# An online application for decision support in siting woody biomass-to-electricity facilities in California

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## University of California, Davis

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BIOLOGICAL AND AGRICULTURAL ENGINEERING

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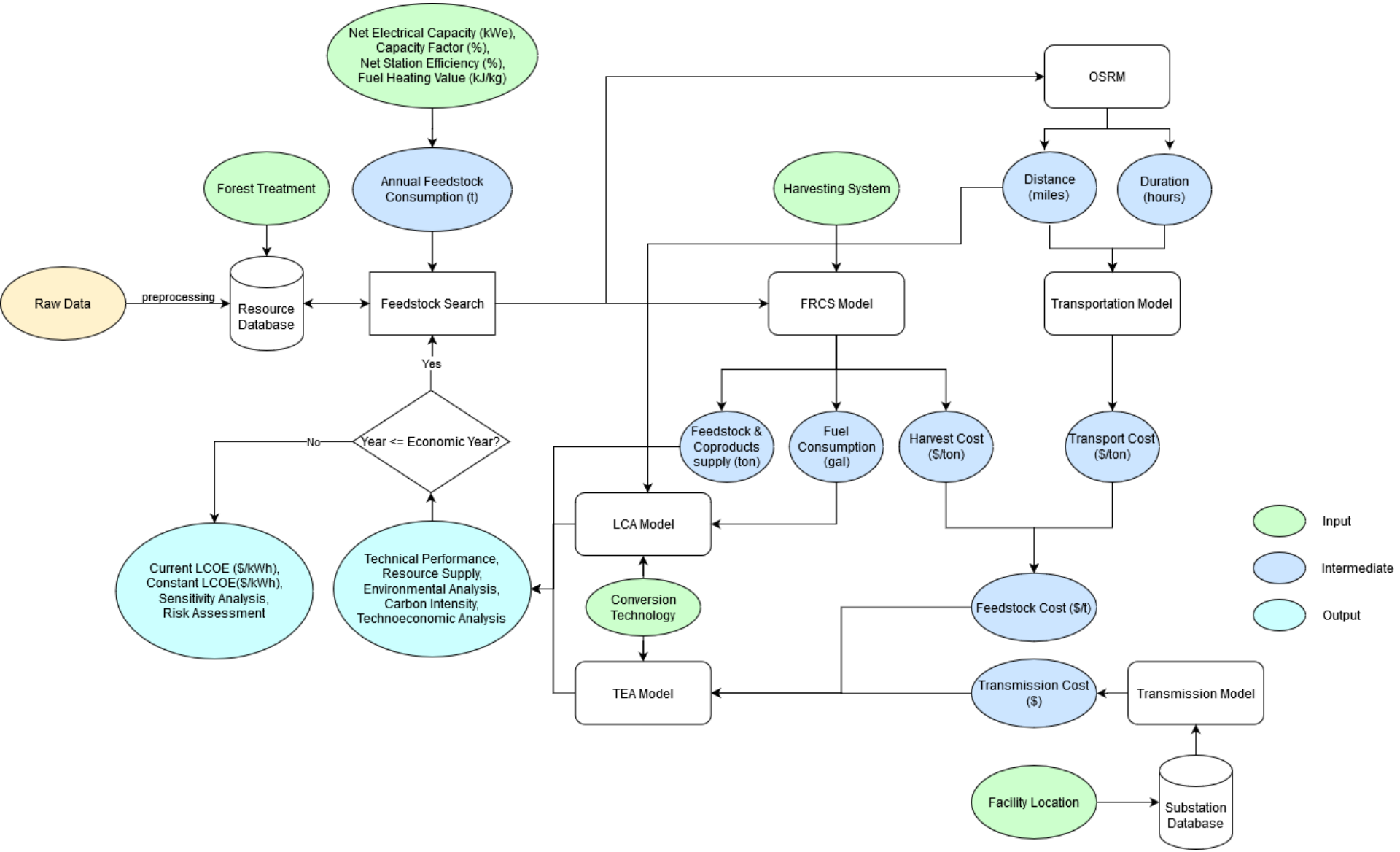
# Goals & Objectives

- To develop a comprehensive **web-based decision support system (DSS)** application that allows users to quickly evaluate economic feasibility and environmental performance potential.
- Answer questions that a user (e.g. communities, potential investors, etc.) might have regarding the potential site location, availability, cost, and location of woody biomass (forest based), transportation routes, and biopower technology cost profiles.
- To provide lifecycle environmental performance metrics including:
    1) criteria pollutant emissions
    2) greenhouse gas emissions
    3) water quality and use
- Perform **case study and sensitivity analysis** at multiple potential locations, particularly at High Hazard Zones in California.

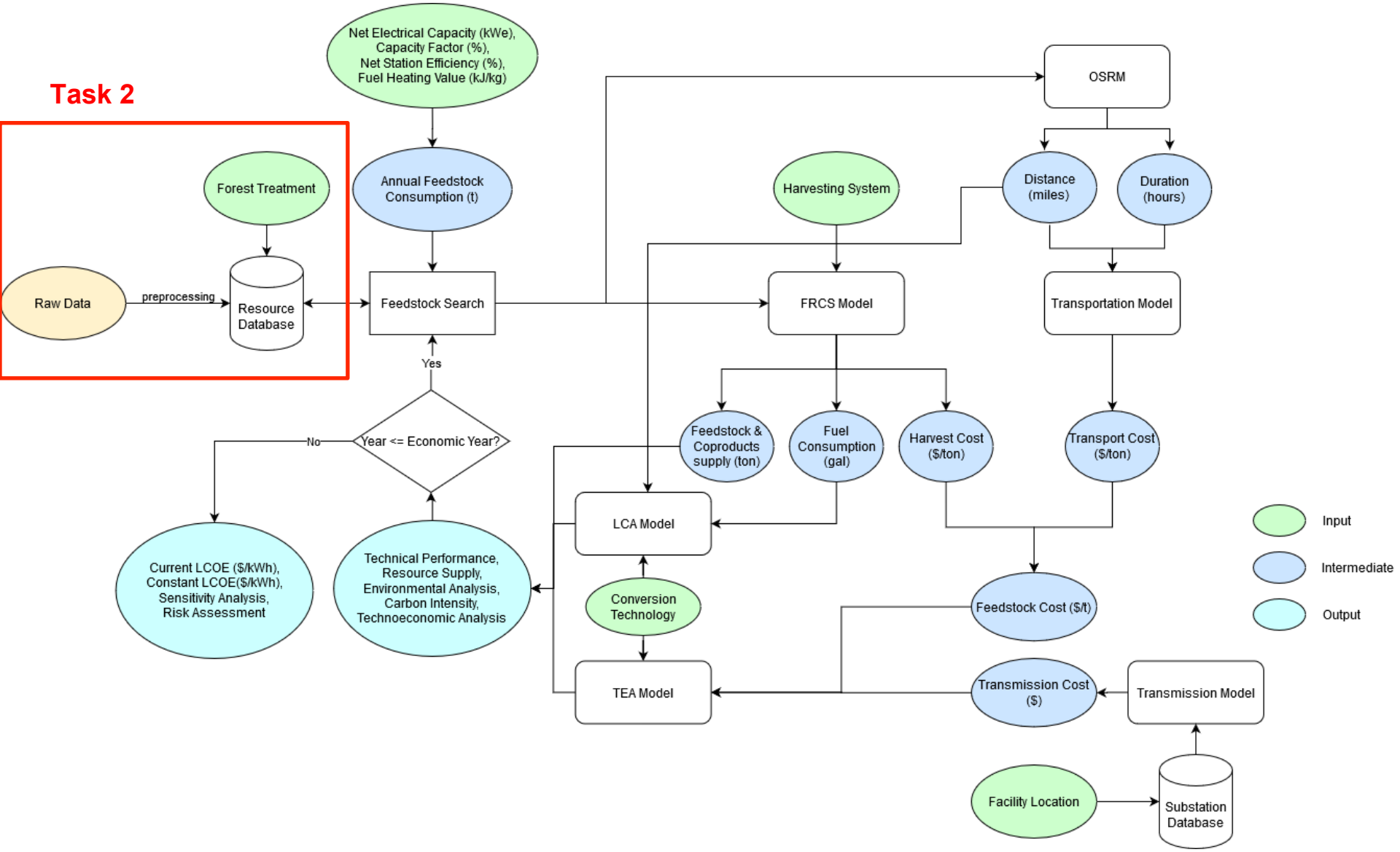
# Project Tasks

- Task 1: General administrative project tasks
- **Task 2: Spatial analysis to locate the residual woody biomass feedstock in California**
- **Task 3: Feedstock logistic analysis to estimate costs associated with feedstock collection and transportation to biopower facility**
- **Task 4: Evaluation of the performance and costs associated with selected current and pre-commercial conversion technologies**
- **Task 5: Lifecycle analysis**
- **Task 6: System integration in the online application and case study analysis**
- Task 7: Evaluation of Project Benefits
- Task 8: Technology/Knowledge Transfer Activities
- Task 9: Production Readiness Plan

# Integrated Model Framework



# Integrated Model Framework

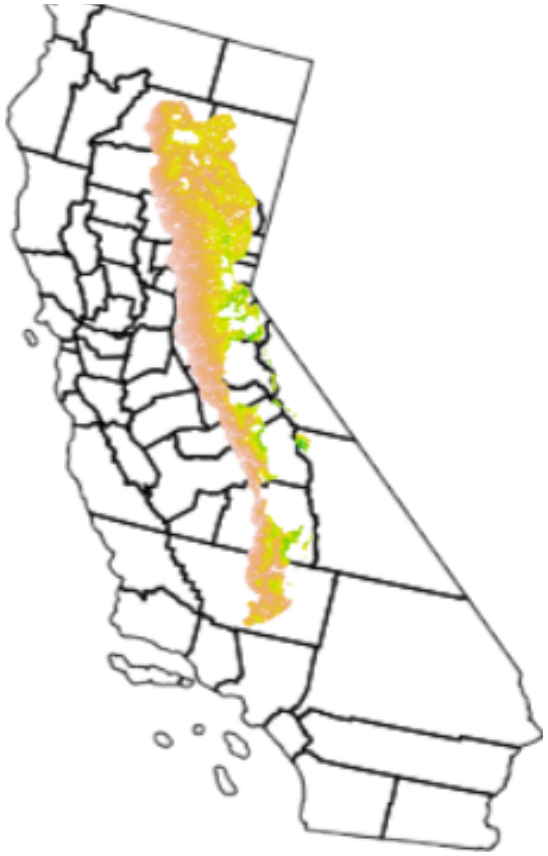


# Task 2: Spatial analysis to locate the residual woody biomass feedstock in California

- The development of a biopower facility requires detailed, spatially-contiguous, and both near- and long-term woody biomass feedstock estimates.
- Acquire $F^3$ current and future biomass estimates for California.
- The $F^3$ modeling framework was developed by US Forest Service.
- $F^3$ integrates:
  - (1) FIA (Forest Inventory and Analysis) plots,
  - (2) Forest Vegetation Simulator (FVS),
  - (3) FastEmap (Field and SatelliTe for Ecosystem MAPping) to simulate spatiotemporal forest change under natural succession and vegetation management.

# Land Ownership under Consideration in the DSS

- Sierra Nevada region



- **Public Lands**
  - ✓ Local government
  - ✓ Non-profit conservancies and trusts
  - ✓ CA Dept. of Forestry and Fire Protection
  - ✓ CA Dept. of Parks and Recreation
  - ✓ CA Dept. of Fish and Wildlife
  - ✓ Bureau of Reclamation
  - ✓ Bureau of Land Management
  - ✓ Bureau of Indian Affairs
  - ✓ Department of Defense
  - ✓ Other Federal and State Lands

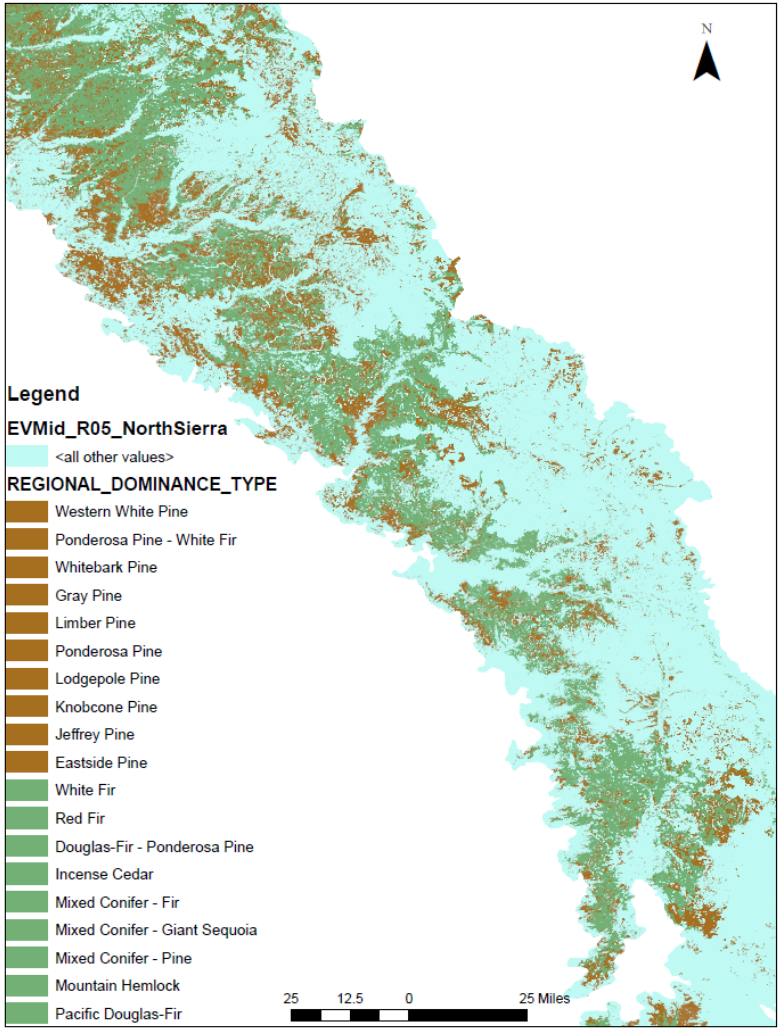
- All forest area that does not fall within the above-mentioned public land categories are considered private lands.

- **Exclude:** National Park Services and Wilderness Areas

# Forest types under consideration in the DSS

- Sierra region:
  - Brown = Pine
  - Green = Mixed Conifer
  - Blue = Other

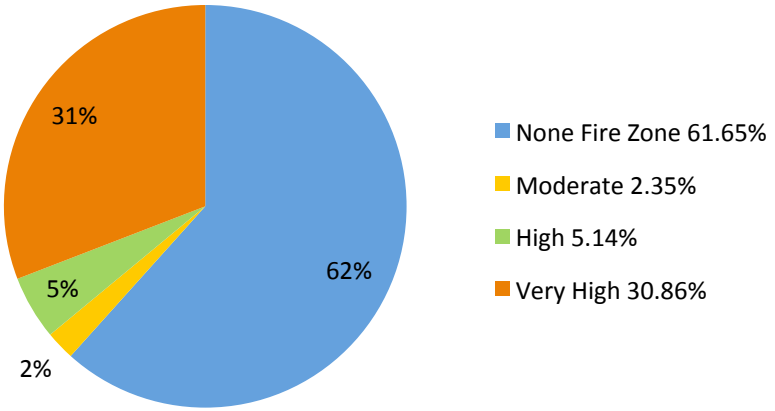
Source: https://www.theunion.com/news/environment/extreme-wildfires-are-transforming-sierra-nevada-forestlands-into-shrublands/

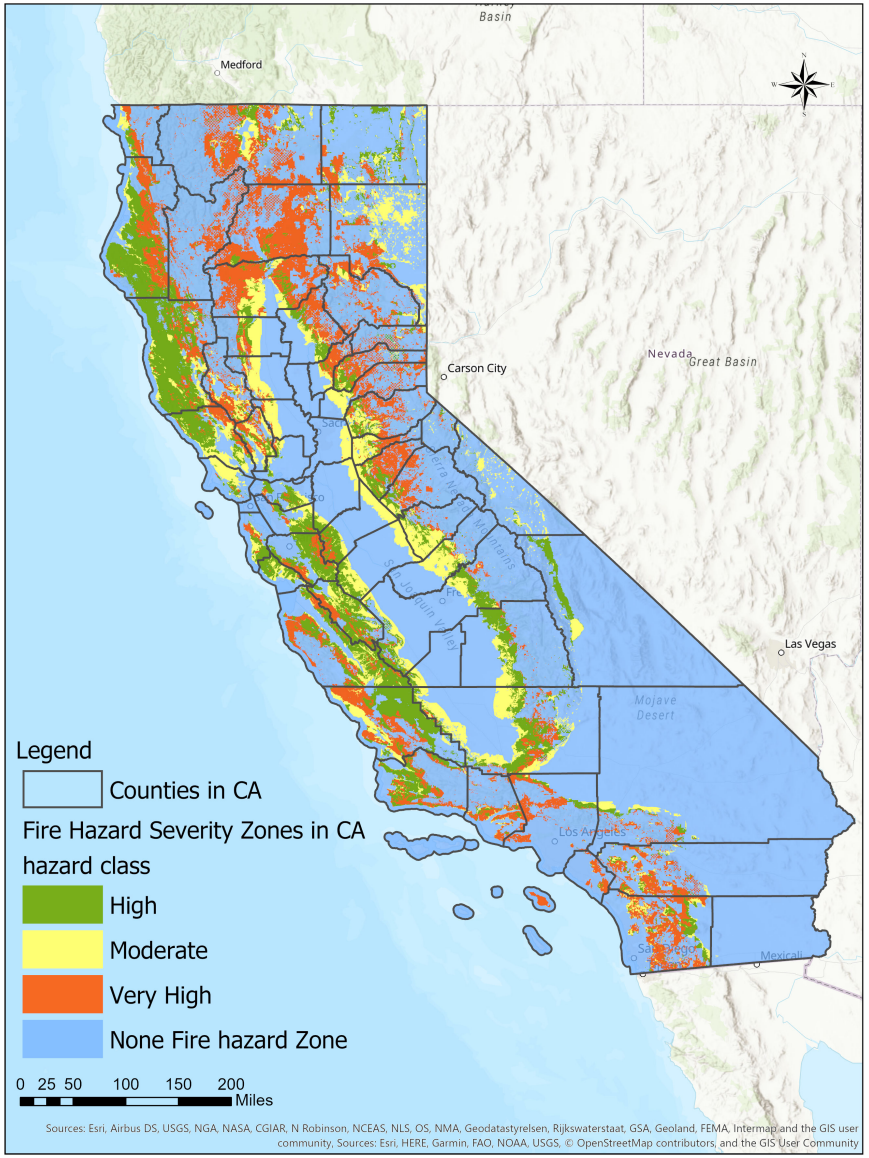


# Fire Hazard Severity Zones in CA

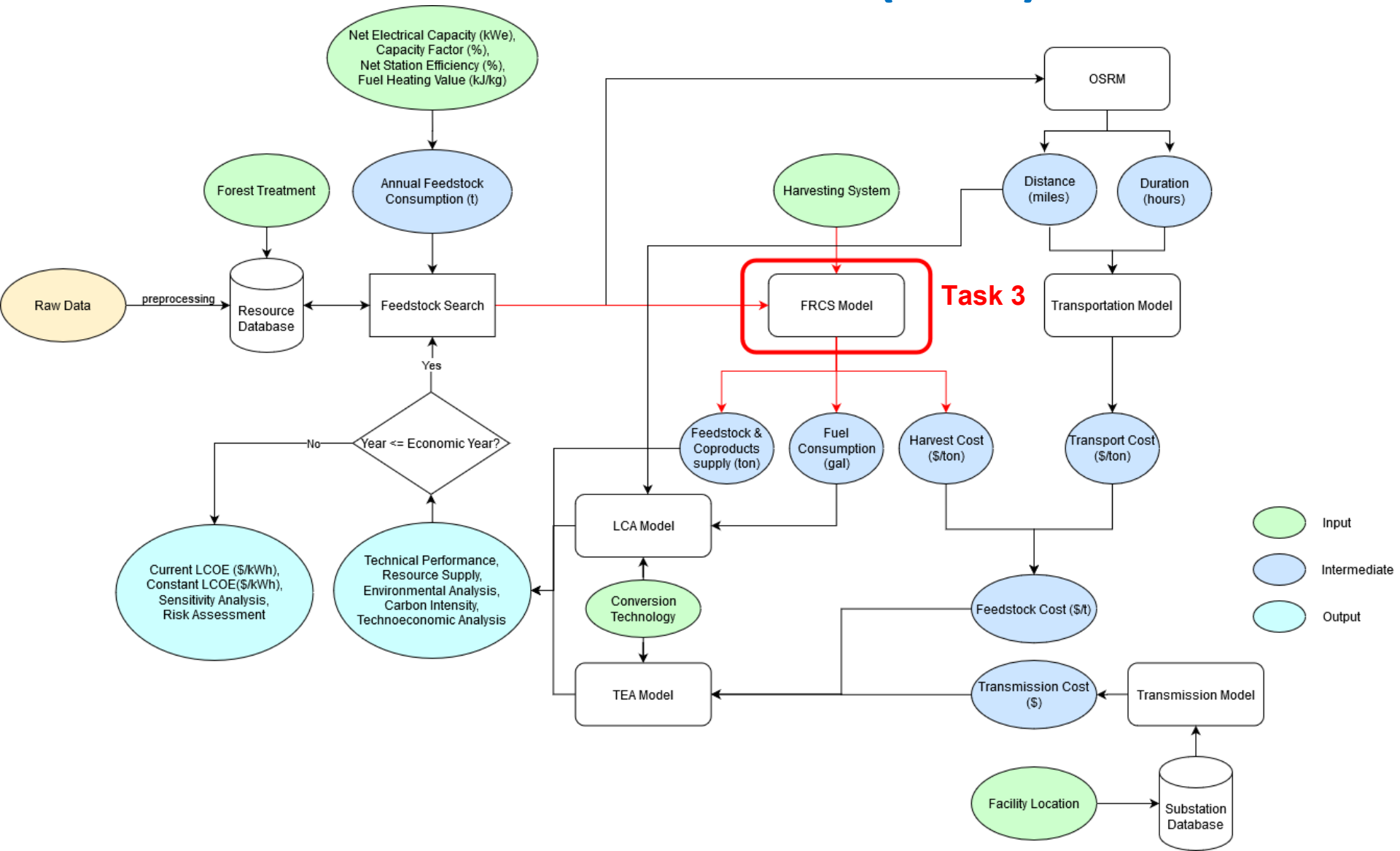
- A Fire Hazard Severity Zone (FHSZ) is based on conditions (e.g. fuel, slope, and fire weather) that create a likelihood that an area will burn over a 30-to 50-year period (source:https://gis.data.ca.gov).

**The percentage of biomass in different fire hazard zones**



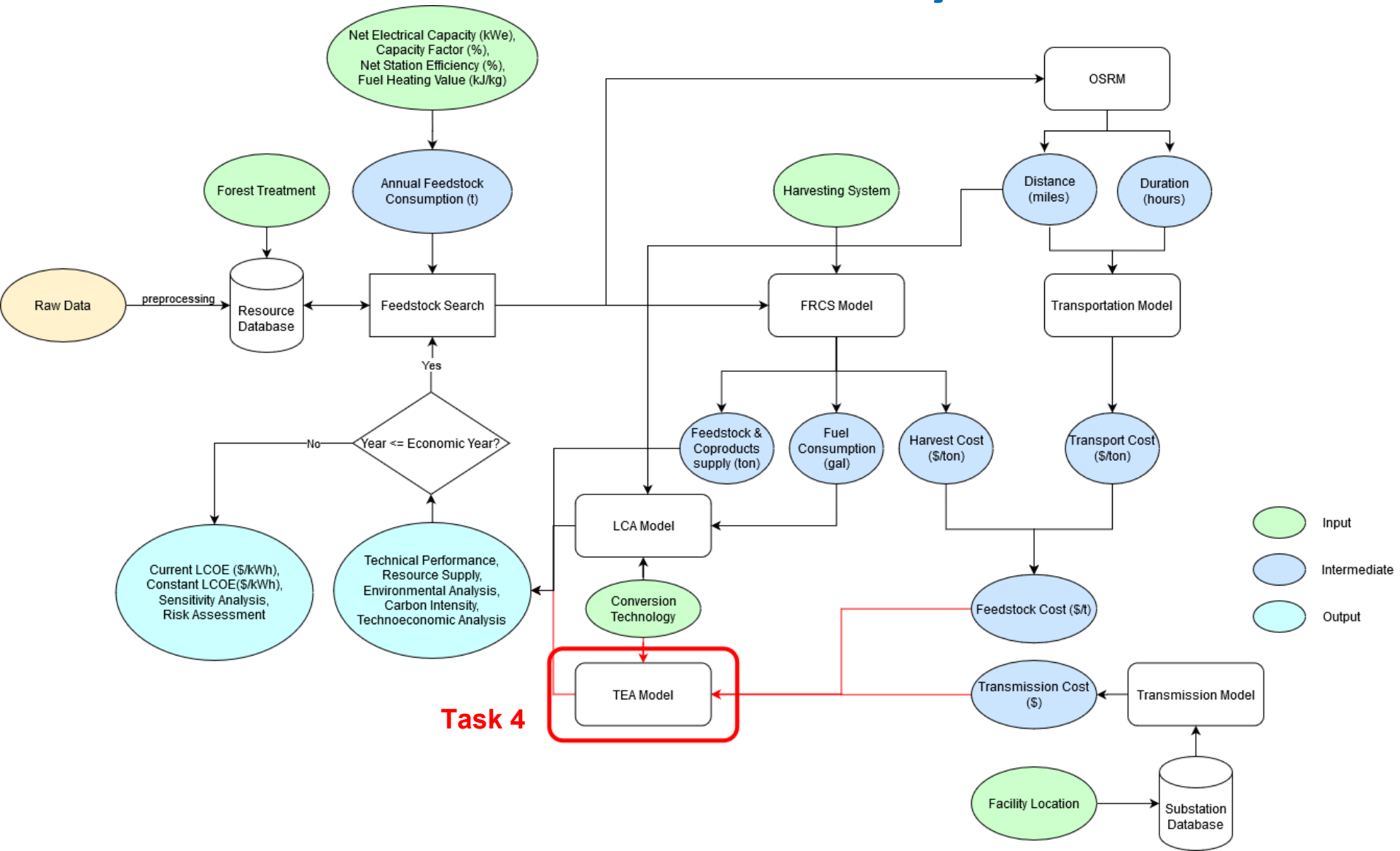
# Task 3: Estimation of Harvesting Costs using Fuel Reduction Cost Simulator (FRCS)



# Task 3: Estimation of Harvesting Costs using Fuel Reduction Cost Simulator (FRCS)

- Fuel Reduction Cost Simulator (FRCS) developed by the USFS designed to estimate costs for fuel reduction treatments involved in the removal of tress of mixed sizes in the form of whole trees, logs, or chips from a forest.
- User can select from the following harvesting systems in the DSS:
  - four ground-based systems
  - four cable systems
  - two helicopter systems
- Originally a spreadsheet application but translated to JavaScript by K. Li on this project for DSS app integration
- Updated FRCS software from 2002 prices to 2019 prices
  - Labor
  - Fuel
  - Equipment

# Task 4: Evaluation of biopower technologies
# Technoeconomic analysis

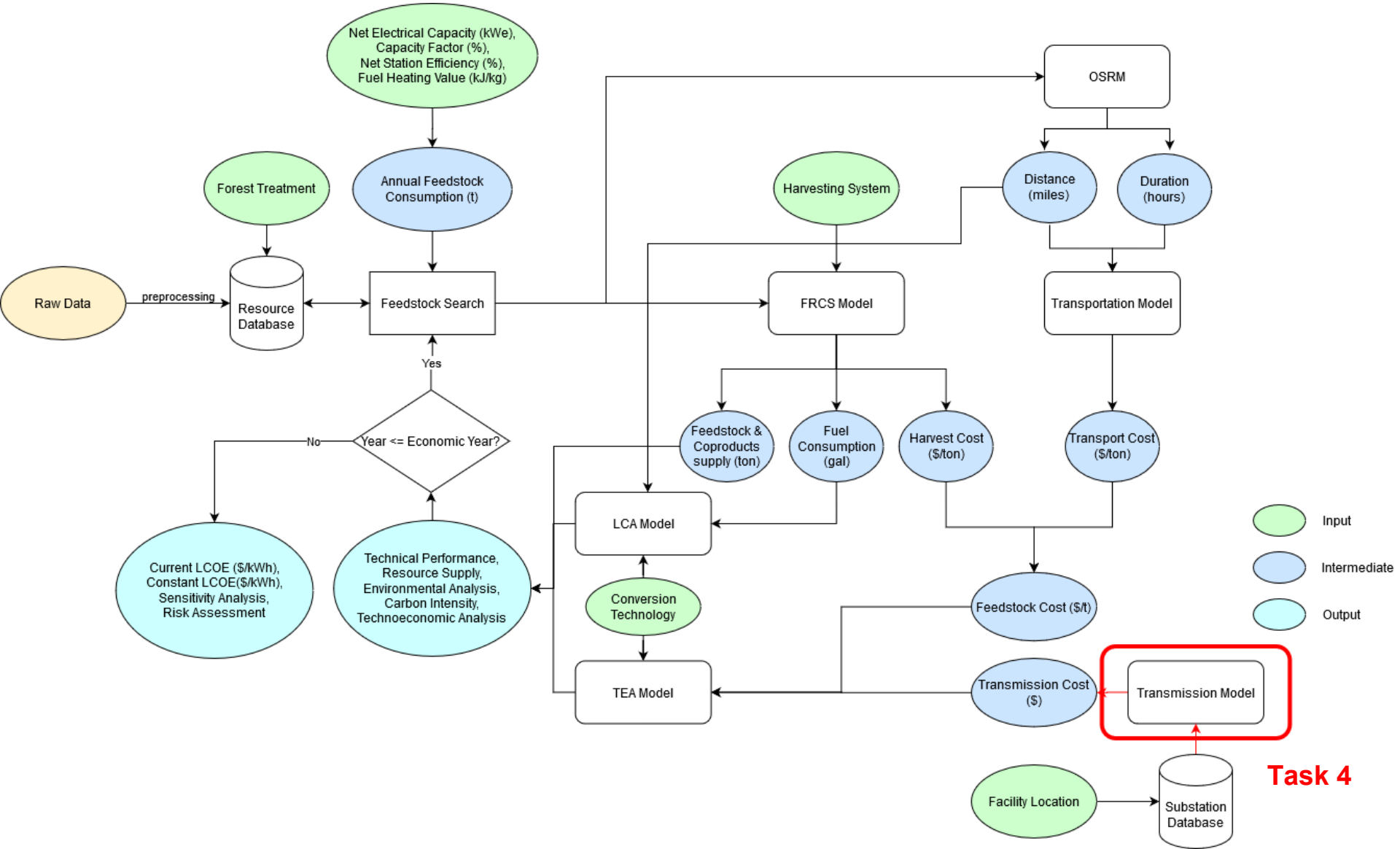


# Task 4: Evaluation of biopower technologies Technoeconomic analysis

Source: https://www.shutterstock.com/search/biomass+power+plant

- **Energy Cost Calculators**
  - Developed and published by California Biomass Collaborative under prior California Energy Commission support
  - User can select from the following three conversion technologies:
    - generic power only
    - combined heat and power (CHP)
    - integrated gasification power
- Originally a spreadsheet application but translated to JavaScript by K. Li on this project for DSS app integration

# Capital Costs for Transmission Lines



# Capital Costs for Transmission Lines

- Based on the transmission calculator developed by Black & Veatch for WECC (used by permission)

**Black & Veatch Transmission Line Capital Cost Calculator**

User Selection
Auto-calculated
Adjustable Parameter

| | Selection | Multiplier | Cumulative Cost/Mile |
|---|---|---|---|
| Voltage Class | 600 kV HVDC Circuit | 1 | $ 1,812,839.00 |
| Conductor Type | ACSS | 1.08 | $ 1,957,866.12 |
| Structure | Tubular Steel | 1.5 | $ 2,936,799.19 |
| Length Category | > 10 miles | 1 | $ 2,936,799.19 |
| New or Re-conductor? | Re-conductor | 0.55 | $ 1,615,239.55 |
| Average Terrain Multiplier | 1 | 1.00 | $ 1,615,239.55 |

| Terrain Type | Miles of Terrain Type | Multiplier | Weighted Miles |
|---|---|---|---|
| Forested | 0.0 | 2.25 | 0.0 |
| Scrubbed/Flat | 1.0 | 1 | 1.0 |
| Wetland | 0.0 | 1.2 | 0.0 |
| Farmland | 0.0 | 1 | 0.0 |
| Desert/Barren Land | 0.0 | 1.05 | 0.0 |
| Urban | 0.0 | 1.59 | 0.0 |
| Rolling Hills (2-8% Slope) | 0.0 | 1.4 | 0.0 |
| Mountain (>8% Slope) | 0.0 | 1.75 | 0.0 |
| **Total Miles** | **1.0** | | |

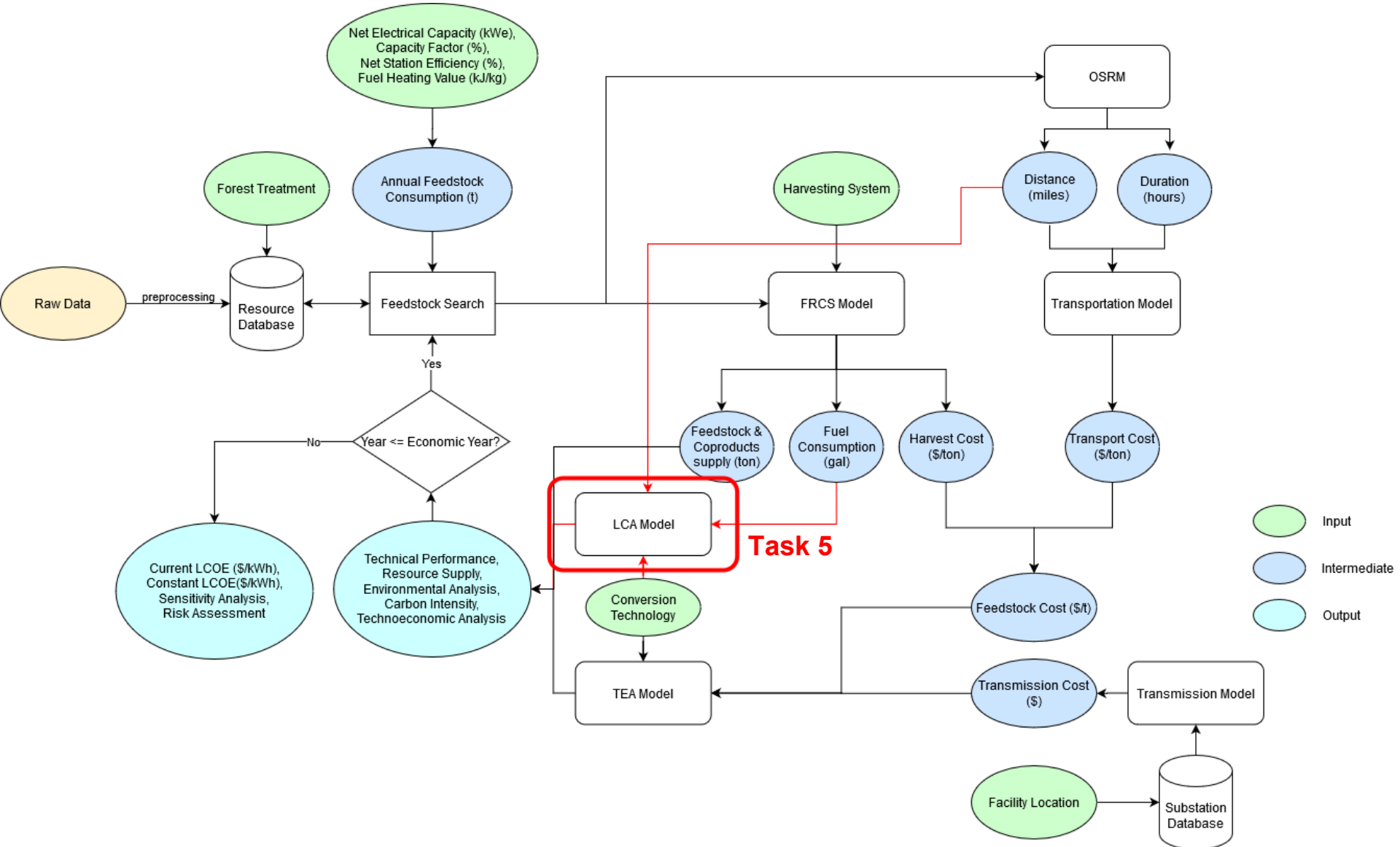
| BLM Cost Zone Number | ROW Miles in BLM Zone | $/Acre | $/Mile of ROW | Zone ROW Costs |
|---|---|---|---|---|
| 1 | 0.0 | $ 85.34 | $ 2,327.40 | $ - |
| 2 | 0.0 | $ 170.68 | $ 4,654.80 | $ - |
| 3 | 1.0 | $ 341.45 | $ 9,312.30 | $ 9,312.30 |
| 4 | 0.0 | $ 512.13 | $ 13,967.10 | $ - |
| 5 | 0.0 | $ 682.80 | $ 18,621.90 | $ - |
| 6 | 0.0 | $ 1,024.25 | $ 27,934.20 | $ - |
| 7 | 0.0 | $ 1,707.06 | $ 46,556.10 | $ - |
| 8 | 0.0 | $ 3,414.11 | $ 93,112.20 | $ - |
| 9 | 0.0 | $ 6,828.23 | $ 186,224.40 | $ - |
| 10 | 0.0 | $ 10,242.34 | $ 279,336.60 | $ - |
| 11 | 0.0 | $ 17,070.57 | $ 465,561.00 | $ - |
| 12 | 0.0 | $ 34,141.14 | $ 931,122.00 | $ - |

| AFUDC/Overhead Cost | 17.5% |
|---|---|

| Project Cost Results | Per Mile | Total |
|---|---|---|
| Line Cost | $ 1,615,239.55 | $ 1,615,239.55 |
| ROW Cost | $ 9,312.30 | $ 9,312.30 |
| AFUDC/Overhead Cost | $ 284,296.57 | $ 284,296.57 |
| **All Costs** | **$ 1,908,848.43** | **$ 1,908,848.43** |

| | Per Mile (MW/Mile) | Total (MW) |
|---|---|---|
| Project Line Losses | 0.3076 | 0.31 |

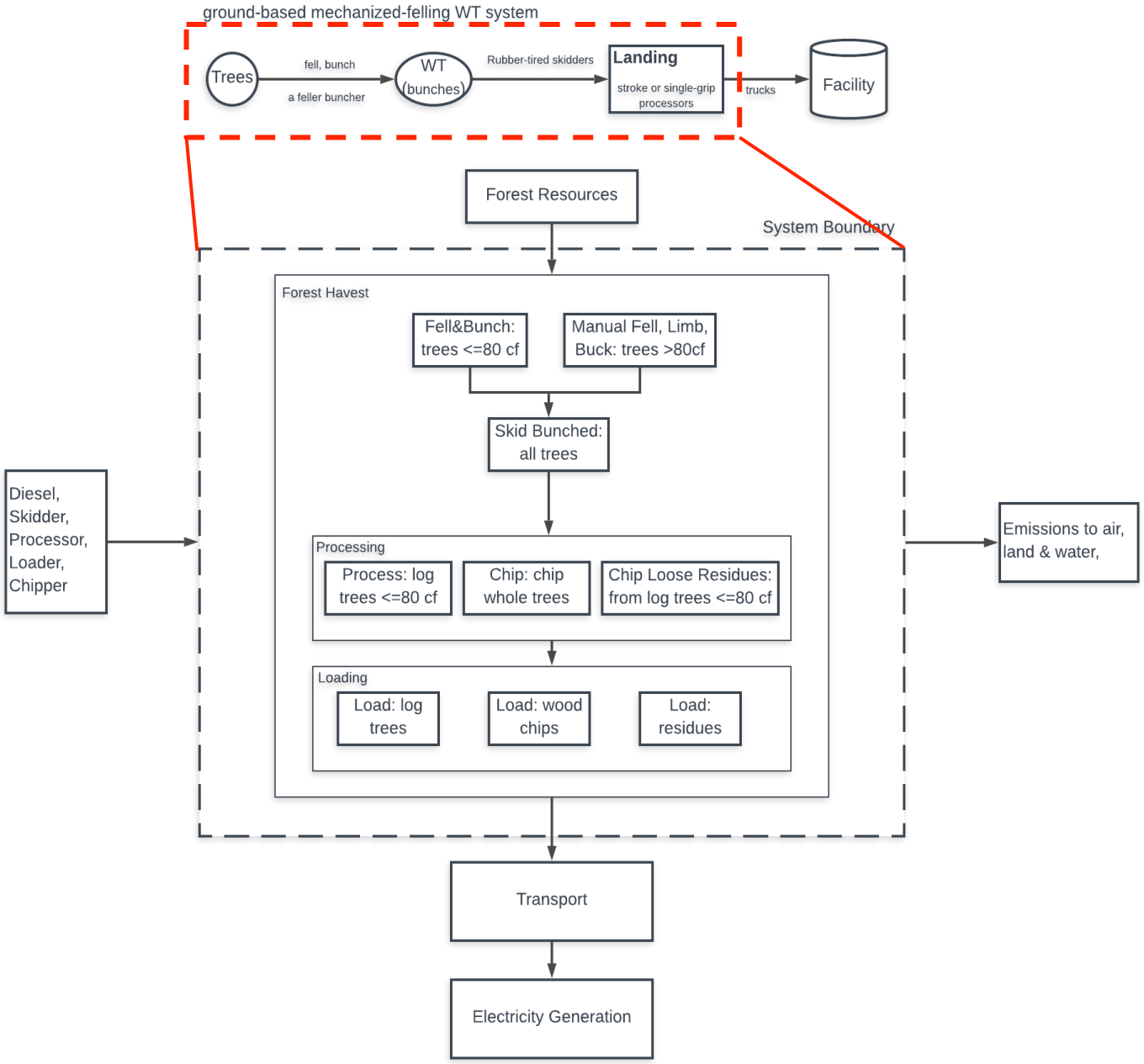
# Task 5: Environmental Impact Analysis (LCA)



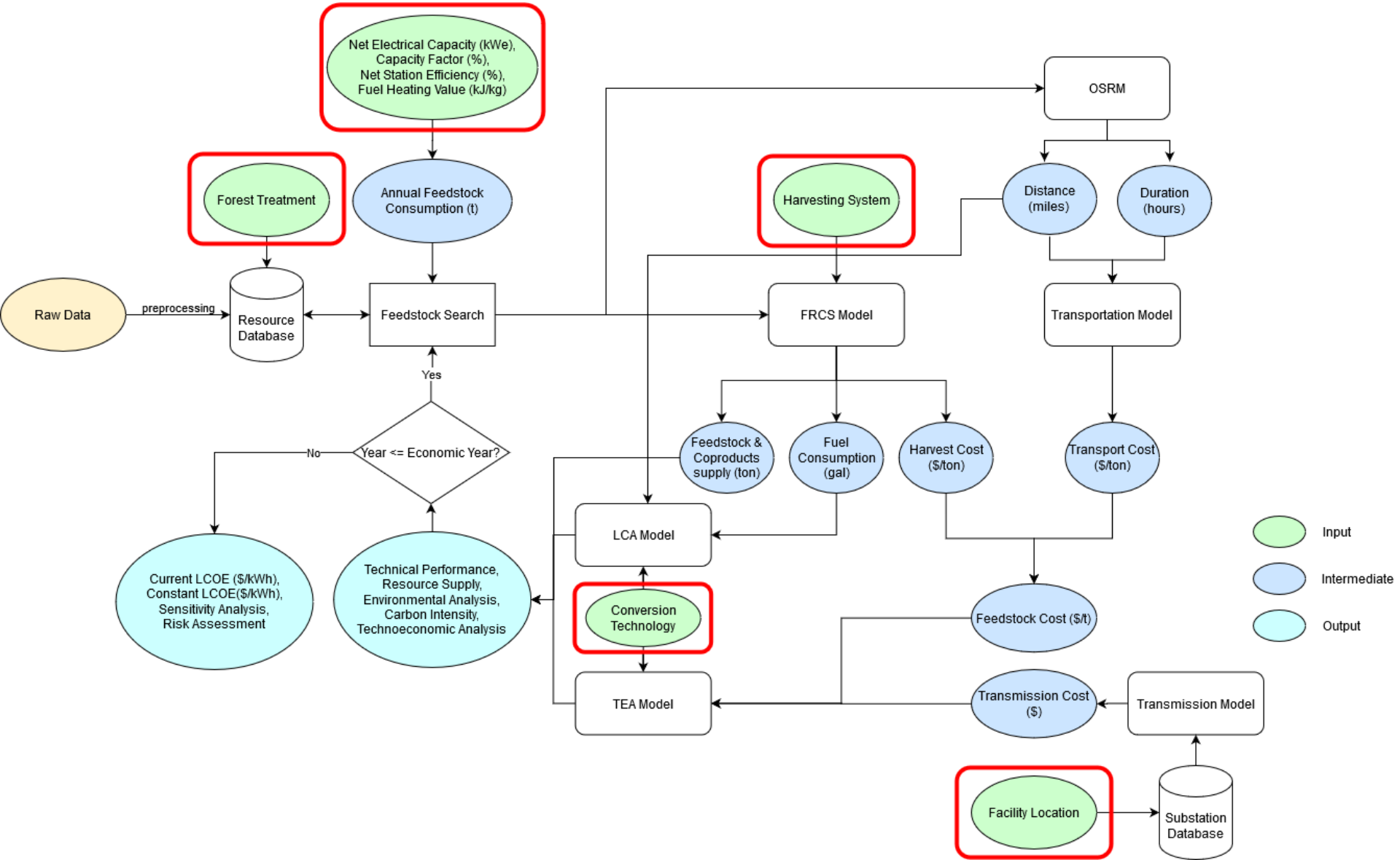
# Task 5: Environmental Impact Analysis (LCA)

- System Boundary: from feedstock harvest to electricity generation
- Inputs
  - Equipment fuel consumption
  - Transportation distance
  - Conversion technology
- Outputs
  - Criteria pollutant emissions
  - GHG emissions
  - Interpretation

# Feedstock Assessment



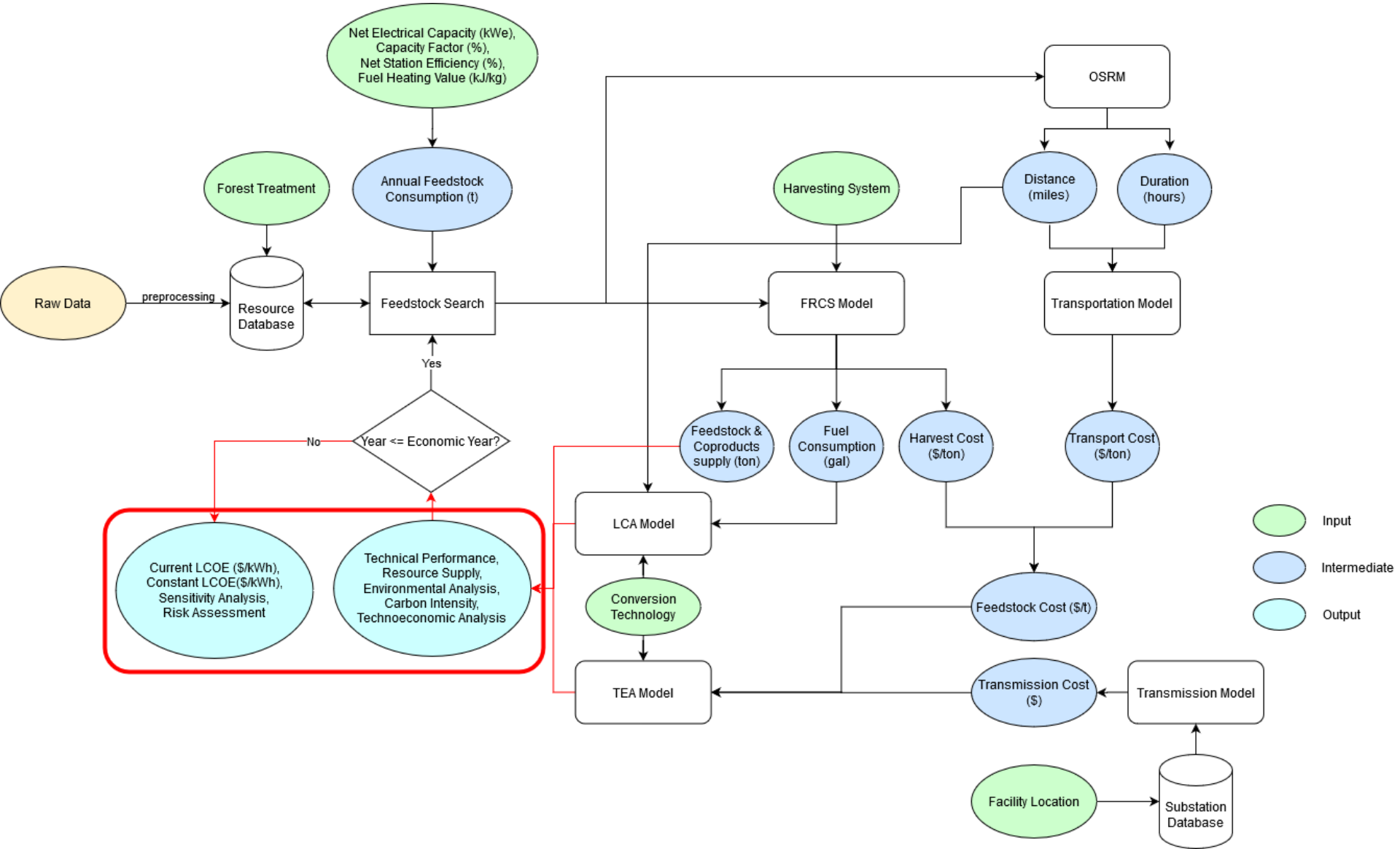
# User inputs to the DSS



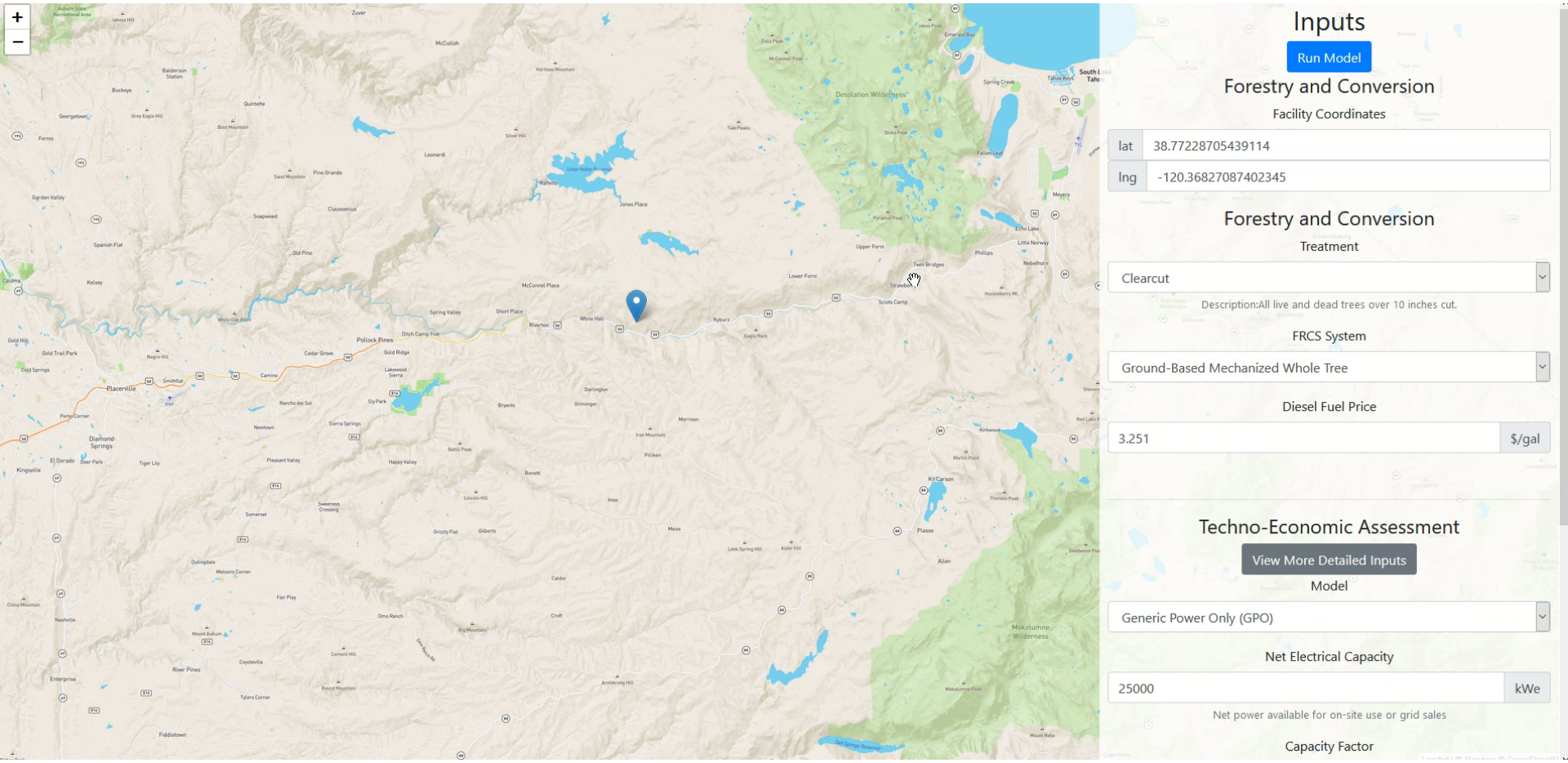
# User inputs to the DSS

- **User defined or default**
  - Facility location
  - Forest treatment
  - Harvesting System (FRCS model)
  - Technology type
  - Performance factors (capacity, efficiency, availability, other performance attributes)
  - Financial factors (investment structure, costs, taxes, incentives, other financial attributes)
  - Environmental factors

# DSS Outputs


Net Electrical Capacity (kWe),
Capacity Factor (%),
Net Station Efficiency (%),
Fuel Heating Value (kJ/kg)
OSRM
Forest Treatment
Annual Feedstock Consumption (t)
Harvesting System
Distance (miles)
Duration (hours)
Raw Data
preprocessing
Resource Database
Feedstock Search
FRCS Model
Transportation Model
Yes
Year <= Economic Year?
No
Feedstock & Coproducts supply (ton)
Fuel Consumption (gal)
Harvest Cost ($/ton)
Transport Cost ($/ton)
LCA Model
Current LCOE ($/kWh),
Constant LCOE($/kWh),
Sensitivity Analysis,
Risk Assessment
Technical Performance,
Resource Supply,
Environmental Analysis,
Carbon Intensity,
Technoeconomic Analysis
Conversion Technology
Feedstock Cost ($/t)
TEA Model
Transmission Cost ($)
Transmission Model
Facility Location
Substation Database
Input
Intermediate
Output

# Model Demonstration



# Backend Services

## Dataprep Program

- Github code: https://github.com/ucdavis/cec-dataprep

## DSS Web-based Application

- Front end Github code: https://github.com/ucdavis/cecdss
- Back end Github code: https://github.com/ucdavis/cecdss-backend

## Techno-Economic Assessment (TEA) Service

- Github code: https://github.com/ucdavis/technoeconomic-assessment/
- Documentation: https://technoeconomic-assessment.azurewebsites.net/
- Node module (npm): https://www.npmjs.com/package/@ucdavis/tea

## Fuel Reduction Cost Simulator (FRCS) Service

- Github code: https://github.com/ucdavis/fuel-reduction-cost-simulator
- Documentation: https://fuel-reduction-cost-simulator.azurewebsites.net/
- Node module (npm): https://www.npmjs.com/package/@ucdavis/frcs

## Life Cycle Assessment (LCA) Service

- Github code: https://github.com/ucdavis/lca
- Documentation: https://lifecycle-analysis.azurewebsites.net/
- Node module (npm): https://www.npmjs.com/package/@ucdavis/lca

# Thank you