

#### RECIPROCAL LANDSCAPES Poplar for Phytoremediation in Design and Construction

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#### Ry Yahn

#### Master of Landscape Architecture Candidate

Master of Landscape Architecture Biochemistry & Cancer Research + Certificate in Climate Community Health Molecular Biology Summer Fellow Change & Health Volunteer ARC Fellowship Reed College University of Colorado Peace Corps Malawi University of Washington **DLR Group** 2014 2021 2010 2015 2017 2018

HEALTH

**SUSTAINABILITY** 



Healthy Materials: Seeking the Balance between Environmental Sustainability and Occupant Health

sequester carbon local

Healthy Materials: Seeking the Balance between Environmental Sustainability and Occupant Health biodegradable renewable nontoxic





### The current material development paradigm



alternative paradigm



### Lessons learned from plastic









### Interview participants



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INTERIOR DESIGN

summer '20

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acoustical

structural

mechanical

structural

**ENGINEERING** 

autumn '20



유국 education [편국] hospitality 『슈子 workplace

INTERVIEWS CONTDUCTED

# Where does the drive towards sustainability stem from?



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What are the biggest barriers designers face when making design decisions related to sustainability?

veracity availability accessibility comparability making case to client no post-occupancy eval

NF( code SOCIA RISK client values BARRIERS public values regional priorities **TO SUSTAIN** ABILITY AVAILABILIT lack of alternatives regional availability manufacturing capacity

no demonstrated success no industry consensus leading edge vs bleeding edge reusing familiar materials client standards

first time vs lifecycle sustainability premium first cut if overbudget time to research & design contractor / installation

lead times

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## The info gap - availability



# The info gap - availability

#### MATERIAL FOOTPRINT Biomass **Direct Consumption** Metals Construction Non-metallic 29% lerals Electrics & electronics Transport equipment Food, textiles, paper & wood Health, social & public work & education Other downstream economy

tons of cultivated biomass, extracted mineral ore and fossils

#### CLIMATE CHANGE IMPACTS



sector greenhouse gas ( $CO_2$ ,  $CH_4$ ,  $N_2O$ , HFCs, PFCs) emissions weighted by GWP to derive the amount of emitted  $CO_2$  equivalents.



particulate matter emission health impacts / burden of disease-DALYs

### The info gap - availability





# The info gap - accessibility



# The info gap - accessibility

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#### DATA AVAILABILITY

#### DATA ACCESSIBILITY

# The info gap - accessibility



## Shift towards sustainability

#### ENERGY EFFICIENCY

#### MATERIAL TRACKING

#### RECIPROCAL LANDSCAPES

- Shared goal for both designers and clients
- Built into design process
- As operational energy decarbonizes, embodied carbon will become increasingly important

Embodied carbon Operational carbon

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- Most often results from code requirements and green building pursuits
- Documenting & mitigating impacts



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- Understanding materials as continuous with the landscape they come from
- Improve environmental and human health through materials
- Circular & local



TIME

### Improvement not mitigation

#### Reciprocal Landscapes

develop construction materials that are continuous with the landscape they come from

Hutton 2019 Kimmerer 2011

### Contaminated sites in the US



- EPA estimates there are over **500,000** brownfields in the US (EPA 2020)
- The US spends \$6 8 billion each year on these sites

   (Doty 2008)
- About 20% of real estate transfers in the US are brownfield sites (Kennan & Kirkwood 2015)
- Over **16%** of global land areas are impacted by soil pollution (Anjum 2013)
- Pose health and environmental hazards











https://www.epa.gov/cleanups/cleanups-my-community

# Environmental justice issue

% people of color

5%

epa superfund / brownfield site

Guardian Guardian C Living near a US toxic waste site could shave a year off your life, study finds

First-of-its-kind study shows stark effects for people living near contaminated Superfund sites in urgent need of cleanup

Paola Rosa-Aquino

Tue 13 Apr 2021 13.49 EDT

The Philadelphia Inquirer

### Seventy percent of Superfund sites are within a mile of public housing, report finds

"Environmental racism has played a central role in this devastation," the report's authors wrote. "Laws and policies have put Black and Brown communities in direct proximity to environmental toxins."

by Michaelle Bond

Published Jul 14, 2020



### Contamination & climate change

2021

Marcantonio et al 2019





### Conventional remediation techniques





- excavation / "dig & haul"
  - contaminated soil is transported offsite for treatment or indefinite storage
- capping
  - barrier between surface and contaminants
- "in situ" / on-site
  - chemicals injected to break down contaminants or convert them into less harmful substances



Although Native American activists are trying to persuade tribes that storing nuclear and other toxic waste is not worth the potential pitfalls, some continue to host it on their sovereign reservations—which are not subject to the same environmental and health standards as U.S. land—in order to generate revenues

March 31 20



### Phytoremediation

plant · detoxification



Kennan & Kirkwood 2015



Kennan & Kirkwood 2015



Kennan & Kirkwood 2015



Kennan & Kirkwood 2015



Kennan & Kirkwood 2015



Kennan & Kirkwood 2015

### Phytoremediation applicability

- 10-30X cheaper
- more time intensive
- less certain

COST

MORE CERTAIN	LESS CERTAIN
Dig and haul	
Incineration	
Low temperature thermal	
Soil washing	
Air sparging and bioventing	
Bioslurry reactors	
	Phytotechnologies



Natural attenuation

## Phytoremediation applicability

- low to moderately polluted sites (i.e. not Superfund sites)
- able to take up and break down certain classes of organic compunds



### Phytoremediation with poplar



hearty survive toxic conditions

fast growth short rotation | store carbon

deep roots groundwater

adaptable grow most places

genetic variation

aesthetics

ecosystem services habitat | erosion control | buffer

secondary products bioenergy | timber

### Phytoremediation with poplar



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genetic variation

aesthetics greenspace

ecosystem services habitat | erosion control | buffer

secondary products





#### Reciprocal Landscapes: Vision



### Phytoremediation: Contaminated to Clean











community members, community-based organizations & community land trusts





#### A Constellation of Remediation, Vancouver

- "decolonizing dirt back to soil"
- 4 Indigenous Remediation Gardens planted on vacant contaminated lots
- will then build a community center for the Urban Native Youth Association on one site
- commissioned by the City of Vancouver's Artist Initiated Projects program

city, state, or federal government



for-profit developers & private landowners



community members, community-based organizations & community land trusts



#### Fresh Coast Capital

- public-private partnership with Rust Belt cities
- leased vacant brownfield properties to plant hybrid poplar
- funded through impact investors
- harvest timber every 12 years for timber



Sawmill Community Land Trust, NM

- non-profit that holds land in trust for the benefit of the community
- community-driven affordable housing
- have reclaimed 34 acres of abandoned industrial sites







community members, community-based organizations & community land trusts



- may sell, lease, or donate remediated land
- site maintenance jobs
- involved in the vast majority of brownfield redevelopment projects
- opportunities with impact investors & innovative sustainability-focused companies
- contribute to revitalization & economic development
- look for return on investment
- risk of gentrification
- affordable housing
- public amenities & green space
- community stewardship
- environmental justice
- site maintenance jobs









### Client applicability: Project Rocket



### Feasibility – client questions

- TIME
  - how long from planting to harvest

#### SIZE

- size of trees
- land size required

#### YIELD

- how much could go to a manufacturer
- product minimums

#### PARTNERSHIPS

• information & partners needed



### Logistics, logistics



organic / inorganic Amount of Contamination low/moderate/high Soil & Water Analysis type / flow Poplar Suitabilty water / sun / contaminant type Species & Variety Selection hybrid/clone

> Policy & Partnerships regulations / funding

Labor Planting Plan spacing / intercropping Other Technologies endophytes / treewells

Weed & Pest Control Pruning & Training Monitoring Harvesting

Plywood Finish Certification

Design **Specification** 





Site Preparation

Site Management

GreenWood Resources

acquisition / forestry management / operations / harvesting

Offshoots, Inc landscape architecture / planning productive landscape installation / phytoremediation

**Environmental Forestry Consultants, LLC** 

forestry / phytoremediation / poplar expert

Ecolotree

phytoremediation / engineered forests / design, installation, maintenance

Intrinsyx Environmental

🚸 Intrinsyx Environmental

ecolotree

phytoremediation / integrated biological systems / design, installation, management

Manufacturer

S1K

Building / Site

DLR Group

DLR Group

chitecture Engineering Planning Interior

Structurlam STRUCTURLAM mass timber / CLT manufacturer

SmartLam SmartLam mass timber / CLT manufacturer hardwood CLT WIG partner

Columbia Forest Products hardwood plywood & veneer manufacturer

#### Manufacturing: Harvest to Product



### Manufacturer Interviews



#### Powering the process

"... the commercial success of phytotechnologies depends on the **generation of valuable biomass** on contaminated land ..."

- Conesa et al. 2012

