Robotic Bamboo Propagation for Accelerated Co2 Sequestration and Biomass Generation

COLORADO STATE UNIVERSITY

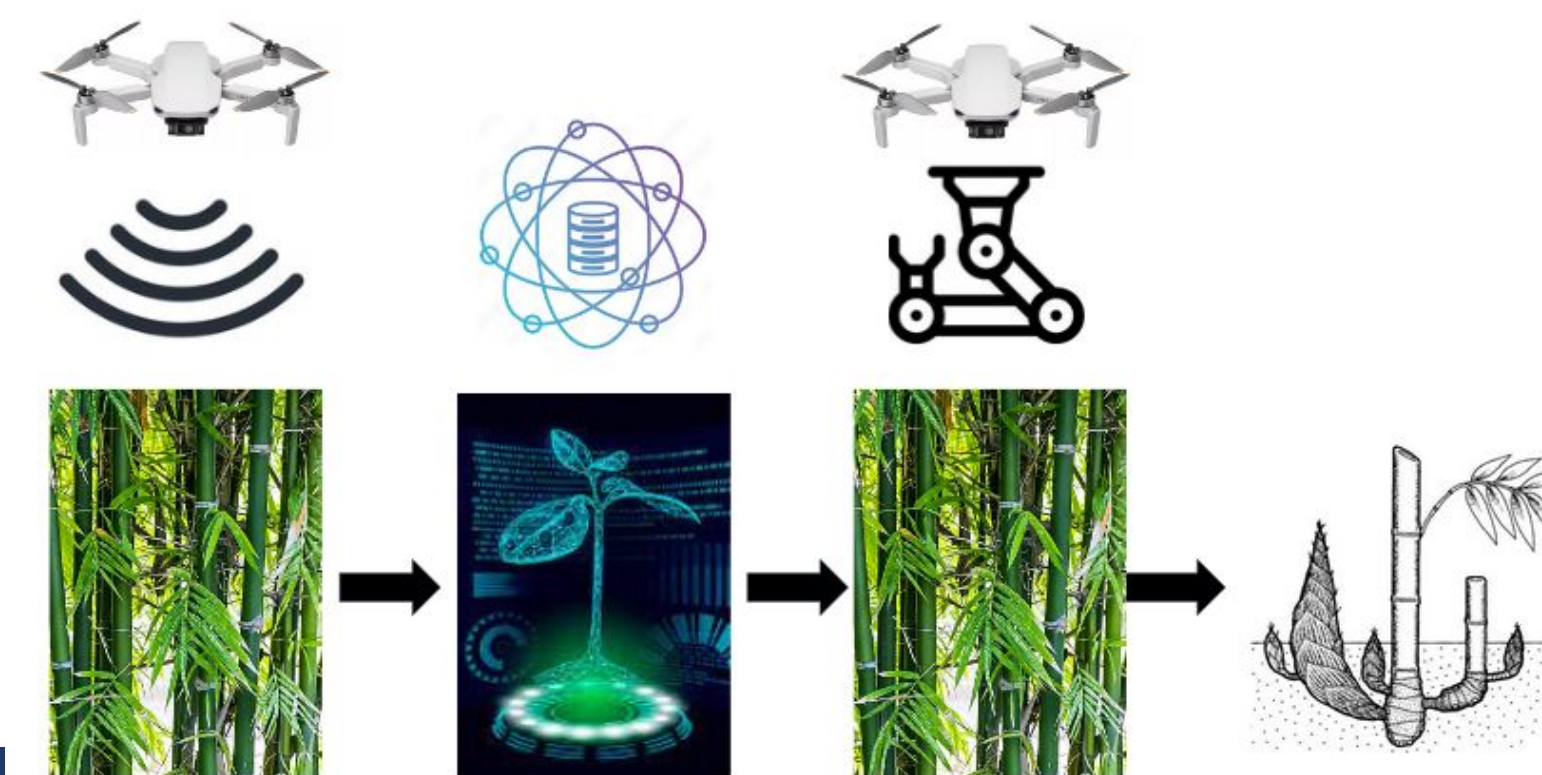Principal Investigator: Bryant K Beeler

Abstract

The growing demand for green and sustainable solutions is forcing the search beyond everyday and contemporary materials. Bamboo presents itself as an ancient and universal solution for the efficient, cheap, and high quality generation of biomass for materials, foods, medicines, construction, and more. Bamboo has growth rates unrivaled by any other land based plant, and boasts carbon sequestration rates that are among the greatest in the land plant ecosystem. However, there is a great opportunity to leverage robotics, data science, and automation to streamline the bamboo value and supply chain. As previously realized in the auto industry, like cars, bamboo spend a large segment of their lives in a middle stage between seedling growth and production or ripe bamboo that is ready to be cultivated for use. Much like the automobiles, the bamboo have stagnant value and limited usage while they are consuming prime real estate and using already limited space. The aim is to change that and tap into the potential value in the middle ground by performing robotic bamboo propagation. The opportunity is captured to grow and spread bamboo faster and realize its benefits at lower cost and greater speed which is needed to achieve global climate goals. Cuttings and the multiple forms of bamboo propagation (clump divisions, rhizomes, offsets, layering, marcotting, culm cutting, branch cutting and macro-proliferation, air propagation) are performed and bamboo is spread and grown much faster than before. Carbon is sequestered faster, timber is produced more often, and medicine and materials can be realized more sustainably. Value added elements of the value cycle are streamlined. Bamboo is the ally in the climate fight, and when paired with robotics, much more can be achieved.

Remote Sensing

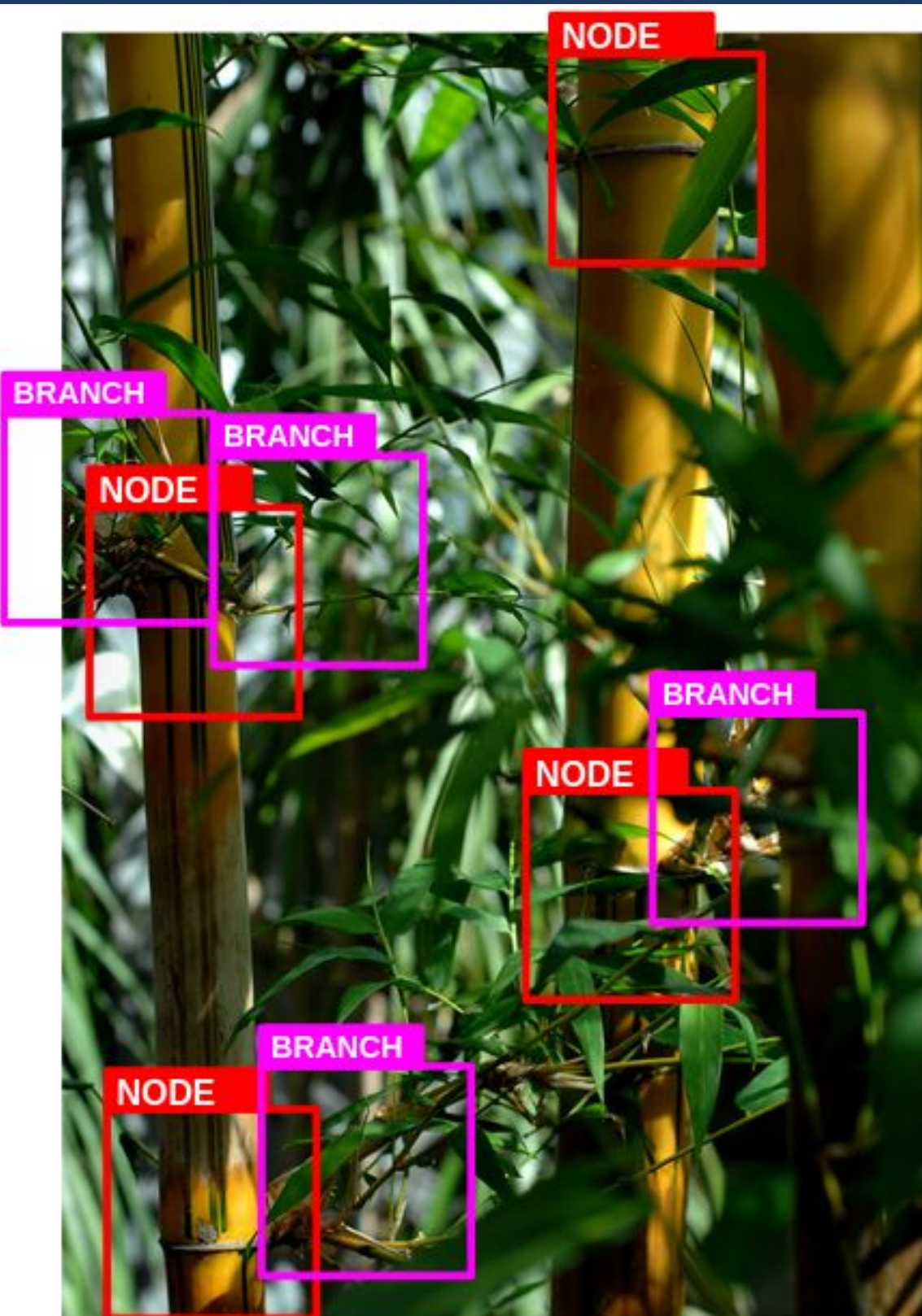## Value Chain

Propagation Techniques

Types of Bamboo Propagation
- clump divisions
- rhizomes
- offsets
- layering
- marcotting
- culm cutting
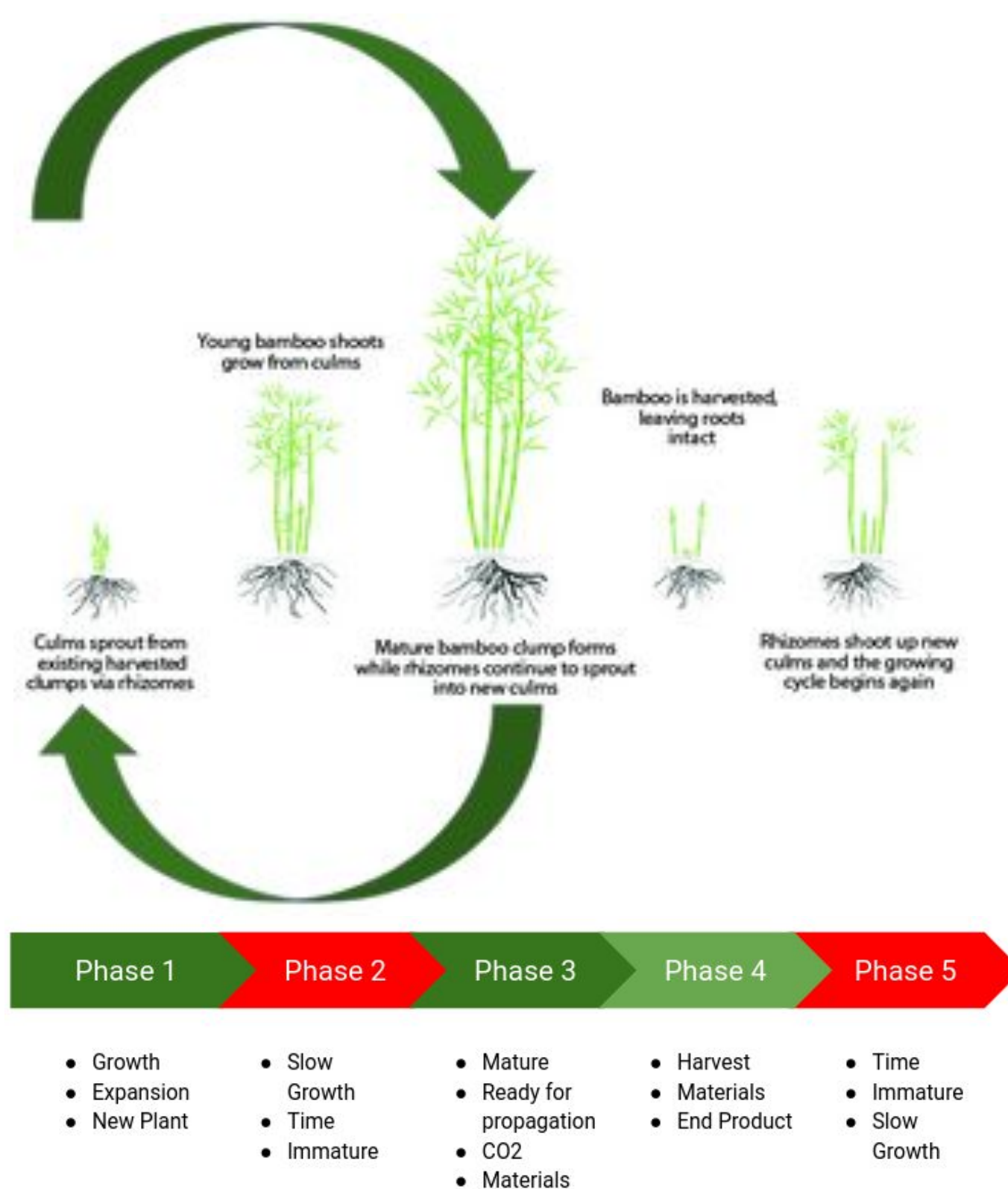- branch cutting
- macro-proliferation
- Air propagation

## Bamboo Physiology

The data generation and data driven process allows for the physiology of bamboo to be observed, recorded, and held as top priority. The digital twin/model facilitates instant analysis and inventory ensuring that cuttings are being taken that are least invasive and of least impact to the bamboo plant.

Data is generated and analyzed in real time allowing for trends and insights to emerge regarding the physiology and how various factors and activities impact wellbeing, growth, and propagation.

Process Diagram
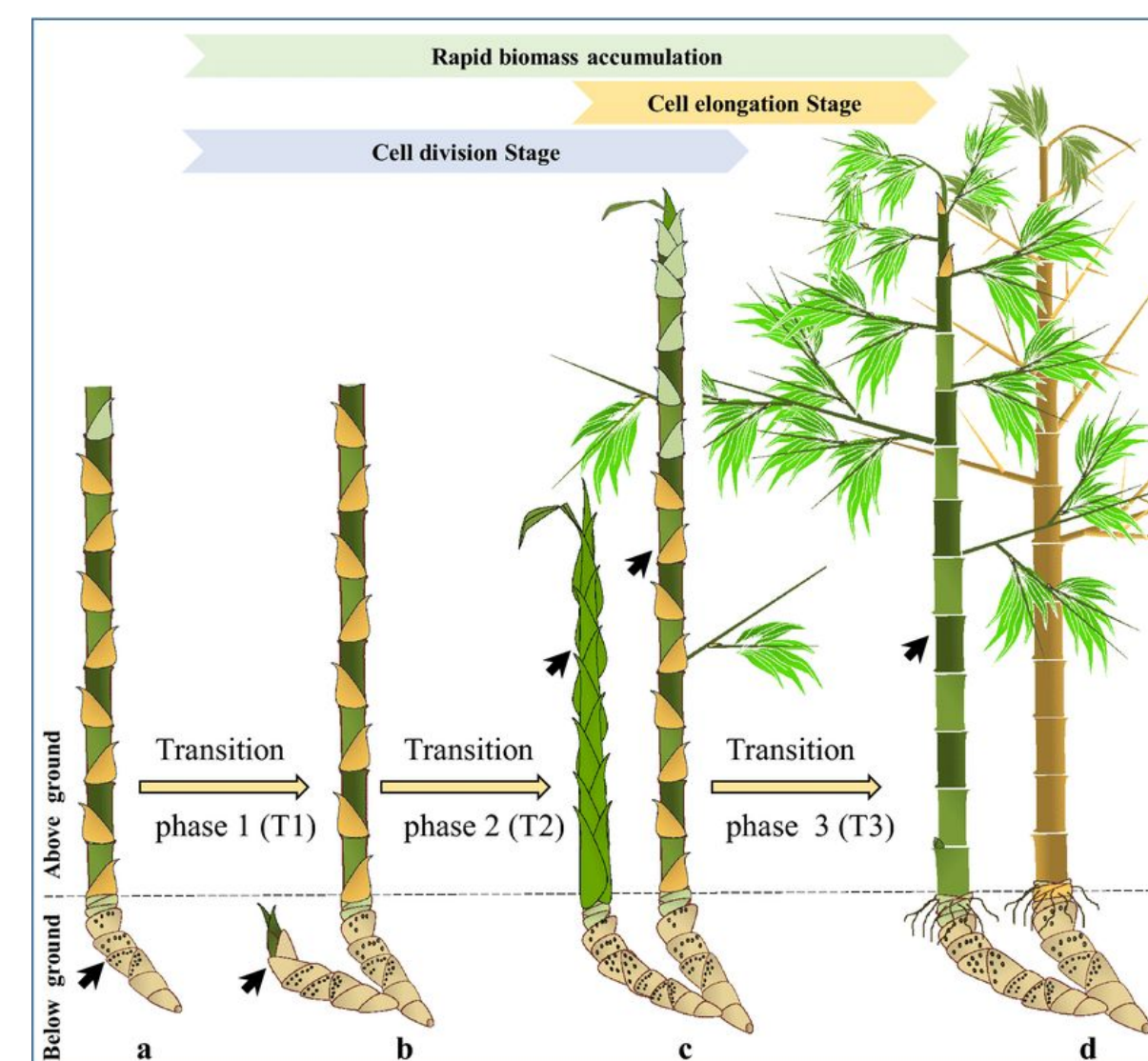
Process

Phase 1
- Remote sensing
- Assessment

Phase 2
- Computation
- Data analytics
- Optimization
- Model reference
- digital twin update

Phase 3
- Propagation
- Transport

Phase 4
- Repot
- Replant
- transfer

Phase 5
- New Culms
- Expansion
- Repeat Cycle

Next Steps/Actions

- University Collaboration
- Grants/Funding
- Prototyping and Phase 1 Development
- SBIR/STTR
  - USDA
  - DOE
- Industry Partners
- Test/Demonstration
- Timber Bamboo Site Visits/Assesment

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5

- Growth
- Expansion
- New Plant

- Slow Growth
- Time
- Immature

- Mature
- Ready for propagation
- CO2
- Materials

- Harvest
- Materials
- End Product

- Time
- Immature
- Slow Growth

Young bamboo shoots grow from culms

Bamboo is harvested, leaving roots intact

Culms sprout from existing harvested clumps via rhizomes

Mature bamboo clump forms while rhizomes continue to sprout into new culms

Rhizomes shoot up new culms and the growing cycle begins again

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NODE

BRANCH
BRANCH
NODE

BRANCH
NODE

BRANCH
NODE

Exodermis
(Greenish outer skin)

Node

Culm

Leaf

Fibers

Internode

Endodermis
(Yellowish inner skin)

Branch Node

Node

Branch *Grown from Node*