



# End-of-Life Challenges for Plastic Mulch

Carol Miles, Kwabena Sarpong and  
Shrijana Shrestha  
Washington State University



CMSF





# Use of Plastic Mulch in Agriculture

- ❖ Plastic mulch is single use polyethylene (PE)
- ❖ Global annual PE mulch market 1.4 million metric tons ([Briassoulis and Giannoulis, 2018](#); [Mormile et al., 2017](#))
- ❖ Provides crop production benefits:
  - Weed control
  - Moisture retention
  - Soil temperature modification
  - Early harvest
  - Increase crop yield and quality



**Strawberry Beds, California**  
Photo: Deirdre Griffin LaHue



# Mulch Disposal

## ❖ Common disposal methods:

- Landfill
- Stockpiling
- Burial
- Field burning
- Incineration

## ❖ Recycling

- Mechanical
- Alternative: Chemical, Thermal, Biological



**Mulch Stockpile, California**

Photo: Pam Krone



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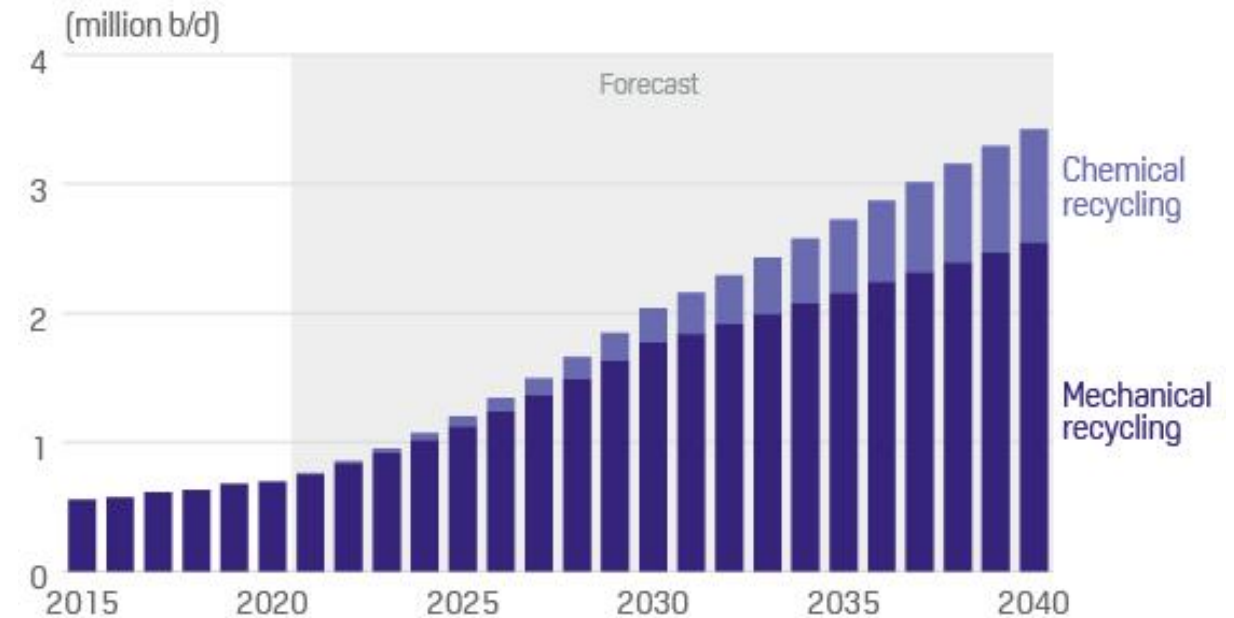




# Plastic Recycling

- ❖ Infrastructure needs:
  - Recycling facilities
  - Transportation
  - Separation and sorting
  - Cleaning to reduce contamination:
    - Max. ~5% for mechanical
    - Max. ~15-20% for chemical
    - More pure recycle
    - higher value product

## VIRGIN POLYMER FEEDSTOCKS DISPLACEMENT BY RECYCLED PLASTICS



Source: S&P Global Platts Analytics



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# Plastic Recycling

Recycling Method	Advantages	Disadvantages
<b>Mechanical</b>		
Shredding and melting to produce pellets	<ul style="list-style-type: none"> <li>Most cost- and energy-efficient method</li> <li>Less energy to produce plastic than from raw materials</li> </ul>	<ul style="list-style-type: none"> <li>Must sort plastic types</li> <li>Contamination limit 5%</li> <li>Melting process can degrade plastic</li> </ul>
<b>Thermal</b>		
<b>Pyrolysis</b> heats in absence of oxygen, breaking down to chemical components	<ul style="list-style-type: none"> <li>Recycle wider range of plastics</li> <li>Produces high-quality product 'plastic</li> </ul>	<ul style="list-style-type: none"> <li>Energy intensive</li> <li>Costly</li> <li>Technology in early stages</li> </ul>



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# Soil-Biodegradable Plastic Mulch (BDM)

Can be a sustainable alternative:

- ❖ Provides crop production benefits comparable to PE mulch
- ❖ Designed to be tilled into the soil after use, eliminating waste and disposal challenges
- ❖ Should not go into recycling facilities, will contaminate recycle



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# Soil-Biodegradable Plastic Mulch (BDM)

- ❖ Made from feedstocks that are biobased, derived from fossil fuels, or a blend of the two
- ❖ Biobased polymers divided into three categories:
  - Extracted from natural materials: starch, thermoplastic starch (**TPS**), cellulose
  - Produced by chemical synthesis: synthetic polymerization of lactic acid into polylactic acid (**PLA**)
  - Produced by microorganisms: polyhydroxyalkanoates (**PHA**)
- ❖ Percent biobased content not an indicator of biodegradation: PLA requires high temperature for biodegradation







# BDMs for Organic Systems

## USDA National Organic Program

- ❖ **Biodegradable biobased mulch film** was added to list of allowed substances in October 2014, but it **MUST**:
  1. Be biobased (ASTM D6866)
  2. Be produced without use of non-biobased synthetic polymers; minor additives (colorants, processing aids) not required to be biobased
  3. Be produced without organisms or feedstock derived from excluded methods (i.e., synthetic, GMO)
  4. Meet compostability specifications (ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088)
  5. Reach  $\geq 90\%$  degradation in soil within 2 years (ISO 17556 or ASTM D5988)
  
- ❖ BDMs approved for use in organic production in E.U. since early 2000s



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# Standards for Biodegradation

Standard Organization	Standard Name	Comments
European Committee for Standardization (CEN)	<b>EN 17033</b> (2018) Plastics–Biodegradable Mulch Films for Use in Agriculture and Horticulture– Requirements and Test Methods	First international standard directly pertaining to biodegradable mulches by an international organization
Association Francaise de Normalisation (AFNOR)	<b>NFU 52-001</b> (2005) Biodegradable Mulches for Use in Agriculture and Horticulture - Mulching Products - Requirements and Test Methods	French standard pertaining to biodegradable mulches
Ente Nazionale Italiano di Unificazione (UNI)	<b>UNI 11495</b> (2013) Biodegradable Thermoplastic Materials for Use in Agriculture and Horticulture - Mulching Films - Requirements and Test Methods	Italian standard pertaining to biodegradable mulches
ASTM, International	<b>ASTM D6400</b> (2012) Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities	Pertains directly to biodegradation under industrial composting conditions, and is often misrepresented <sup>1</sup>
TUV Austria (formerly Vincotte) <sup>2</sup>	<b>OK Biodegradable SOIL</b> (label)	Certifies that plastic materials will biodegrade fully and will not promote ecotoxicity in the soil

<sup>1</sup> ISO (International Organization for Standardization) has equivalent standards

<sup>2</sup> TUV Austria is not a standards organization but is a certification body authorized by European Bioplastics, an association representing the interest of the European bioplastics industry.



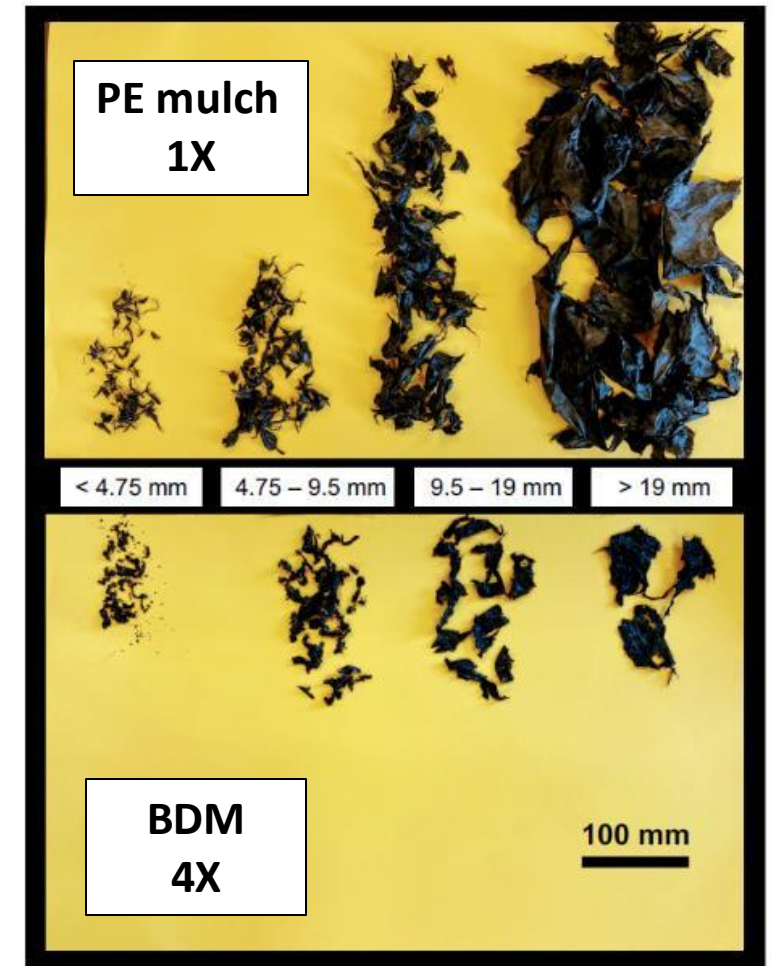


# Mulch Field Degradation

Mulch recovery in Fall 2020:

- PE mulch incorporated **1X**:  
Spring 2015
- BDM (PBAT feedstock) mulch incorporated **4X**:  
Fall 2015, 2016, 2017, 2018

Film → Fragment → Micro-particle → Nano-particle → CO<sub>2</sub> + Biomass



Source: Yu et al., 2022



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# Hydromulch for Organic Systems

- ❖ USDA-NIFA-**OREI** Award 2021-51300-34909 project at NDSU and WSU
- ❖ Developing biodegradable cellulose-based sprayable mulch (hydromulch) to suppress weeds and mitigate plastic pollution
- ❖ Formulations tested in strawberry: cellulosic material newsprint paper + plant-based tackifiers (guar gum and psyllium) using various proportions
- ❖ Next trials: test in blueberry, onion, and broccoli; measure weeds and yield, soil impacts, economics







# Concern

- ❖ **Oxo- and photo-degradable plastic is not biodegradable**, made with conventional plastic (HDPE, LDPE, PP, PS, PET or PVC) plus additives (e.g., starch) that cause the material to become brittle and break apart into fragments when exposed to UV light, heat and/or oxygen
  - Not biodegradable, compostable or recyclable, and cannot be placed in anaerobic digester
- ❖ EU prohibits single-use plastic products made from oxo-degradable plastic (European Parliament Directive 2019/904 Article 5)





# Drip Tape Recycling

## California:

- ❖ Plastic Pollution Prevention and Packaging Producer Responsibility Act (SB 54), signed June 2022
  - Plastic manufacturers finance recycling programs, charge fees based on: weight, recyclability, toxic/carcinogen content
- ❖ Drip companies in CA now have recycling programs:
  - Polyethylene (PE) tape, low contamination, no non-plastic winding cores, galvanized metal repairs
  - For large quantities,  $\geq 10,000$  lbs per site
  - Site pre-pickup inspection for loading access (tractor trailer)



Drip Tape Stockpile, California

Photo: Pam Krone



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# Plastic Pollution

## There is no 'away'

- ❖ Research expands knowledge and technology
- ❖ Policies create recycling programs
- ❖ Distribute costs across stakeholders
- ❖ Learn from successes and failures



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<https://smallfruits.wsu.edu/plastic-mulches/>

