

Recycling Agricultural Plastics

What Have We Learned?

NRC & PARMC Webinar Series, April 25, 2016



Lois Levitan

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Cornell University

Photo: Lois Levitan, RAPP

Why has recycling been difficult?



Post-consumer • Bulky

Used & stored outdoors, in mud, rain & snow

Often with residues of soil, plant debris, moisture, stones & grit

Dispersed across rural landscape → high collection costs

Possible or perceived pesticide residues & soil pathogens

Acknowledging the Team



Photo: Blake Putman, RAPP



Agricultural Plastics Recycling Conference & Trade Show

Join us August 17-19, 2016 in San Diego
to talk about Recycling Solutions to Ag Plastics!



<http://agplasticconference.com>

LIFE CYCLE OF HORTICULTURAL FILM

Lois Levitan, PhD

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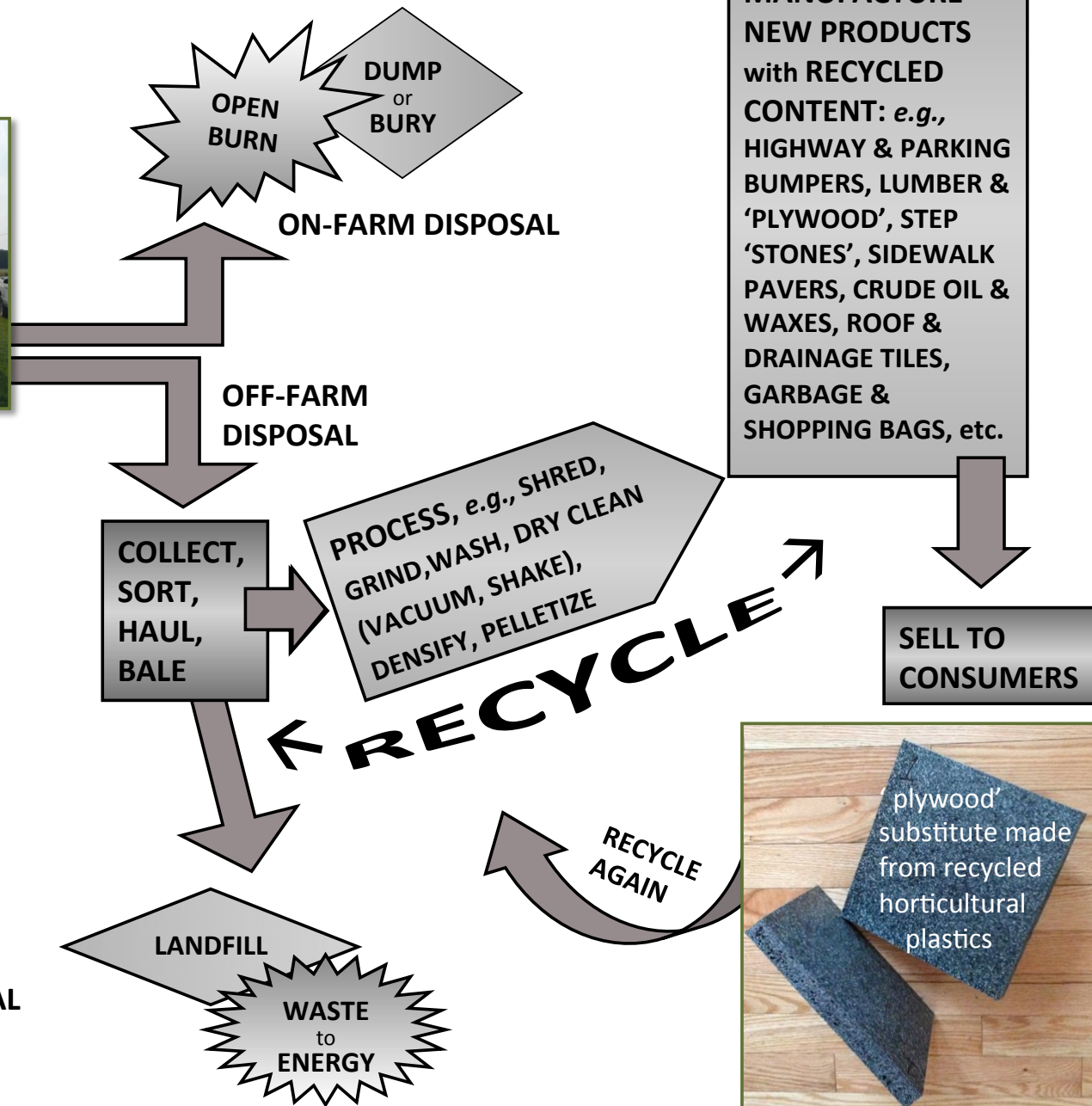
December 2014



Plastic film is used in fields & nurseries with fruit, vegetable, ornamental & tree crops:
e.g., as mulch & fumigation film •
hoophouse, high tunnel, &
greenhouse cover • irrigation
tubing • low tunnels • F.I.B.C.
• fertilizer bags • etc.

**PLASTIC
FILM**

**GLOBAL SUPPLIERS OF TECHNICAL
FILMS FOR AGRICULTURAL USE**
(MOSTLY LDPE PLASTIC RESINS + ADDITIVES)



RECYCLE AGRICULTURAL PLASTICS

resources for recyclers, organizers, end-users, plastic manufacturers

recycleagriculturalplastics.net

HOME / AGRICULTURAL PLASTICS ▾ / RECYCLE AGRICULTURAL PLASTICS ▾ / RECYCLING PROGRAMS ▾ / RECYCLING MARKETS ▾ / MORE ▾

Agricultural Plastics: What are they? Why are they 'hard stuff'? Can the challenges be surmounted?

Slides from a presentation to the March 2014 Plastics Recycling Conference, Session *The Hard Stuff: Recycling Film, Foam and Other Difficult Plastics*, which took place in Orlando, FL.

Illustrates in 15 slides the array of agricultural plastic products, the plastic resins they are made from, and qualities and practices that increase suitability for recycling.

What Are Agricultural Plastics?

Answer: agricultural plastics include the many different film and rigid products now used in all sectors of agriculture.

Bunker silo covers. Sheets of heavy duty black/white film, some reinforced with polyester.



Bale wrap. Stretch film wrapped around individual bales of hay or a line of hay bales.

Drip tape, irrigation pipe, greenhouses



Net wrap, polytwine, boat wrap, manure pond liners, mulch film, fumigation film, maple sap tubing, etc., etc., etc.



More details in 2012 presentation <http://hdl.handle.net/1813/35999>

PLASTICS RECYCLING CONFERENCE 2014 - LEVITAN, CORNELL UNIVERSITY

Why Is Agricultural Plastics Recycling DIFFICULT?

Which challenges can be overcome?



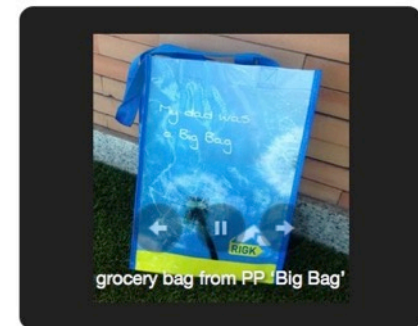
Dirty • Dispersed across rural landscape • Bulky
Dark colors • Possible or perceived pesticide residue
Unidentified mix of resins & additives • Soil pathogens

PLASTICS RECYCLING CONFERENCE 2014 - LEVITAN, CORNELL UNIVERSITY

Outlines reasons that agricultural plastics have been difficult to recycle:

- often contaminated with more soil, moisture, etc. than typically permissible for recyclable materials
- possibility of contamination with equipment-damaging grit, gravel and rocks

NEW PRODUCTS FROM RECYCLED PLASTIC



grocery bag from PP 'Big Bag'

PLASTIC RECYCLING EVENTS

ASSOCIATION of PLASTIC RECYCLERS WEBINAR:
Celebrating Innovations that Support the Growth of Plastics Recycling

April 19, 2016 at 1:00 pm - 2:00 pm
<https://attendee.gotowebinar.com/register/7049867719981269249>

PENNSYLVANIA RECYCLING MARKETS WEBINAR:
AGRICULTURAL PLASTICS RECYCLING

April 19, 2016 at 1:30 pm - 2:30 pm
name.org Register: <https://attendee.gotowebinar.com>



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• fertilizer bags • etc.

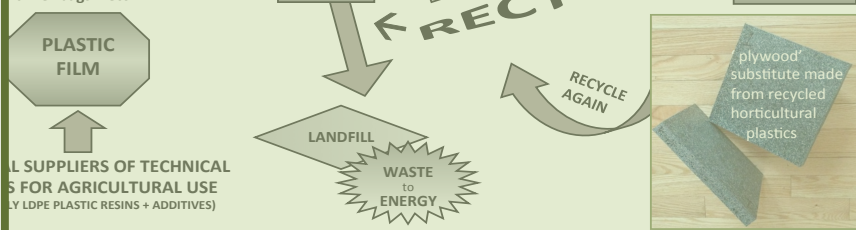
On the Farm

CYCLE OF HORTICULTURAL FILM

Dr. David
 Agricultural Plastics Program (RAPP)
 Cornell University, Ithaca NY 14853
 2014



Plastic film is used in fields & nurseries with fruit, vegetable, ornamental & tree crops: as mulch & fumigation film • hoophouse, high tunnel, & greenhouse cover • irrigation tubing • low tunnels • F.I.B.C. • fertilizer bags • etc.

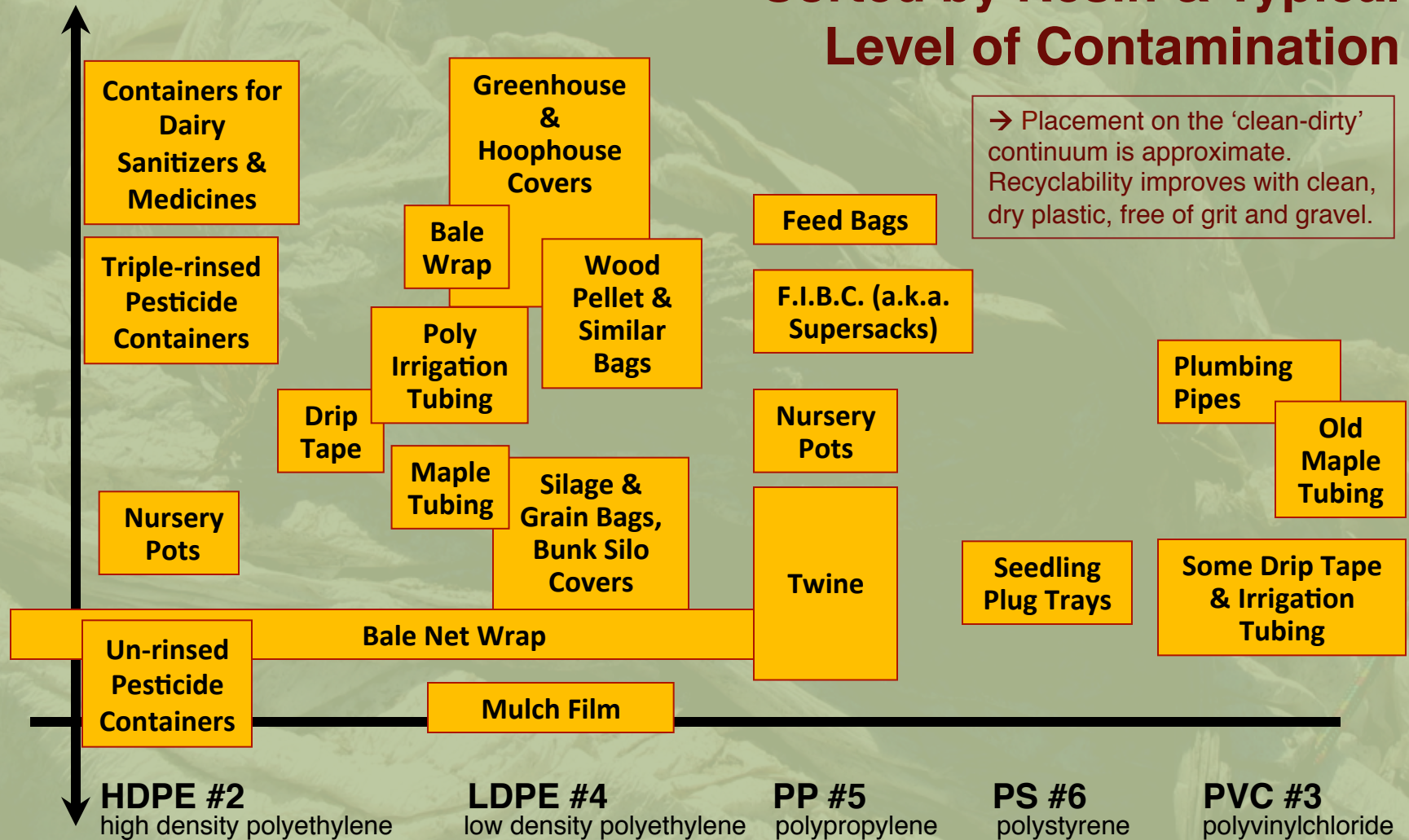


File: LifeCycleHorticulturalFilm-LCL2014Dec

Used Agricultural Plastics

Sorted by Resin & Typical Level of Contamination

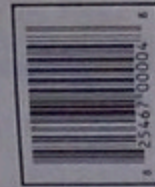
CLEANER



DIRTIER



**RIPE DE BOIS
WOOD SHAVINGS**



**Polyethylene bags for wood
pellets, animal bedding, soil
amendments, etc.**

low-density polyethylene film – LDPE

**RIPE DE BOIS
WOOD SHAVINGS**

Photo: Lois Levitan, RAPP

Polypropylene bags for feed, grain, etc.

woven polypropylene – PP

FIBC=Flexible
Intermediate
Bulk Container.
also called totes,
bulk bags, &
supersacks

smaller sacks



Photos: RAPP

Photo: Lois Levitan, RAPP

Bale netting

(also called net wrap, hay netting)

polyethylene (PE) or polypropylene (PP)



Photo: Lois Levitan, RAPP



Bale wrap

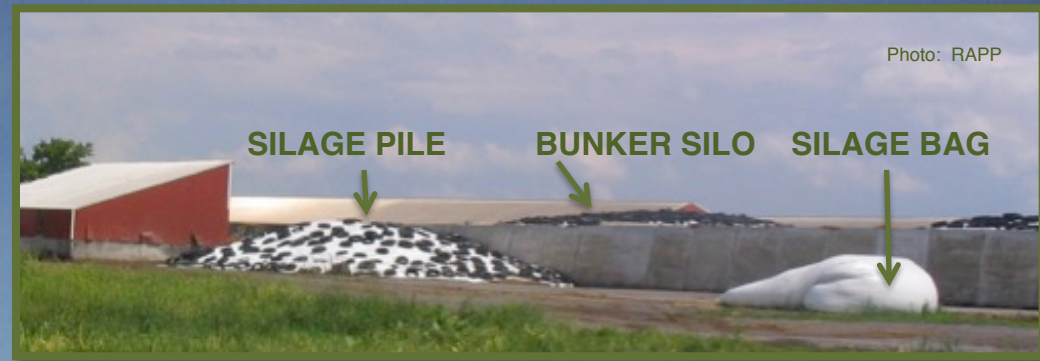
LDPE low-density polyethylene,
machine-wrapped around rectangular or
round bales of hay, individually or in a row.
Usually all white, sometimes green.



Bunker silo & silage pile covers

also called *silage sheeting*.

Heavy sheets of LDPE* film, black inside, white outside, some reinforced with embedded polyester string, some with an EVOH** oxygen barrier layer. Covers can be 10+ bonded layers of plastic, each layer with special characteristics. Tire slabs keep plastic sheet in place.



similar film is used for silage covers, grain bags & tuber bags



*LDPE = low-density polyethylene

**EVOH = ethylene vinyl alcohol

Photo: Judith Wright, Cayuga Co CCE

Dairy medicinal injectors

e.g., dry cow infusion tubes

LDPE barrel, HDPE plunger



low-density polyethylene barrel high-density polyethylene plunger


Photo: <http://hambydairysupply.com/>

Drainage pipe

HDPE – high-density polyethylene

Photo: oregonlive.com

Fumigation film

A photograph showing a tractor pulling a specialized machine that lays out a long, continuous roll of white plastic film in a field. Two men are operating the machine. The machine has a large white tank and various hoses and rollers. The film is being laid out in a straight line across the field. In the background, there are trees and a building.

polyethylene (PE), typically with an inner gas-barrier layer of EVOH (ethylene vinyl alcohol) or nylon. Nylon is less effective as a barrier & cannot be recycled with polyethylene because its melt temperature is much higher.

Photo: www.agr123.com

Copyright reserved @ Department of Pesticide, IPP, CAAS

Greenhouse, hoophouse, high tunnel covers

clear or white sheets of (L)LDPE – linear low-density or low-density polyethylene film. Some sheets glued together with non-recyclable adhesive.



Low tunnels & row covers

clear or white sheets of linear low-density or low-density polyethylene (L)LDPE

Floating row covers

cloth-like polypropylene (PP) or polyester



Photo: Lois Levitan, RAPP

laying mulch film

lifting mulch film

Horticultural Mulch film

(L)LDPE, typically ≤ 1 mil thick (mil=1/1000"), 3'-5' wide. White, black, silver, occasionally clear or other colors. Some with different colors top & bottom. Some embossed for more flexible fit on raised beds—but embossing holds grit & moisture. When mulch film also serves as a fumigation barrier film, it will have an inner layer of nylon or EVOH.



Photo: SkyPlastic USA 2011

Photo: Paul Zittel, Eden Valley Growers



Irrigation drip tape

polyethylene (PE);
polyvinylchloride
(PVC) is used for
some imported drip
tape

Irrigation pipe

HDPE
high-density
polyethylene

Irrigation polytube (L)LDPE


linear low-density
& low-density
polyethylene

Photo: Delta Plastics

Maple syrup tubing

(L)LDPE polyethylene tubing;
older tubing may be
polyvinylchloride (PVC); fittings,
connectors, & ball valves are nylon,
polycarbonate, rubber or steel





Nursery plant pots, seedling trays, flats, etc.

high-density polyethylene (HDPE), polystyrene (PS), polypropylene (PP). Can be made in different ways – blown, molded, thermo-formed

Photo: Lois Levitan, RAPP

Oxygen barrier film,

e.g., SiloStop

EVOH (ethylene vinyl
alcohol)



SILOSTOP

THE ULTIMATE OXYGEN BARRIER FILM



Pesticide containers & other rigid containers

that held oils, chemicals, etc.

high density polyethylene – HDPE

The ACRC (Ag Container Recycling Council) oversees pesticide container recycling, maintaining strict protocols and a national network of collectors, processors, & end-product manufacturers.



Photos: Lois Levitan, RAPP



Photo: Lois Levitan, RAPP

Twine also called polytwine
polypropylene – PP

Bridon
Cordage's
Revolver
twine is
made from
recycled
polytwine



Photo: Bridon Cordage



Photo: Lois Levitan, RAPP

Increasingly complex

Thin films with multiple extrusion layers, each with additives and colorants for specific agronomic or horticultural purposes:

- Block UV
- Reflect sunlight
- Repel insects
- Absorb heat
- EVOH O₂ barrier
- Hold moisture
- Reinforce structure
- Prevent backwash
- Stretchability
- Stickiness
- Tensile strength
- Flexibility
- Rigidity
- Longevity
- Degradability



Silage bag



AGRICULTURAL PLASTIC PRODUCTS

Differentiating products by resin & color—Characteristics that matter to recyclers

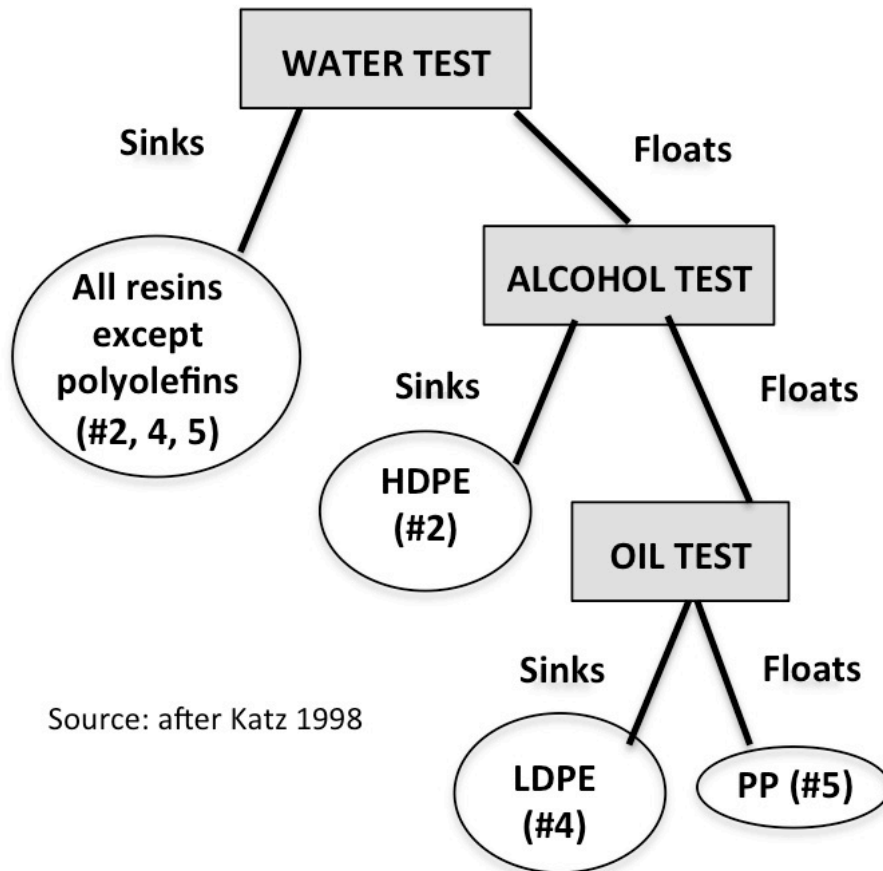
Agricultural Plastic Products	F/R/O	Typical Resin	Usual Color(s)
Bags for wood pellets, peat moss, soil amendments, etc.	F	PE	white, some with print &/or black interior
Bags for food, grain, birdseed, etc., from small to FIBC's (Flexible Intermediate Bulk Containers)	F or O	Woven PP	white, some printed (exter. concrete all white)

Differentiating Products by Resin & Color

<http://recycleagriculturalplastics.net/agricultural-plastics/differentiating/>

Biodegradable film	F	PE + additive	various
Boat wrap, blue	F	PE + colorant	blue
Boat wrap, white	F	PE + titanium dioxide	white
Bunker silo cover (a.k.a. silage sheeting) - <i>with</i> embedded layer of string webbing for reinforcement	F	LDPE/LLDPE, polyester, some with embedded EVOH layer	white exterior, black interior layer
Bunker silo cover (a.k.a. silage sheeting) - <i>without</i> embedded layer of string webbing for reinforcement	F	LDPE/LLDPE, some with embedded EVOH layer	white exterior, black interior layer
Dairy medicinal injectors, e.g., dry cow infusion tubes	R	LDPE barrel, HDPE plunger	white with print
Drainage pipe	R	HDPE	black or white
Drums (typically 55 gallon container for soaps, sanitizers, etc.)	R	HDPE	various
Fumigation and solarization film (a.k.a. soil disinfection film)	F	LDPE/LLDPE	clear or green
Grape cover film (protection from rain)	F	LDPE/LLDPE	clear
Greenhouse, hoophouse, tunnel covers, perforated row covers	F	LDPE/LLDPE	clear or white
Floating row cover (cloth-like material, e.g., Reemay™)	O	Non-woven PP or polyester	white
Horticultural mulch film	F	LDPE/LLDPE	black, less commonly white, clear, or other
IBCs (Intermediate Bulk Containers) (a.k.a. tote, pallet tank)	R	HDPE	translucent milky hue
Irrigation pipe	R	HDPE	black
Irrigation drip tape	O	PE, PVC	black
Irrigation polytube	F	LDPE/LLDPE	white
Maple tubing without fittings (fittings, connectors removed)	O	LDPE	blue or black or clear
Maple tubing, with plastic fittings (metal removed)	O	LDPE, with nylon or PC fittings	blue or black or clear
Nursery plant pots, seedling trays, etc.	R/O	HDPE or PE &/or PP	various
Oxygen/moisture barrier film (e.g., Silostop)	F	EVOH	translucent orange or with yellow-green tint
Pesticide containers (cleaned per ACRC protocols)	R	HDPE	various (see acrecycling.org)
Plastic-lined paper sacks and paper-lined plastic sacks	O	Paper, PE	paper of various colors; plastic typically clear
Silage bags, tuber bags, bulk grain bags	F	LDPE/LLDPE	white exterior, black interior layer
Twine (a.k.a. polytwine, used to tie bales of livestock feed)	O	PP	various
Twine (cordage for tying tomatoes, other horticultural material)	O	PP	various
Water membrane pond liners (a.k.a. geotextiles)	O	PE or PP or EPDM synthetic rubber	black

Identifying Common Plastics Used in Agriculture



Source: after Katz 1998

Density of Common Plastic Resins:

Plastic Resin		Density g/cm ³ at 70°F
POLYOLEFINS	PP (polypropylene, #5)	0.90
	LDPE (low density polyethylene, #4)	0.92
	LLDPE (linear low density polyethylene, #4)	0.92
	Mid-density polyethylene	0.94
	HDPE (high density polyethylene, #2)	0.94-0.97
Water		1.0
Nylons		1.02-1.14
ABS (acrylonitrile-butadiene-styrene)		1.05
PS (polystyrene, #6)		1.05
Polycarbonate		1.20
PVC (polyvinyl chloride, #3)		1.29-1.44
PET, polyester (polyethylene terephthalate, #1)		1.38-1.39

<https://recycleagriculturalplastics.net/>

Best Management Practices (BMPs)

- Keep plastic clean and dry as possible
- Shake out pebbles & clumps of soil
- Fold into pillow-sized bundles
- Store off ground, out of mud, grit, gravel
- Separate plastic by color and type



keep
under
cover

fold, put
weight on
top

contain in
a crate

Photo: RAPP

Photo: RAPP

Photo: Blake Putman, RAPP

Best Management Practices (BMPs) for Bale Wrap

problematic
strapping

**3. Stuff bundles
into 'totes'**

1. Shake

2. Bundle

Photos: RAPP

Photo: Low Carbon RAPP

Best Management Practices (BMPs) after Baling

see *Guidelines for Storing Bales of Plastic Awaiting Shipment To Markets*

<https://recycleagriculturalplastics.net/>



Do not store on gravel

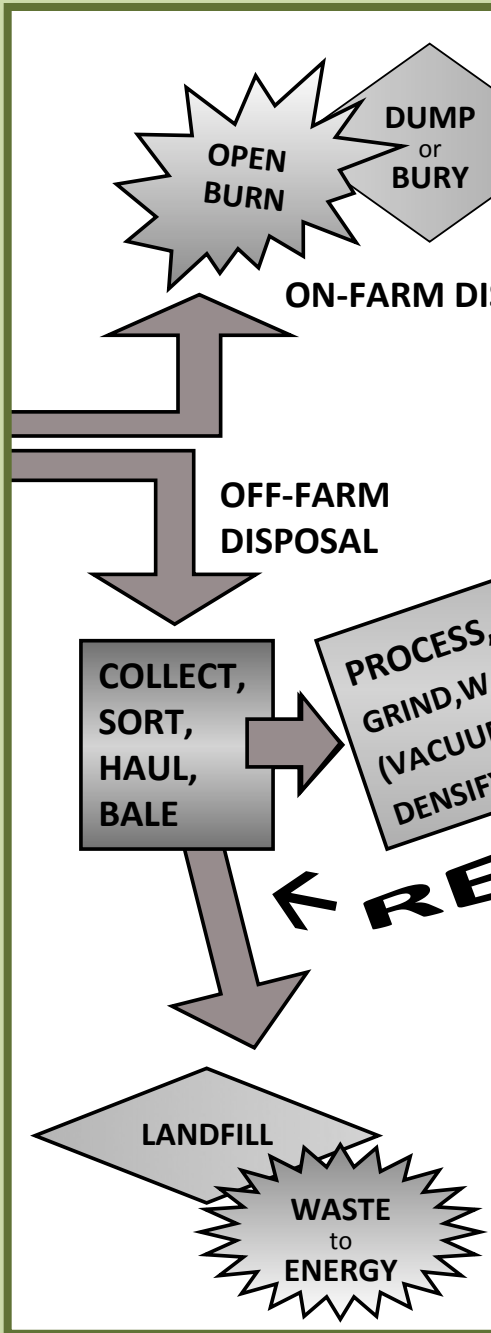
store on
pallet

or on clean
surface



Photos: RAPP

Moving Plastic from the Farm



LIFE CYCLE OF HORTICULTURAL FILM

Lois Levitan, PhD
Recycling Agricultural Plastics Program (RAPP)
Cornell University, Ithaca NY 14853
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PLASTIC FILM

GLOBAL SUPPLIERS OF TECHNICAL FILMS FOR AGRICULTURAL USE
(MOSTLY LDPE PLASTIC RESINS + ADDITIVES)



ON-FARM DISPOSAL

OFF-FARM DISPOSAL

COLLECT, SORT, HAUL, BALE

PROCESS, *e.g.*, SHRED, GRIND, WASH, DRY CLEAN (VACUUM, SHAKE), DENSIFY, PELLETIZE

LANDFILL

WASTE to ENERGY

MANUFACTURE NEW PRODUCTS with RECYCLED CONTENT: *e.g.*, HIGHWAY & PARKING BUMPERS, LUMBER & 'PLYWOOD', STEP 'STONES', SIDEWALK PAVERS, CRUDE OIL & WAXES, ROOF & DRAINAGE TILES, GARBAGE & SHOPPING BAGS, etc.

SELL TO CONSUMERS



File: LifeCycleHorticulturalFilm-LCL2014Dec

Criteria for Selecting a Storage Site



*see Guidelines for Storing Bales of Plastic
Awaiting Shipment To Markets*
<https://recycleagriculturalplastics.net/>

Why Compact Plastic?

40-50,000 lbs. or more baled plastic to fill a trailer van. Bale ~ 1000 lbs.



← 1000-lb bale

3 pallets stacked plastic
(each ~ 350 lbs.) = 1000 lb. bale
Estimate: $\leq 16,000$ lbs of this plastic
would fill trailer van



Totes hold ~ 200 lbs. of bale wrap.
~ 80 bags fill trailer van,
capacity $\leq 16,000$ lbs.



Where & How to Compact Plastic



Photo: www.mcfaulkner.com

Contact Us...
 Dennis or Jody
 Office: 941-761-8293
 Web-Site
www.BigFootBaler.com
 E-Mail
bigfootbalers@mac.com

BIGFOOT

Balers

Quality Balers Made
Right Here In The USA

THE ALL NEW BF-300. PORTABLE PLASTIC BALER

THE BF-300 WAS DESIGNED WITH ONE THING IN MIND, PORTABILITY. THIS BALER OFFERS A LITTLE BIT OF IT ALL. SIMPLY PULL UP TO THE JOB-SITE, LOWER THE TRAILER, AND START BALING.

BALING - PORTABILITY & SELF CONTAINED, are just a few of the features of the new BF-300...

The BF-300 was built to comply with all high-way safety standards and regulations. With its recessed lights (tail lights and clearance lights), break away cable, coupling for a 2-5/16" ball, and a standard seven pin plug to power the brakes, lights and turn signals. All built into one package, this unit is ready to hit the road running for all your baling needs...

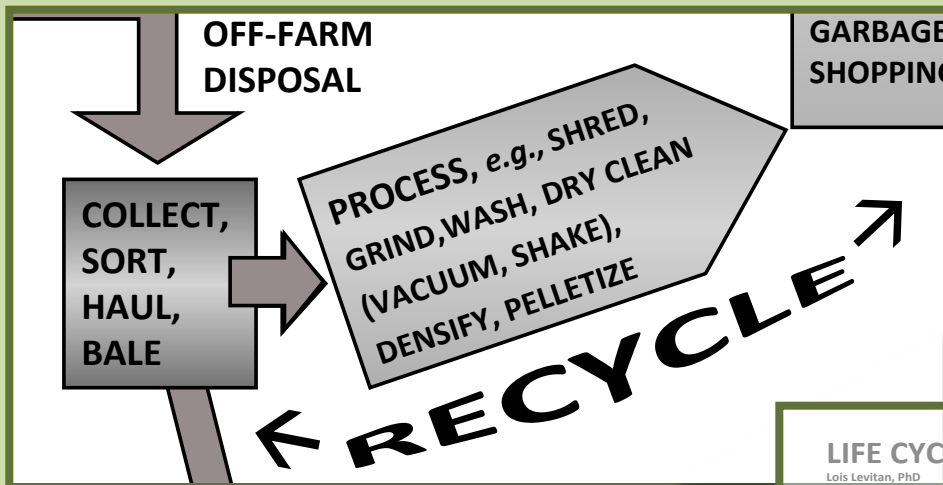
BF-300 Dimensions
 16' - Long
 8.25' - Wide
 8' - Tall
 Weight - Appx 6,000 lbs.

HIGHLIGHTS OF THE BF-300

- 20 HP, 4 Stroke Honda Engine
- Electric Start
- 20 GPM @ 2500 PSI Hydraulic Pump
- 50 gal. Hydraulic Tank
- 7 gal. Fuel Tank
- Tandem Torsion Axles
- Electric Brakes
- Spare Tire
- Lowering Trailer Bed
- Hydraulic Latching Door
- Hydraulic Ejection System
- 12 gauge Tie Off Wires
- 40" x 40" x 40" Finished Bale Size
- 1,000 lb Finished Bales

Control Panel
 Locks & Un-Locks Door
 Lifts Plunger Up & Down
 Ejects Finished Bale

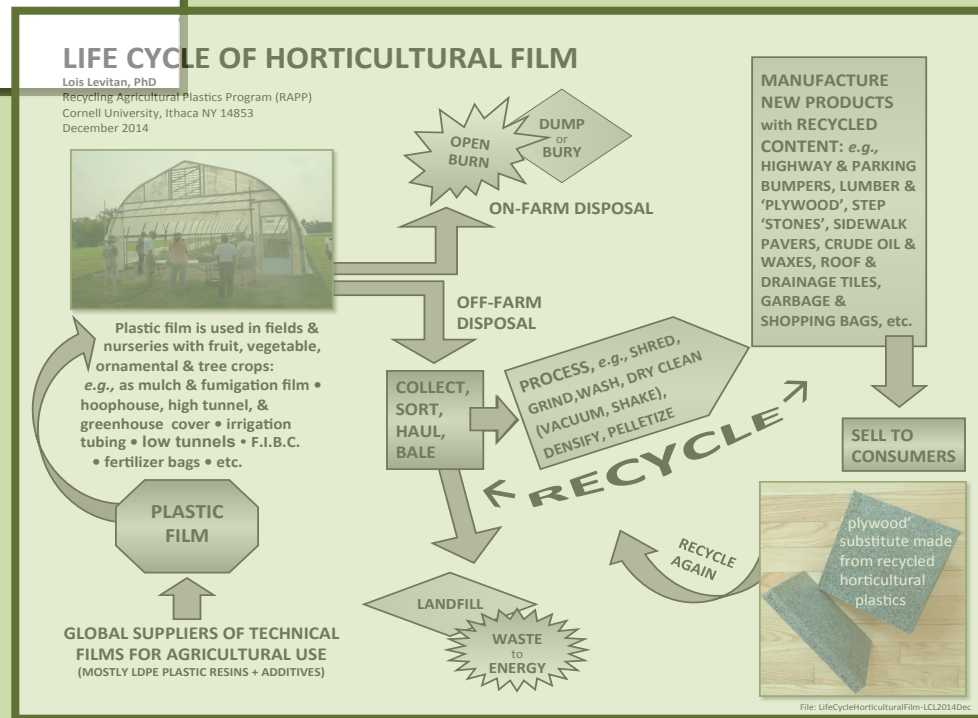
1000 lb. bale ~ 36-37 cu'
 Density ~ 27 lb./cu'



Collect & Process

Recycling: multi-stage process

- collecting discarded plastic from farms is just the first step.
- reclamation* takes plastic from 'whole cloth' (original form) to small pieces ready to use in making new products.
- processed form could be powder, pellets, shreds, chips...
- old plastic is finally recycled only when something new has been made from it.



Vertical Integration/Affiliation



Daly Plastics collects →
CeDo cleans (w/o water),
processes, manufactures
& markets disposable bags.

Based in The Netherlands,
serves much of Europe



Photos: Lois Levitan, RAPP

On-site collections, Andalucia, Spain



photo taken from the road

photo taken from the air →

Homogeneous LDPE greenhouse/tunnel covers & mulch film is used, discarded & recycled in close proximity.

75% recycled.

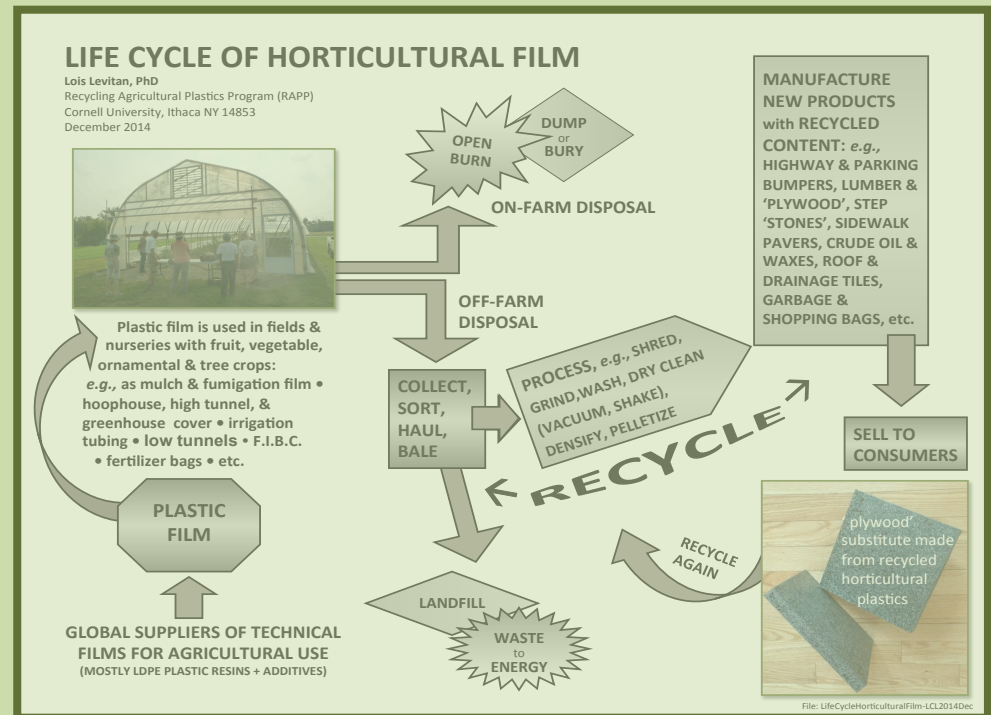
Cicloagro, a member organization representing 20 of the largest farms, organizes mandatory recycling. By law, farmers must clean, sort, provide temporary storage & deliver to one of five approved recyclers.



Photos: Lois Levitan, RAPP

Photoa Lois Levitan, RAPP

SELL TO CONSUMERS



PlasticsMarkets.org



Purpose: connect suppliers and buyers of all types of scrap plastic (from bales to post consumer resin). Intended for use by the recycling industry in North America, NOT intended for the general public. (source: plasticsmarkets.org)

Changes afoot: adding nuance about agricultural plastics to be useful to suppliers and markets for the array of agricultural plastics.





For Farmers



For Dealers



For Recy

<http://www.deltaplastics.com/>



Recyclers: Welcome To Delta Plastics

Join us in preserving the environment through our recycling efforts for used polytube, other ag-related plastics, and oil and gas material

[Learn More](#)

Capacity to recycle 200 million lb/yr, with potential to double. Only (L)LDPE

POLYTUBE



POND LINER



OTHER PLASTICS



recycling@deltaplastics.com 800.277.9172



News

Delta Plastics Launches H2O Initiative
18-Aug-2014



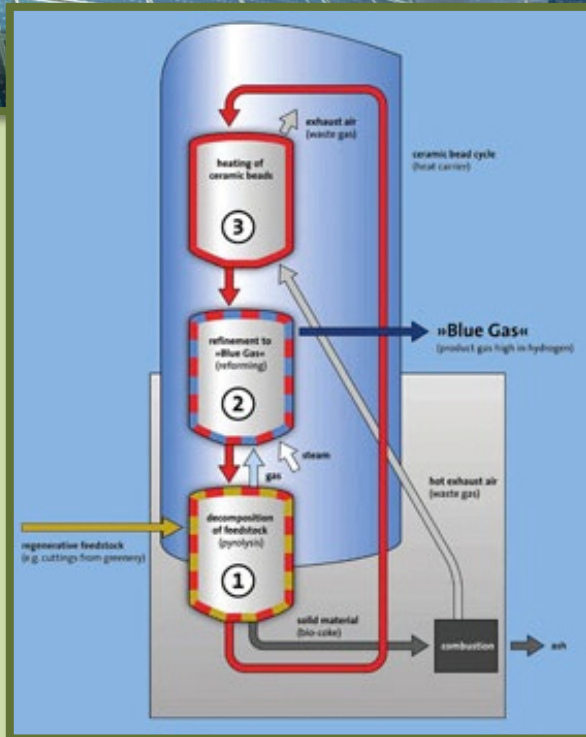
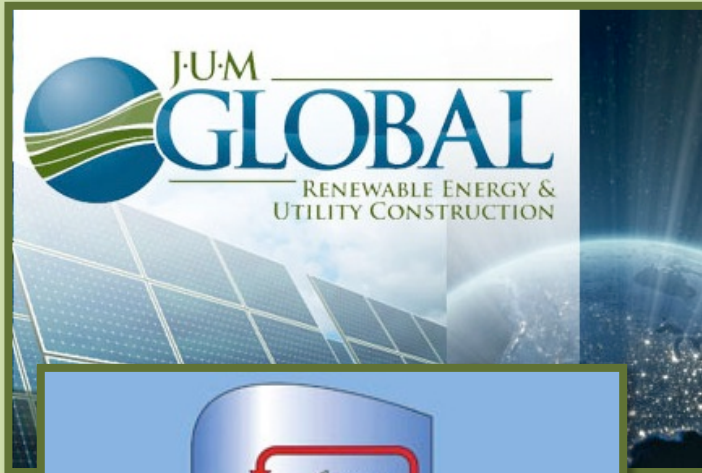
Thank you

& thanks to current and past funders, USDA SCRI for 'Tunnel Berry' project, NYS Environmental Protection Fund, NY Farm Viability Initiative, Cornell Cooperative Extension Administration, US EPA Region 2, USDA Rural Development, NYS Empire State Development



Photo: Lois Levitan, RAPP

Plastics-to-Oil: will it be a panacea for ag plastics?



HEAT + PRESSURE (+ catalyst) → oil or wax + inorganic residue (e.g., carbon black)

**PLASTIC
FILM**

**GLOBAL SUPPLIERS OF TECHNICAL
FILMS FOR AGRICULTURAL USE
(MOSTLY LDPE PLASTIC RESINS + ADDITIVES)**

Design for Recyclability

**Extended
Producer
Responsibility**

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