Northeast bio-based materials collective

2023 Summit Proceedings

About the Summit

The following document is a summary of the inaugural Northeast Bio-Based Materials Summit and is intended to provide a comprehensive overview of the event's dialog and workshop outcomes. On November 15th 2023 a collective of over 60 individuals representing the full spectrum of the bio-based construction value chain attended the Summit in Boston, Massachusetts We convened to begin answering the following prompt: *How can regionally produced renewable building materials be brought to market, at scale, across the Northeast of North America?*

Understanding the answer to this question requires continued participation across the full spectrum of the construction sector. The Summit's key objectives were as follows:

1. Investigate challenges and solutions for scaling bio-based materials in the Northeast.
2. Establish a peer network to address challenges and leverage opportunities collaboratively.
3. Promote the adoption and advocacy of bio-based materials within the region and beyond.

To meet these objectives the Summit was structured into both networking and workshop activities. The day's introduction was led by inspirational presentations from Kelly Alvarez Doran, Jacob Deva Racusin, David Lewis, Jonsara Ruth, and Ace McArleton, each highlighting the importance of cross-sectoral collaboration and bio-based materials in our just transition to a healthy, equitable, climate positive future. The presentations have been generously shared and can be found here: https://massdesigngroup.org/work/research/northeast-bio-based-materials-collective

Attendees then broke into three working group sessions over the course of the day. The first working session grouped attendees by thematic groups of Raw Material Supply, Manufacturing & Distribution, Building Design, Construction, and Ownership & Use to outline the key challenges to scaling of bio-based materials in the region. These groups prioritized two challenges to identify their 'root-causes'. Attendees were then mixed for an afternoon workshop session that looked at developing as many solutions as possible to the challenges brought forward from the first session. Thematic groups then reconvened in a final session to organize the solutions into actions that could be taken in the short, medium and long term. Finally, all attendees reconvened to share-out the findings of each group and discuss their observations and the common themes that emerged. Please see the notes from each group's workshop in Appendix A for greater detail.

Comments from a follow-up webinar with over 100 participants held on January 24th, 2024, have been integrated into these proceedings.

Primary Themes of the Day

1. **Misunderstanding and Communication**
   Bio-based materials, as a category, lack significant visibility, with many people not fully aware of their existence or understanding their importance. In cases where bio-based materials are recognized, they often carry a negative perception as having inferior performance in terms of thermal properties, durability, and cultural value. Additionally, there is a misconception that bio-based materials are more expensive, complicated, and risky to deploy in projects. To overcome these challenges, effective communication strategies, using data driven evidence, are essential. This includes the dissemination of case studies, technical reports, architectural features, and professional training programs targeting all industry stakeholder groups to enhance awareness and correct misconceptions about bio-based materials. The significance of data transparency, in particular the benefits regarding carbon storage, toxicity and economic support of rural communities, emerges prominently as a crucial requirement and valuable asset for bio-based materials in tackling climate and health benefits.

2. **Structural Barriers and Policy/Regulatory Engagement**
   Several legal and regulatory impediments hinder the widespread adoption of bio-based materials. These include existing codes, incentives, and policies that predominantly favor traditional petro/mineral industries, thereby actively discouraging the growth of biomaterial industries. To overcome these challenges, it is crucial to actively participate in the development of codes and policies, while also enhancing compliance documentation (e.g. fire test verification) for both existing and emerging biomaterial products. These efforts represent key strategies to effectively address the existing structural barriers in the bio-based materials sector.

3. **Industry Growth and Development**
   The biomaterial sector presents promising prospects for self-organization and the enhancement of infrastructure related to code engagement, business development, research and development (R&D), marketing, and promotion, which are currently constrained or deficient. However, securing financing for these initiatives poses a significant challenge and, simultaneously, a substantial opportunity for like-minded investors. Emerging companies encounter obstacles in reaching scale and require support. The establishment of a biomaterial trades organization has been identified as a pivotal strategy to bolster these initiatives.

4. **Supply Chains**
   Effectively optimizing supply chains and fostering collaboration with sustainable agricultural and forestry partners are integral components in enhancing and conveying the market value of bio-based materials. This approach is pivotal in overcoming specific challenges related to raw material supply, processing, and logistics. Strategic marketing and policy initiatives aimed at amplifying the market value associated with ecological and social benefits will play a pivotal role in endorsing the enhancements in supply chain and data transparency. Initiatives to fortify regional material supply chains, embrace variability within products, and actively cultivate relationships among AEC, manufacturers, and agriculture/forestry are essential endeavors in this pursuit.

Suggested Key Next Steps

The following are recommended tasks under five working groups that were collectively established during the summit.

1. **Collaboration: Develop the collective vision and coordinate group efforts for larger systems change.**
    a. Develop of a comprehensive multi-year Northeast Bio-based Materials Plan that integrates strategies across actions in communication, education, innovation and regulation, in a holistic manner with an approach that recognises the importance of systems-level change to deliver a safe and equitable built environment. The Two Loops model (Appendix B) provides a theory of change that can help us understand our role in the transition from the dominant system to the emergent one, and to establish and communicate a system-wide strategy of transition to bio-based building materials.
    b. Manage the collective quarterly meetings and annual convenings.
    c. Identify and engage other initiatives already underway in forestry, agricultural and non-building sectors, in the northeast and beyond.
    d. Identify current members of the group and engage supply chain actors that are not currently prominent in this group, such as sales people and retailers.
    e. Suggest the aspirational definition and tiered alternative of what a bio-based material is and the core principles of the group to be voted upon.
    f. Support working groups to be diverse with regards to people and knowledge
    g. Develop practical means for centralizing this group's information.

2. **Communication: Address misunderstandings related to bio-based materials and promote positive stories and metrics.**
    a. Develop a comprehensive communication strategy to highlight the importance and benefits of bio-based materials.
    b. Develop, source and disseminate case studies, technical reports, and architectural features targeting all industry stakeholder groups.
    c. Identify positive important metrics, stories and practical benefits that need to be highlighted, and do so in a fun engaging manner, such as videos.
    d. Think about how we collectively reimagine the future and communicate this vision.

3. **Education: Support existing learning opportunities and generate new ones around bio-based materials.**
    a. Identify the groups to engage, such as future industry individuals, existing practitioners, users, and policy makers.
    b. Collaborate with educational institutions to integrate biomaterial-related topics into curricula.
    c. Establish continuing education courses with regards to bio-based materials.
    d. Share industry practices and cultivate relationships among AEC, manufacturers, and harvest.
    e. Facilitate dialogue between labor unions and this organization for cross-education.

4. **Regulation: Engage in policy and code development, and support regulatory compliance of bio-materials.**
    a. Engage in policy and code development and advocate for incentives to promote the use of bio-based materials and address barriers to their use.
    b. Enhance compliance documentation for biomaterial products to ensure alignment with existing and emerging regulations, fostering industry acceptance.

   c. Develop a standard methodology for the valuation of biogenic carbon storage in life cycle assessment accounting that considers factors such as short- and long-cycle carbon timeframes, dynamic LCA and the time-value of carbon accounting, and production criteria qualifying the inclusion of carbon storage values for bio-based materials.

5. **Innovation: Explore financing options for the collective and guide its path toward professionalism.**
   a. Facilitate financing for initiatives identified within the Northeast Bio-based Materials Plan
   b. Define and establish a values orientated bio-based materials trade association.
   c. Grow a cooperative model of developing small businesses.
   d. Research the actual demand for building products regionally and what it would take to meet that demand with bio-based materials.
   e. Perform a true cost benefit analysis of using bio-based materials.

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Appendix A

Raw Material Supply

Identifying Challenges

Categories	Example challenges
Image and Perception	Negative images of “logging” and wood use
	bio-based materials as “weak” and vulnerable to mold, degradation, pests, etc - not durable
	Lack of public awareness of source of materials - both bio-based materials and conventional materials - difficult to assess benefits vs challenges of each
	Partial co-optation by dominant industries, which muddies the communication of true benefits vs negative effects of materials
Regulatory	Fire codes, building codes prohibitive to bio-based materials
Cost	Material choices are often made at the end of design or development process, where cost is then only true major consideration (lack of prioritization of materials in planning)
Industry and/or Business support	Lack of nurturing structures for emerging biomaterial industries
	Lack of equitable business ecosystems that build critical mass and resilience needed to tackle this scale of problem
Funding and Financing	It takes time and resources to have innovations penetrate market/society and we don’t have enough of either
	Lack of adequate financial & funding options for biomaterial innovators
Transportation	Transportation emissions as a part of the bio-based materials carbon/toxic/social impact picture
	International shipping seems to negate need for local or bioregional focus
Certification	Verified provenance of bio-based materials lacking & creates challenge to confidently communicate and have confidence in quality of positive effects of bio-based materials (improved certification processes)
	Existing certifications are cumbersome, expensive, and not always available
Supply Chain	Extreme weather events & climate crisis creates inconsistent access to bio-based materials (fires in forests, floods in grain fields, etc) - R&D for resilience
	Local supply chain is missing some links - need regional manufacturers using regionally-grown material
	Availability and variability of raw material is a challenge for bio-based materials
Equity & Social Justice	Social justice of biomaterial solutions not always centered - let’s not create our own false externalities

Categories	Example challenges
	Lack of acceptance of & forming inclusive and just forms of business operating models (cooperatives, etc)
	Workforce development doesn't currently center DEI and it needs to

Root Causes and Effects

Challenge	Identified root causes	Identified effects
Stigma: Mis-Perceptions of bio-based materials	-Human/social disconnection from nature prevalent -Commodity form within capitalism invisibilized the nature of things	-hard to see a healthy way for humans/societies to be in connection/relationship with "nature" -creates false distance between us and "nature" that is hard to bridge -people think "protecting nature" means not touching it (ie "leave forests alone") -we then are also alienated from ourselves and our human senses and bodies -creates "externalities" and sacrifice zones to prop this up -True cost hidden in perceptions of value
Separation of Actors in Biomaterial Supply Chain	-Commodification of all things -Intellectual property -Geopolitical conflicts -Elevation of aesthetics -siloed groups of practice/trades/industries	-interconnected, systems nature of actors & processes is invisibilized - ineffective interventions happen because they don't speak to the systems nature of the problem and solution -resources siloed

Identify Solutions

Challenge 1: Negative stigma and perception of bio-based materials

Category	Solution	Effort	Effectiveness
Image and Perception	Documentation & publicization of case studies	Low	High
	Monitor existing projects w data collection	Low	High
	Compile key statistics in central place	Low-medium	high
	Short-term rentals (Air BNBs) of biomaterial homes	Low	High
	Keystone/Trendsetter projects (public, large, visible, high-clout) ie large industry buildings or public buildings with lots of visitors	medium	high
	Change and/or decide on language to best communicate bio-based materials	low-medium	low-medium

Category	Solution	Effort	Effectiveness
	Cross-industry media (like Patagonia straw bale video)	low-medium	High
	Media, PR and skilled promotional support for bio-based materials	low-medium	High
Certification	3rd party verified bio-based materials	low-medium	low-medium
Supply chain	Create a Vision of Northeast Bio-based future (like NE Food Vision)	medium	high

Challenge 2: Separation of actors in bio-based materials supply chain is not effective

Category	Solution	Effort	Effectiveness
Supply Chain	Network building with us (regional bio-based materials chain)	medium	high
	Zoom call with us	low	medium
	Interdisciplinary grant & research projects between agriculture AEC & policy	low-medium	medium
	Build connection in our network by providing incentives & funding for travel etc to gatherings to support and incentivize participation	low-medium	medium
Industry and/or Business support	Peer, consultant, or other business support network for bio-based manufacturing companies so we can succeed & be around	low-medium	high
	Producers' cooperative for bio-based materials	low-medium	high
Funding and Financing	Subsidize early incentives with consumer & designers	medium	high
Certification	Build a 3rd party, verified certification for bio-based materials	medium-high	high

Steps Towards a Solution

Category	Immediate (0-3 months)	Short Term (3-12 months)	Long Term (12+ months)
Demonstration Projects/ Case Studies	1. Better documentation of case studies/data from existing 2. Compile key statistics in central place (online?)	1. Short term rentals of biomaterial buildings that also connect to place, food, etc.	1. Public buildings "flagship" project as demo- high visibility, partnerships, etc.
Data Testing &	1. Monitor existing	1. Data collection on	1. Ongoing data

Category	Immediate (0-3 months)	Short Term (3-12 months)	Long Term (12+ months)
Research	projects data collection	occupants from short term rentals above	collection on projects and ongoing reporting of that (public/accessible)
Network Building	Zoom call with this group!	Create bio-based materials Ally Network	bio-based materials Innovation Park <3 2nd Annual bio-based materials Summit
Media & Messaging		Professional Videos/art projects/podcasts highlighting bio-based materials	1. ...even more great media/art projects, ideally that cross industries (for example Patagonia Strawbale video) 2. Work to hone our language so it's most effective and both speaks to ppl and creates the new system
Education	Workshops & training	Workshops & training	Workshops & training & workforce development
Strategic Planning			Create a Northeast bio-based materials Vision (like Northeast Food vision) (project for the 2nd Annual bio-based materials Summit)
Business Development	Business support for producers & manufacturers of bio-based materials		Create Producers Cooperative and/or Trade Association

Manufacturing & Distribution

Identifying Challenges

Categories	Example challenges
Supply Chain	Logistics and transportation challenges (bulky material, cost, storage)
	Disconnected supply chains for nat. materials
	Feedstock supplies - consistency, avail.
Product Development/Fulfillment	Fiber processing (esp hemp)
	Massive demand, insufficient supply, hard/risky to scale
	Labor shortage for advanced manfr.
	Funding for startup; scaling up hard for smaller companies entering into this space
	Testing: fire, acoustic, thermal = $$$ (part of startup costs?)
	Lack of manufacturing standards development
	Poor transfer of tech/research from universities to manufacturers; lack of research support
Deployment	Leverage extg installers, skill gaps in trades
	Insurance companies unfamiliar/unwilling to protect novel materials
	Detailing for new products
	Disclosure of materials (transparency) and benefits
	Code (building, fire, etc) heavily favors extg materials/fossil-based solutions; no regulation of carbon emissions in materials; code geared towards operational emissions not material emissions; code often restricts adoption of novel materials; prescriptive code builds in structural barriers
Marketing and Sales	Not enough competition to create competitive bid structure for public projects
	Unjust labor practices, subsidies, externalization of costs depreciating price of fossil-based products; low market value, incentives for benefits of bio-based materials (e.g. toxicity, climate impact)
	Case studies, performance testimonials
	Architect/trade/public awareness of product/value
	“Mind shift” required to adopt new material/values; burden of change (cost, effort)

Categories	Example challenges
	Perception of performance (low tech, inferior product due to natural material sourcing)

Root Causes and Effects

Category	Identified Root Causes	Identified Effects
Supply Chain Gaps (SCALE)	Technology development and transfer	Lead time/access
	Cultural values/language/expectations	Distribution (diversity of options)
	Investment	Feedstock
	Regulatory barriers	Manufacturer costs
	Education (industry and market)	Underdeveloped supply chain
	Lack of goals/metrics/tools	
Demand/Marketing (TRUST)	Value awareness	Lacking subsidies/incentives
	Education (industry and market)	Investor confidence
	Cultural values/language/expectations	Consumer awareness
	Risk awareness	Industry knowledge
	Vision/experience visibility	
	Regulatory barriers	

Identify Solutions

Challenge 1: Supply Chain Gaps

Category	Solution	Effort	Effectiveness
Education/information	Online database of materials and sources	Lower	High
	University/college info transfer/research	Moderate	High
	Regional summit showing solutions	Moderate	Low
	Raw material source mapping	Moderate	Low

Category	Solution	Effort	Effectiveness
Workforce	Robust wages and benefits for manufacturers	Moderate	High
	Training local panelized labor forces	Moderate	High
	Outreach to extg regional workforce development efforts	Lower	Moderate
	Trade skill introduction in early education	Moderate	Moderate
Supply Chain	Develop distribution channels in each market	Lower	Lower
	Localize production (large scale)	Higher	High
	Financial incentives for farmers to expand market	Higher	High

Challenge 2: Demand/Marketing

Category	Solution	Effort	Effectiveness
Education and Information	Honest, personal conversations	Low	High
	Meet with union reps	Lower	High
	Online database of materials and sources	Lower	Moderate
	Regional summit offering solutions	Low	Moderate
	Find grant opportunities, including grants to find grants	Low	Low
	Get performance data	Low	Low
	Make bio-based the “new sexy” for architects	Higher	Moderate
	Appeal to mission-driven developers (sense of	Higher	Higher

Category	Solution	Effort	Effectiveness
	responsibility)		
	Initiate mainstream conversation about health impacts of status quo	Higher	Higher
	Demonstration projects	Moderate	Moderate
	Train subs	Higher	Moderate
	Tradeshow/festival/conference on bio-based materials	Moderate	Low
Funding and Policy	Municipal zoning incentives	High	High
	Carbon Tax	High	High
Supply Chain	Make it cheaper than other options	High	Moderate

Steps Towards a Solution

Category	Immediate (0-3 months)	Short Term (3-12 months)	Long Term (12+ months)
Determine appropriate distribution channels in each market	Engage & partner with unions and training orgs	Trade skill introduction in early education	Train subcontractors
	Early workforce outreach to existing regional partners	Program development within existing models	New programs and scale
	University/college info transfer/research		Train and maintain local discrete labor pool
			Co-train installers and architects in bio-based materials
Material feedstock and data	Material mapping (see CASBA)	Connect farmers with product manufacturers → network	Co-locate mfr with timber and ag production
	Determine appropriate distribution channels in each market		Localize production at large scale
	Collective pricing		

Category	Immediate (0-3 months)	Short Term (3-12 months)	Long Term (12+ months)
	through building ease (?)		
	CMF enabling owners to express demand consistently		
Manufacturer Support	Cost reduction to try it at scale	Drive manufacturer tech support for scaled tech integration	Financial incentives for farmers to grow plants for building products
		Bio-based materials trade organization	Make it cheaper than other options
Policy	Policy advocacy - join CLF, participate in public engagement	Code change proposal to ICC Jan 2025	Resolve regulatory hurdles (fire codes, etc)
		Identify regulatory hurdles	City to implement zoning incentives

Building Design

Identifying Challenges

Categories	Example challenges
Image and/or Perception	General resistance to change
	Lack of sense of urgency
	Risk aversion / Fear of change
	Client decision structures
	Perception that it's too complicated to employ
	Time (Production & Manufacturing)
	Carbon does not have a value on the proforma
Workforce	Lack of contractor buy-in
	Coordination between design trades
Governance	Stringent permitting / building codes
Constructability	Fear that it will impact construction schedule
Cost	Warranties for adjacent materials
	Insurability
	Perception that it's too expensive
	Cost leap comparative to today's norms
Education and Information	Lack of awareness about products
	Architects have bad design habits (high carbon is default / all we teach)
	Limited expertise/lack of resources to go to

Root Causes and Effects

Category	Identified root causes	Identified effects
Design & Construction Status Quo & Culture	Lack of well-rounded and cohesive metrics	Lack of metrics for bio-based value Linear material flows
	Push for constant economic growth	Designers as consumers
	Culture/standards of aesthetics	Designing without material in mind

Category	Identified root causes	Identified effects
		Reliance on “image” and “render”
	Lack of whole-life thinking	Narrow understanding of “resource”
Current & Future Economic Market Culture	Profit driven mindset	Systemic cycle of perpetuating “growth”
	Lack of value on carbon	Little incentive to reduce embodied carbon universally outside of performance rating systems (e.g. LEED)
	Racial & ethnic “othering” for extraction	Unknowns of forced labor Hidden effects of extraction
	Lack of value on toxicity	Unequal health and economic impacts
	Centralized equity ownership	Fear that new alternatives can be competitive

Identify Solutions

Challenge 1: The design and construction culture and status quo

Category	Solution	Effort	Effectiveness
Project Delivery	Switch from “project based” to “platform based” design processes	Higher	Moderate
	Design buildings for adaptive reuse from the start	High	Moderate
Governance	Create an update to typical single family home zoning	Higher	High
Education/Information	Create and popularize standard metrics for the evaluation of upfront carbon	High	Moderate
	Develop detailed typical case studies to highlight high level issues	Moderate	Moderate

	Elevate the knowledge around the problems of current typical construction	Moderate	Moderate

Challenge 2: Current economic market factors driving building and development

Category	**Solution**	**Effort**	**Effectiveness**
Governance	Develop incentives for upfront carbon	Higher	High
Education and Information	Develop popular media about bio-based materials and upfront carbon (HGTV)	High	Moderate
	Create a “healthy host” standard for AirBNB/Hotels/Etc	Moderate	Low
	Connect bio-based materials to the larger health/wellness movement	Moderate	Moderate
Project Delivery	Engage with existing organizations primed for new solutions (Habitat for Humanity)	High	Moderate

Steps Towards a Solution

Category	**Immediate (0-3 months)**	**Short Term (3-12 months)**	**Long Term (12+ months)**
Create shared metrics for health and upfront carbon			
Educate developers on the benefits of better materials	Begin to develop content	Workshop conversations with sympathetic existing partners	Publish and promote documents that are open for all to use
Create a database of rigorous case studies and academic information	See what is out there already, and begin to aggregate examples of projects and papers	Interview relevant folks, compile information	Publish and promote documents that are open for all to use

Construction

Identifying Challenges

Categories	Example challenges
Contractor Knowledge/Literacy/Training	Lack of skill/training in on site trades; lack of product knowledge in on site trades; need for clarity around quality control procedures; need for CM/sub to be on board; Compatibility with other materials
Lack of Precedent/Knowledge	No clear local/regional precedents; status quo bias; short term / long term durability concerns;
Perceived Risk / Lack of Knowledge	Perceived risk of long term performance; complicated liability change; disruption of established supply chains; unwillingness to try something new; need to educate owners and get buy-in
Not Part of Original Project / Not Fully Vetted	Lack of integrated design intent; difficulty in injecting bio-based materials after design stage; disconnect among healthy material specs overall
Code / Approvals	Inspector/building inspector skepticism and/or lack of knowledge; need for complex code approvals; limited consistency between physical properties and engineering data; limitations to actual capabilities (relative to fire code specifically)
Lack of Champion / Focus	Overall goal of decarbonization allows bio-based materials to be sidelined at times; each project team needs one (or more) champions of the product/methodology
Lack of Incentive/Demand	Client values not aligned; market awareness is low and some clients (part. residential) have limited knowledge; project requirements not aligned; no clear incentives for owners/clients; real estate value not aligned with high performance building costs;
Value / Cost	High Cost of materials; Ability to 'sell' is low (demonstrate value to clients);
Lack of Testing	Health documentation missing; lack of cohesive testing and validation; missing test data
Procurement / Availability / Access	Sourcing material is challenging, especially at scale; limited transparency in manf/procurement; need for local/regional materials not aligned with current options; supply chain not steady; supply relationships limited/non-existent (as compared to other products);
Storage & Handling	Storage and Lead time requirements more complicated than with other materials; climate can be non-conducive to install; handling methods are novel; more vulnerability to environmental factors than other materials

Root Causes and Effects

Category	Identified root causes	Identified

		effects
Procurement (Price/Buy/Train)	Lack of Skills/Tradespeople < Lack of Value in Tradeswork	
	Inherited Norms in Construction (buy x from y person)	
	Business Industry Incentive < Economic System Value (& Justice) < Skewed Value in Economic System	
	Industrialization (Globalized and Extractive)	
Perceived Risk / Lack of Precedent	Time Sink (short vs. long term benefit)	
	Profitability < Obscured return for an indv./org. < Liability Chain	
	Lack of Global View	
	Lack of Demand	

Identify Solutions

Challenge 1: Procurement

Category	**Solution**	**Effort**	**Effectiveness**
Policy	Subsidies for Material Production	Medium High	High
	[Rubric for] Tax Credits for Bio-based Materials	Medium High	Medium High
Industry Support / Association / Trade Group	Forestry/Ag Support of best practices	Medium	Medium
	Product Demand Prediction (projects coming on line, visibility and incentive)	Medium Low	Medium High
	Identification of Waste Streams and Highest and Best Use	Medium	High
	Technology and Investment in Feedstock	Medium	Medium High
	Cooperative Buying (in bulk)	Medium	Medium
Training and Workforce Development	Include in trade school curriculum, pay students for training/apprenticeships	High	Medium
	Training at large scale across multiple trades	High	Low

Benefits from enacting tomorrow: Leadership and Momentum and Lower Cost

Challenge 2: Perceived Risk

Category	**Solution**	**Effort**	**Effectiveness**
Industry Support / Association / Trade Group	Insure the Risk	High	High
	Re-Branding (straw to cellulose)	Medium Low	Medium
	Broaden Stakeholders, create reward ($$) for implementation/use	High	Medium
	Architectural Awards (positive or negative) like 'Exemplary Forestry Practice'	Low	Low
	Demonstration Center (like BREEAM campus)	Medium	Medium
	Subsidize education of designers and builders	Low	Medium
	Communicating Network / Lessons Learned Feedback Loop	Medium	High
Policy / Government	Government (Fed/State/Local) statement of priorities and a commitment to them	Medium High	High
	Standards and regulations for quality products and performance in the building code	High	High
	"Bio-Decathalon" at federal level	Medium	Medium High
Design Industry adjustments (or project delivery changes)	Consolidate Service Companies - design/build or architect/developer	Medium High	Medium

Benefits from enacting tomorrow: Brand Communication network, common language, metrics, clear articulation of value of bio-based materials, public perception shifts/broadens

Steps Towards a Solution

Category	**Immediate (0-3 months)**	**Short Term (3-12 months)**	**Long Term (12+ months)**
The Next Project (we just all do it on the next one)	Provide clients info (on cost, maintenance, risk, and reward)	Project Management Stewardship	Stunning photos of straw bale buildings
Build Momentum	- Pledge to Work Together (whole group) - Create Sustainability Action Plan for org/group/person/gov	- Create Focus and build momentum - Connect to networks (suppliers and contractors)	- Central Organization (like CLF?, how formal TBD) - Lobby the Dept. of Ag for support

Category	**Immediate (0-3 months)**	**Short Term (3-12 months)**	**Long Term (12+ months)**
Leverage Trades and Existing Workflows		Collaborate with historic preservation trades and organizations (some of the skills are out there already)	Nationally recognized trades training program focused on (or integrated with at least) bio-based material education
Thought Leadership	- Identify Gaps - **Share** and Create Info	- **Marketing** - Demystify the concerns	Leverage Project Opportunities for pilot projects
Accountability	- Sign AIA Material Pledge - Develop Language and Requirements	- AGC Sustainability Committee standard development - Low Carbon/Bio-based materials as bid requirements for all projects	GC/CM Working Group to share info
Indirect Incentives		- Make case to DEP (MA/ME or at Fed level)	- DEP increases tipping fees or other costs - Reduce landfill use and de-incentivize traditional materials

Ownership & Use

Identifying Challenges

Categories	Example challenges
Fear of Change	Neighborhood organizations may not want this type of construction and discourage any change
	Banks reticent of supporting unknown types of construction.
Financial Support	Developers are bottom line and profit driven, beholden financers. Lenders need incentives. Where are the incentives for landlords to create these units?
	Limited subsidy for affordable housing - caps on sale rent = caps on subsidy
	Grants requiring competitive bidding - can I get my three bids?
Cost	Pay for the “cool factor” (popularity, early adopter prices)
	Economic return. It is expensive when you don’t externalize costs.
	Money to pay for added engineering & extended timeline
	Labor shortage, too specialty
	Fear of operational costs (OPEX) being increased as a landlord
Schedule and Supply chain	Adjust construction schedule with seasoning to get adapted to harvest cycles
Knowledge	How do I maintain and care for this house?
	Lack of public understanding of the pros and cons of these materials
	Fear of getting sued

Root Causes and Effects

Category	Identified root causes	Identified effects
Fear of Change	Lack of evidence Lack of awareness More cost Mixed information/messages	Hesitance from banks insurance Lack of demand Why me first? Means to quantify externalities Lack of information / Not being taught
Bio-based are more costly	Training of workforce Not subsidized (ie Acts) Labor shortage Limited availability (market, materials...)	Limited market (3 bids) Reduced lending options Compromised decisions / not whole. Need to reduce costs somewhere else.

Category	Identified root causes	Identified effects
	More construction constraints Pay for the "cool factor"	Costly maintenance

Identify Solutions

Challenge 1: Fear of Change

Category	Solution	Effort	Effectiveness
Educational	Storytelling Effort Public awareness campaign Simplification of facts and demystifying myths through known to unknown	Low	High
	Training programs	Medium	High
Knowledge Spread and Need for Precedents	Develop metrics to communicate externalities in a compelling way	Medium	Medium
	Regional knowledge-sharing network	Medium	High
	Rewrite the 3 little pigs story	Medium	Medium
	Precedents list. Learn from others (Europe, West coast universities...)	Low	Medium
	Data + Case Studies/Pilot Projects to help owners right-size their sense of risk	Medium-High	High
	Human comfort analysis to prove expanded thermal comfort range around bio-materials (and reduced operational carbon)	Medium	High
Awareness and Action	You are the demand!	Medium-High	High

Category	**Solution**	**Effort**	**Effectiveness**
	Grassroot campaign	Low	High
	Acknowledge change is a constant. Failure to evolve is falling behind. Future legislation is unknown.	High	High
	Future is a mindset, not a timeframe.	High	High
Financial Support	More home-grown, not donor driven	Medium	Low
Corporate	Link to corporate commitments / ESG / sustainable goals (ie net-zero by 20XX)	Medium	High
Cost and Affordability	Remain competitive	Medium-High	High

Challenge 2: Bio-based are more costly

Category	**Solution**	**Effort**	**Effectiveness**
General Knowledge	Start with the low fruit and build from there. One thing at the time	Low	High
Educational	Understand back-end / ROI savings of materials and frameworks (more now, less later)	Medium	High
	Teach how (and why) to use bio-materials as “substitutions” to professionals, estimators and students	Medium-High	High
Research	R+D into new material applications	High	Low
Design Process	Integrated design process. Get stakeholders talking to each other earlier in the project	Low	Medium
	Less is more. Build with	High	Medium/High

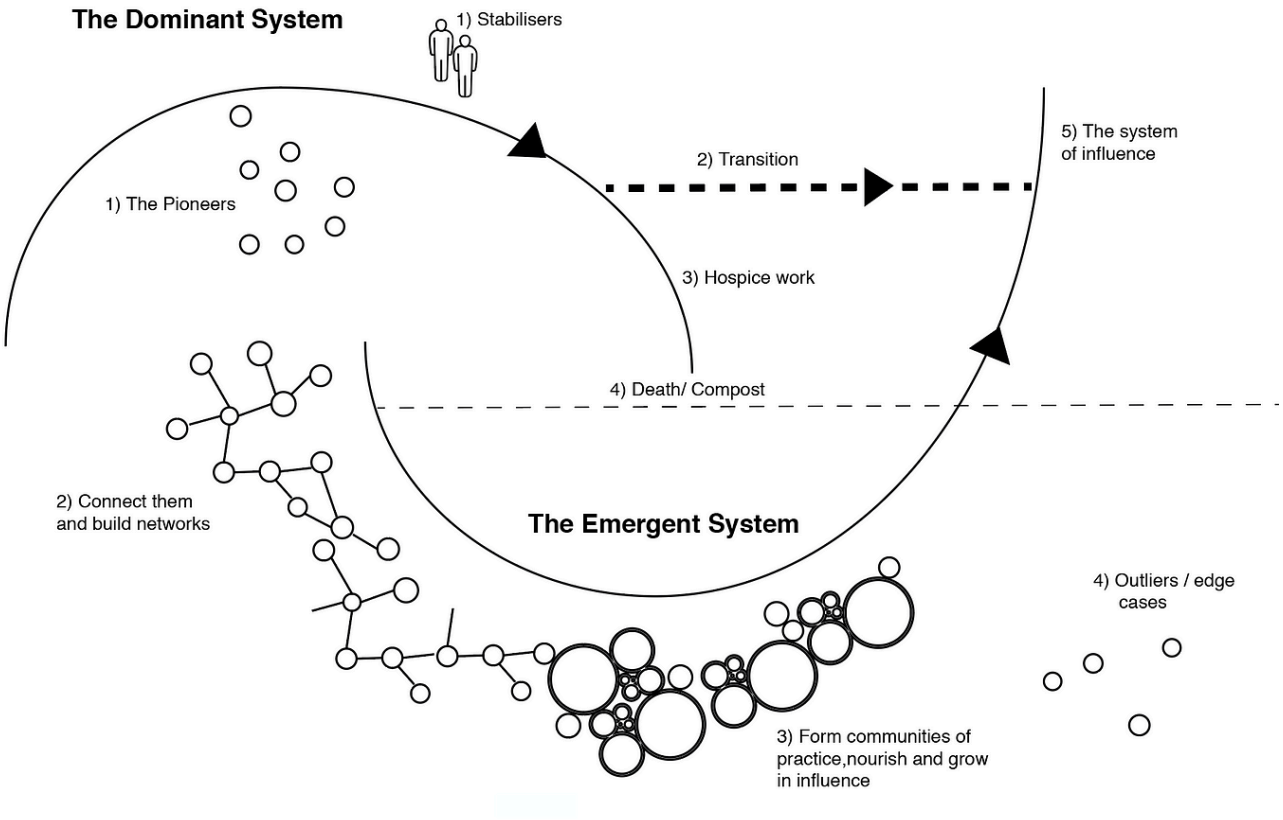
Category	Solution	Effort	Effectiveness
	less (layers, space, etc)		
	Make sustainability a baseline. Remove passive / wishy-washy language from requirements (no "when feasible" or add alts)	Low	High
Supply Chain	Provide local storage depots to ensure seasonal material availability (ie silos)	High	Low
	A short and local supply chain can reduce cost	Low	Medium
Legislative	Get rid of NAFTA. Avoid importing.	High	High
	Public procurement to secure pipelines which will grow the number of suppliers and reduce the cost.	Medium-High	High
	Lobbying + Political Action to get subsidies + incentives	Medium-High	High
	Whole Life Carbon Policy	Medium-High	High
	Monetize Ecosystems (True Cost)	Medium-High	High

Steps Towards a Solution

Category	Immediate (0-3 months)	Short Term (3-12 months)	Long Term (12+ months)
Legal support	Understand cost Owner req's	Fundraising (private and public) Establish priorities	Hire lobbyist Educate Deploy
Standardization (establish codes, requirements...)	Convene Establish consensus Establish stakeholders	Create outline / plan Baseline expectations	Write standards Advocate
Standardization	University-led case-study list across		

	departments		
Educational + Training	Training programs	Engage academia Establish curriculum	
Awareness + Action	Schedule meetings Steering committee	Understand cost Establish an organization 501(c)(6) Hire a lawyer	Create a bio-material trade organization

Appendix B - Two Loops Model



The 2 Loops Model is a visualization of a theory of organizational or systems change which explores the transition of a dominant system in decline towards an ascendant emergent system. The value of this model is showing what the transition process looks like, including the stages of decline of the dominant system, the stages of development of the emergent system, and how to organize a transition between these systems. The model also identifies roles to be played in these different stages. The model was developed by Meg Wheatley and Deborah Frieze from the Berkana Institute.

In the model, the Dominant System starts with its zenith, and identifies roles and processes related to supporting the unwinding of the system and reallocation of its resources. The Emergent System identifies the development of individual trailblazers, who connect within networks, which coordinate as communities of practice, to establish a sufficiently influential system to attract a transition from the Dominant System. A contemporary example of this would be the decline of a fossil fuel-based economy, which requires the unwinding of many businesses and technologies, and the reappropriation of money, technology, and power to an emergent renewable energy-based economy.

This model holds relevance in the context of scaling bio-based materials as we identify this not as a simple technological shift in material resources, but a systems-level transition into a new basis of how we develop the built environment, akin to and aligned with the energy transformation.

Appendix C - Bio-Based Material Network

Over 250 individuals have been identified as part of a bio-based materials network.

Name	Organization
Hala Abdul-Rasool	East Branch Studio
Brigid Abraham	Grace Farms
Rachelle Ain	Utile, CLF NE
Elizabeth Allen	Consigli
Kelly Alvarez Doran	Ha/f
Valerie Amor	City of Alexandria
Navneet Anand	Design Veritas
Randall Anway	New Tapestry
David Arkin	Arkin/Tilt
Christopher Armstrong	PACE Representatives
David Ayers	New England Forestry
Laura Cavin Bailey	Vermont Council on Rural Development (VCRD)
Lindsay Baker	ILFI
Kyle Barker	Kyle Barker
Michal Bartko	NRC
Barbra Batshalom	BuildingEase & Sustainable Performance Institute
Lola Ben-Alon	Columbia GSAPP
David Benjamin	The Living
Tedd Benson	Bensonwood
Annie Bevan	mindfulMaterials
Simon Blakeley	reThink Green
Brandon Bless	Bread & Butter Farm
Jacob Bloom	CambridgeSeven
Forest Borch	reLoad Sustainable Design
Martin Boulay	NRCan
Christopher Briley	BRIBURN
Floris Keverling Buiman	475.supply
Auri Bukauskas	RMI
Massey Burke	CASBA
Steven Burke	Consigli
Buddy Burkhalter	Self-employed
Lee Burnett	Local Wood WORKS
Brianna Bussinget	University of São Paulo
Naomi C.O.Beal	passivhausMAINE
Olga Beatrice Carcassi	Columbia University
Dennis Carlberg	Boston University
Steph Carlisle	CLF
Jean Carroon	Goody Clancy
Mark Carver	CanmetENERGY
Laura Cavin Bailey	Vermont Council on Rural Development and VT Green Building Network
Victoria Chaney	MASS Design Group
Monty Chong-Walden	Calmura Natural Walls Inc.
Alex Cicelsky	GTI Energy / Ben Gurion University / Lotan Center for Creative Ecology
Funda Cinar Karakaya	Hill West Architects (former)
Heather Clark	White House
Ellie Cody	Rhode Island School of Design
Matt Coffey	South Mountain Company
Rachel Cohen	Verdant Structural Engineers and Verdant Building Products
Bria Cole	Humber College
Felipe Colin	Studio Joseph
Francisco Colom Jover	MASS
Kevin Connors	Eco-Logic Studio
Juliette Cook	Half Climate Design

Name	Organization
Billy Craig	BC Productions
Gabrielle Davis	BlueGreen Alliance
Rachel Denny	EwingCole
Anthony Dente	Verdant Structural Engineers and Verdant Building Products
Christine Dilallo	Arrowstreet
Jack Dinning	Bright Works
Scott Dionne	TimberHP
Allie Ditzel	Hga
Bennett Doherty	VEIC
Della Donahue	LLB Architects
Sam Dufaux	SvN
Patrick Duffy	Wood Works
Anna Dyson	Yale CEA
Dan Edelman	TimberHP
Brent Ehrlich	BuildingGreen
Robin Elkin	Refuge Industrial Hemp Building
Ethan Ellingboe	Carbon Leadership Forum
Ian Erickson	Graft
Cecile Faraud	C40
Ana Fernandez	MASS
Sandra Ferreira	Arquiteta
Lori Ferriss	Northeastern University
Carl Fiocchi	UMass Amherst
Alex Fischer	USFWC Vermont Organizer
Douglas Flandro	CambridgeSeven
Ivett Flores	TU Braunschweig
Andrew Frederick	Croft
Susan Frosten	TJU
Randi Garber	Healing Spaces
Miriam Gee	CoEverything
Valli D. Geiger	Maine House of Representatives

Name	Organization
Freedom Gerardo	SEAmarron Farmstead
Tommy Gibbons	Hempitecture
Alan Gibson	G O Logic LLC
Vanessa Giraldo	University California, Berkeley
Liz Gleason	Vermont Housing and Conservation Board
Z Grabowski	Center for Land Use Education and Research - UConn
Satori Greene	Utile
Will Grupenhoff	Global Wholesale Supply
Michael Gryniuk	Cora Structural
David Hall	Hall and Moskow Corp./ Hillside Center for Sustainable Living
Pope Hamish	NRCan
Haley Hardwick-Witman	CoEverything
Jennifer Hardy	Goody Clancy
Chris Hardy	MASS
Zada Harris	Pure Architects
Vaclav Hasik	Building Transparency
Patrick Haydon	Haycon
Kent Hicks	UMass
Michael Hindle	Passive to Positive
Alejandra Hinojosa	SWA Group
Joel Holton	Gro Enterprises/J.B. Holton and Associates
Dominic Hosack	Earthbound Builders
Bill Hulstrunk	Self Employed
Ken Hultquist	gti energy
Chris Huston	ReArch
Kelly Hutzell	Wentworth Institute of Technology
John Hyde	Chapman Construction/Design
Kiley Jacques	Green Building Advisor

Name	Organization
Aurora Jensen	Brightworks Sustainability
Peter Jensen	EcoCocon
Scott Johnston	TimberHP
Brian Just	Vermont Energy Investment Corporation
Bridget Kane	Thornton Tomasetti
Alexander Katreczko	Alexander Katreczko Architect
Brendan Kavanagh	Byggmeister
Ramzi Kawar	Knowledge and Development Associates
Declan Keefe	Co-Everything
Diana Khalifeh	Arrowstreet
Caleb Killian	Croft
Sae Kim	cbt architects
Jessica Kiser	n/a
Kelvin Kithetu	University of Nairobi
Scott Kleiman	State of Maine
Nicole St.Clair Knobloch	Olifant
Vanessa Komada	New England Forestry Foundation
Lukasz Kos	Kos Architecture
Roshni Krishnan	Wulff Architects
Kaja Kuehl	Youarethecity
Ahamed Kulam	Columbia university
Johnnie Kuo	J Kuo
Wei Lam	RDH Building Science
Michelle Lambert	Carbon Leadership Forum
Ben Leinfelder	UMass
Seth Leonard	Vermont Housing Finance Agency
David Lewis	LTL Architects
Timothy Lock	OPAL, AIA Strategic Council
John Locke	Autodesk

Name	Organization
Lindsey Love	Regenerative Building Solutions
Florence MacGregor	Northeastern Sustainable Energy Association (NESEA)
Chris Magwood	RMI
Francis Maina	FRANCHICE GREEN DESIGNS
Jon Makar	National Research Council
Carver Mark	NRCan
Harsh Maru	Space Matrix
Jeremy Mason	Howe Engineers
Aidan Mayer	Northeastern University
Ace McArleton	New Frameworks
Aaron McCormack	475.supply
Christine Dorsey McGowan	Vermont Sustainable Jobs Fund
Conor McGuire	Columbia
Cameron McIntosh	Americhanvre
Ricky McLain	Wood Works
Mattie Mead	Hempitecture
Anna Mezheritskaya	NBBJ Design
Dennis Michaud	Saint Gobain
Russ Miller-Johnson	Engineering Ventures, PC
George Miroshnikov	JLL
Deepakshi Mittal	University of Waterloo
Paige Molloy	TimberHP
Linnea Morgan	BlueGreen Alliance
Christina Morrison	HELM Construction Solutions
Keith Moskow	Moskow Linn Architects
Elsa Mullin	Skanska
Elizabeth Murphy	Shawmut Design and Construction

Name	Organization
Munkaila Musafa	UMass - Amherst
Munkaila Musah	Building and Construction Technology, UMass, Amherst
Dalia Niazy	Deakin university
Didier NKURIKIYUMUKIZA	Solektra
Josh Oakley	Mass Kingdom
Grace Oedel	Northeast Organic Farming Association of Vermont
Michael Orbank	STO Building Group
Alan Organschi	Gray Organschi
Mark Ostrom	Joy Collaborative
Sugra Panvelwala	Dreyfuss + Blackford
Craig Peltier	Vermont Housing & Conservation Board
Robert Perschel	New England Forestry Foundation
John Peterson	aether
Tena Petrovic	THEMA STUDIO; CSFEP
Hannah Pingree	Governor Mills' Office of Policy Innovation and the Future
Katie Poss	Building Transparency
Shelly Pottorf	Architend + New Frameworks
Brad Prestbo	Studio NYL
Mike Price	Commodore Builders
Sharon Prince	Grace Farms
Jude Smith Rachele	Vermont Prosperity Project
Jacob Deva Racusin	New Frameworks
Lindsay Rasmussen	RMI
Rubab Razvi	ABA Architects Inc
Aidan Regan	Unispace
Joshua Jay Reyes	Northeastern University

Name	Organization
Jared Reynolds	Northern Vermont University
Nicky Rhodes	Harvard GSD
Brad Richards	HELM Construction Solutions
Marco A Rico Thirion	Mantle Developments
Nora Rizzo	Grace Farms
Suzanne Robinson	LeMessurier
Ben Roland	RISD
Matt Root	Integrated Eco Strategy
Tom Rossmassler	Hempstone
Megan Roush	VHFA
Andrew Ruff	Gray Organschi
Sarah Ruiz	Runor
Ivan Rupnik	MOD X
Jonsara Ruth	Parsons Healthy Materials Lab
Isaura Sagredo	Endicott College
NIYIKIZA Samuel	BEIJING JIAOTONG UNIVERSITY
Travis Samuels	Zion Growers
Daphne Rose Sanchez	Kinetic Communities
Brian Sandford	MASS Design Group
Lys Roberta Sangwe	PUNDA Group Ltd
Kelsey Saunders	RDH Building Science
Alexander Sexsmith	Sexsmith Architects / US Hemp Building Association
Jennifer Shakun	New England Forestry Foundation
Andy Shapiro	Energy Balance, Inc.
Joe Short	Northern Forest Center
Kate Simonen	CLF
Stacy Smedley	Building Transparency
Deeksha Somaiya	Karnavati University

Name	Organization
Linda Sorrento	mindfulMaterials
Kate Spinelli	isgenuity
Chris Spychalski	bicycle Mower
Borivoj Stankovic	Boris4D
Mike Steffen	Walsh Construction Co.
Rachel Stern	Cellulose Insulation Manufacturers Association
Paul Stevens	ZAS Architects Inc.
Frank Stone	Frank Stone
Wes Sullens	USGBC
Mandy Sykes	Agriboard Green Building Systems
Stephanie Taylor	Building4Health
Theresa Te	AHS
Jess Thies	Parsons Healthy Materials Lab
Jarron Tichenor	Meticulous
Ben Titcomb	Casco Consulting
Laura Tomlinson	Isgenuity
Shreejay Tuladhar	ArchSolar Designs
Aimé Patrick TWIRINGIYIMANA	Freelancer
Marie Chance Uwineza	University of Rwanda
Harshini Varanasi	University of Illinois Urbana Champaign
Garrett Velasquez	AIAS, Masters Student
Nicole Voss	Isgenuity
Phil Walsh	Havelock Wool
Sarah Waring	USDA Rural Development
Ginger Watkins	ORB Technologies
Mark Webster	SGH
Josephine Wermuth	East Branch Studio
Chris West	EHofVT

Name	Organization
Greg West	G West Building Services
Colin Widdoes	RVC Architects, Inc.
Robert Williams	UMass Amherst Department of Architecture
Ummi Fathima Zakir Hussain	polirtecnico di milano
Rick Zytaruk	Tooketree Passive Homes
Melinda Zytaruk	Tooketree Passive Homes