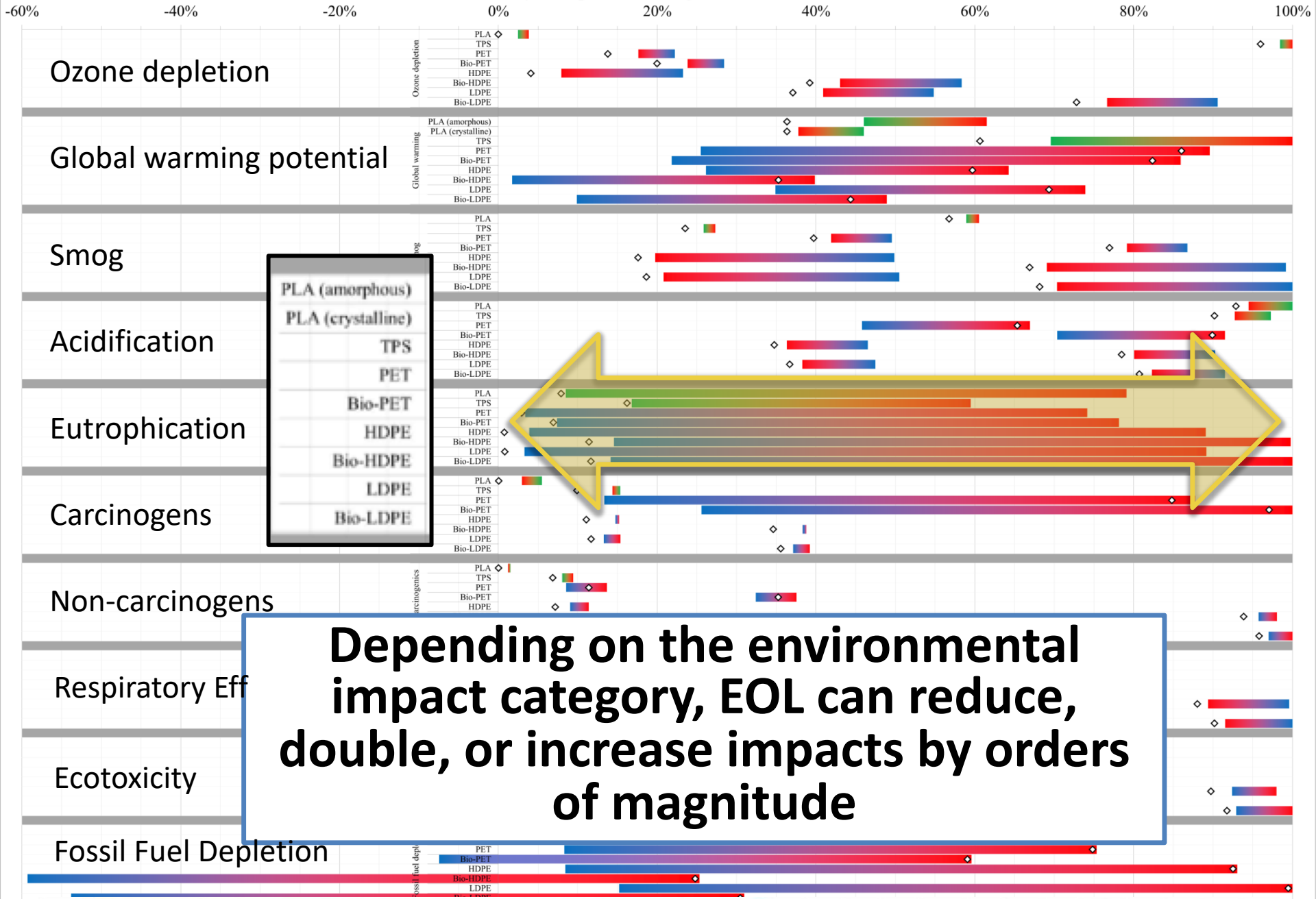
<http://www.cnhxcups.com/new/Compostable-material-Poly-Lactic-Acid-to-say-PLA.html>

# MFA: Is Waste Management Failing?

## Plastic End of Life



# Normalized Life Cycle Impacts Including EOL Scenarios and Production



PLA (amorphous)
PLA (crystalline)
TPS
PET
Bio-PET
HDPE
Bio-HDPE
LDPE
Bio-LDPE

**Depending on the environmental impact category, EOL can reduce, double, or increase impacts by orders of magnitude**

Landfill

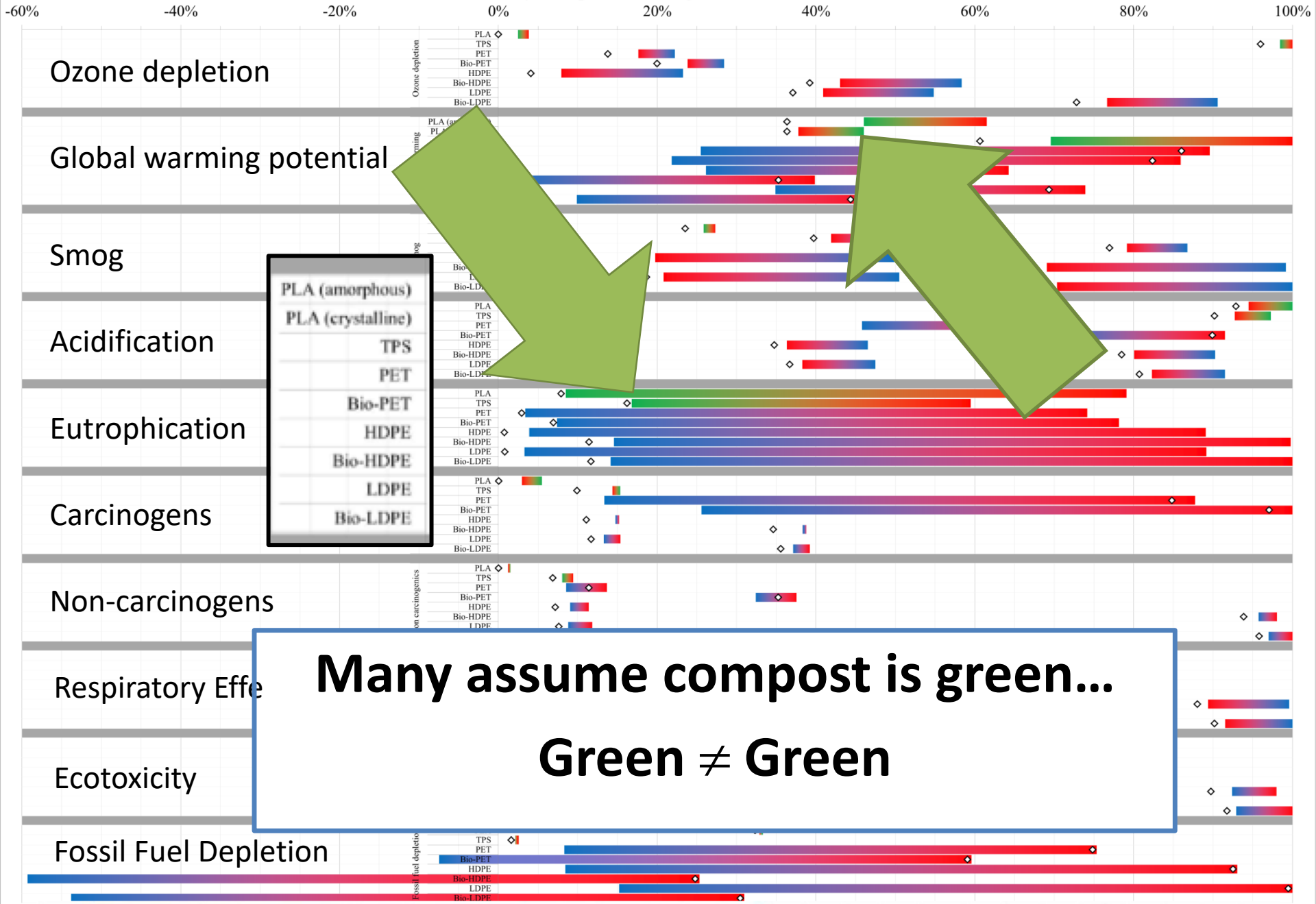
Recycle

Compost

Production



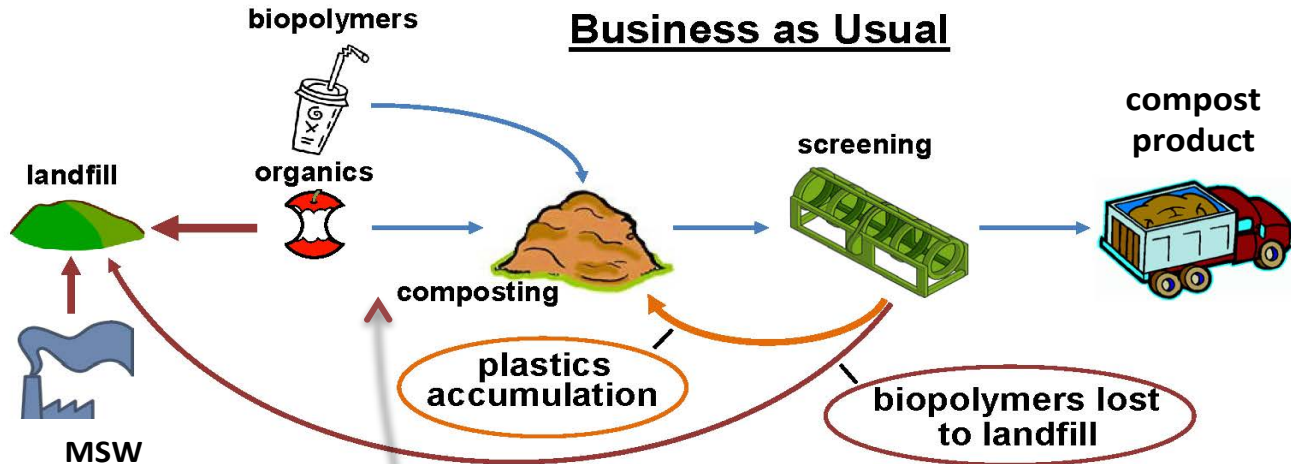
Normalized Life Cycle Impacts Including EOL Scenarios and Production



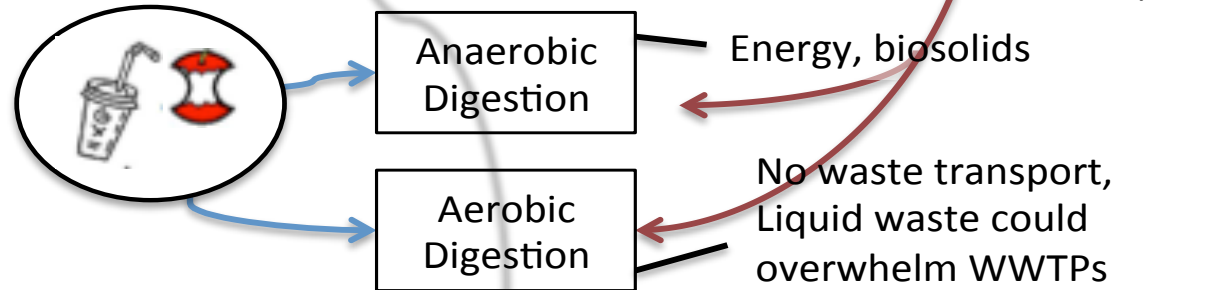
PLA (amorphous)
PLA (crystalline)
TPS
PET
Bio-PET
HDPE
Bio-HDPE
LDPE
Bio-LDPE

**Many assume compost is green...**  
**Green ≠ Green**

# new ways of managing waste



## **What happens with new waste scenarios?**



**Q: What happens to anaerobic digester effluent & products?**

**Q: What happens to WWTr load from aerobic digesters?**

# It's not the straws...

**STARTING YOUNG**

## ***This Kid Single-Handedly Ignited the Plastic Straw Ban Movement***


At the tender age of 9, Milo Cress nudged his local cafe into simply offering straws instead of automatically serving them with drinks. Then his idea went national.



Tanya Basu  
Senior Editor, Science

Updated 07.24.18 1:09PM ET  
Published 07.24.18 5:13AM ET



- 
- July 2018 Seattle bans plastic straws
  - Est 5-13M tons plastic enter ocean ea yr\*
  - Straws ~**0.03%**\*

In order to ensure that policies, circular economy, new technologies, new plastics, and EOL management are truly sustainable, & to avoid unintended consequences, We must use LCA, TEA, MFA during design.

\*Jambeck et al 2015 Science

# Sustainability for plastics

*LCA, MFA, TEA &  
systems thinking*

**VeeAnder Mealing, PhD candidate  
Amy E. Landis, PhD**

**Email: [amylandis@mines.edu](mailto:amylandis@mines.edu)**

# Landis Research Group: Sustainability of Bio-based Products




amylandis@mines.edu

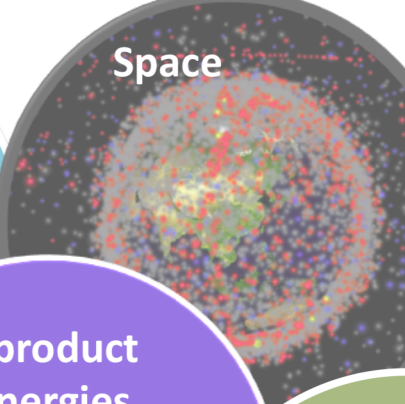
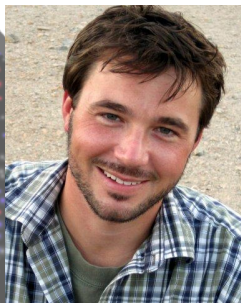


**Healthcare**


- supply chain
- waste & energy



**Space**

**Biopolymers**



**Byproduct Synergies**

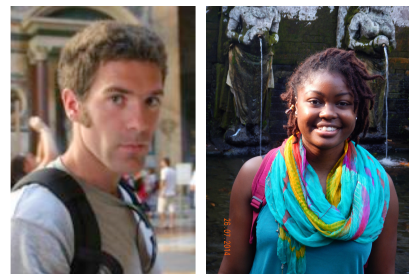
- Wastewater
- Mining waste
- Waste CO2

**Biofuels & Energy**

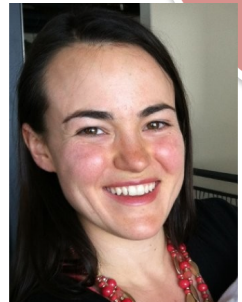


**Agriculture**

- Nutrient mgmt
- Reclaiming spent land

Dr. Troy Hottle  
Dr. Shakira Hobbs





# References

- [1] Kawecki, D., P. R. W. Scheeder and B. Nowack (2018). "Probabilistic Material Flow Analysis of Seven Commodity Plastics in Europe." Environmental Science & Technology **52**(17): 9874-9888.
- [2] Hottle, T. A., M. M. Bilec and A. E. Landis (2017). "Biopolymer production and end of life comparisons using life cycle assessment." Resources, Conservation and Recycling **122**: 295-306.
- [3] Hobbs, Shakira R., "Strategic Sustainability Assessment of Enhanced Anaerobic Digestion of Food and Bioplastic Waste for Municipalities" (2017). *All Dissertations*. 2321.  
[https://tigerprints.clemson.edu/all\\_dissertations/2321](https://tigerprints.clemson.edu/all_dissertations/2321)
- [4] Jambeck, J. R., R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman, A. Andrady, R. Narayan and K. L. Law (2015). "Plastic waste inputs from land into the ocean." Science **347**(6223): 768.
- [5] <https://www.thedailybeast.com/this-kid-single-handedly-launched-the-plastic-straw-ban-movement>