Why focus on the round bale?

1. Single layer ambient storage
2. Uncouple baling from in-field hauling
3. Lower cost baler, lower power tractor---more opportunity for a wide range of different size farmgate contracts

Labor Productivity

1. Single bale handling is not going to work
2. Uncoupling the unit operations in the logistic chain can maximize labor productivity (ton/h) for each operation

Baling

1 bale every 2 minutes

Bale weighs 900 lb

Productivity: 13.5 ton/h

Suppose I want one operator to haul bales from the field to an SSL and have a labor productivity rate of 13.5 ton/h

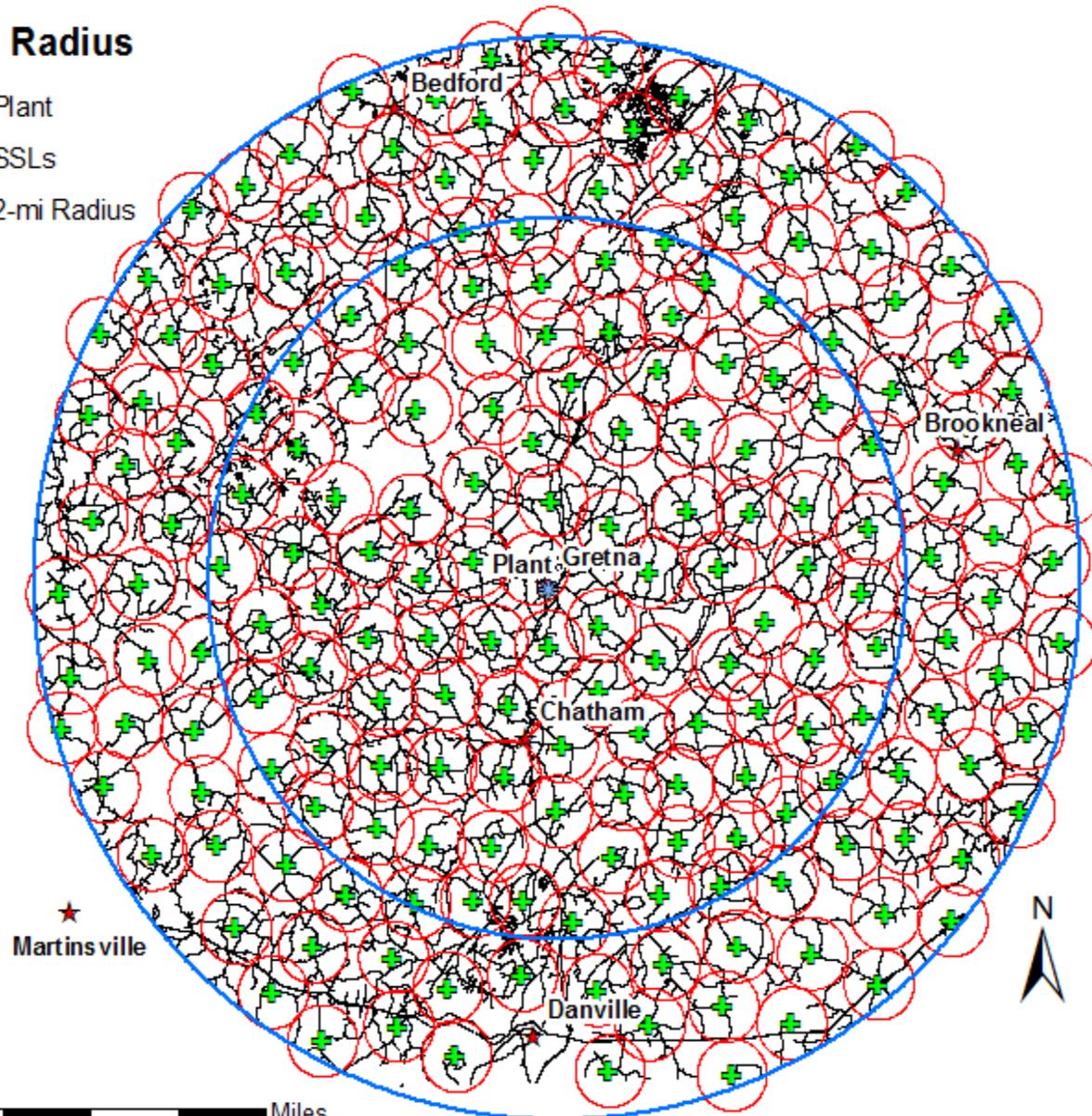$$\frac{10 \text{ bales/load x } 900 \text{ lb/bale}}{2000 \text{ lb/ton}} = 4.5 \text{ ton/load}$$

This means the distance from the field to the SSL cannot be more than 2 miles

30-mi Radius

* ✳ Plant
* ✚ SSLs
* ▢ 2-mi Radius

Bedford

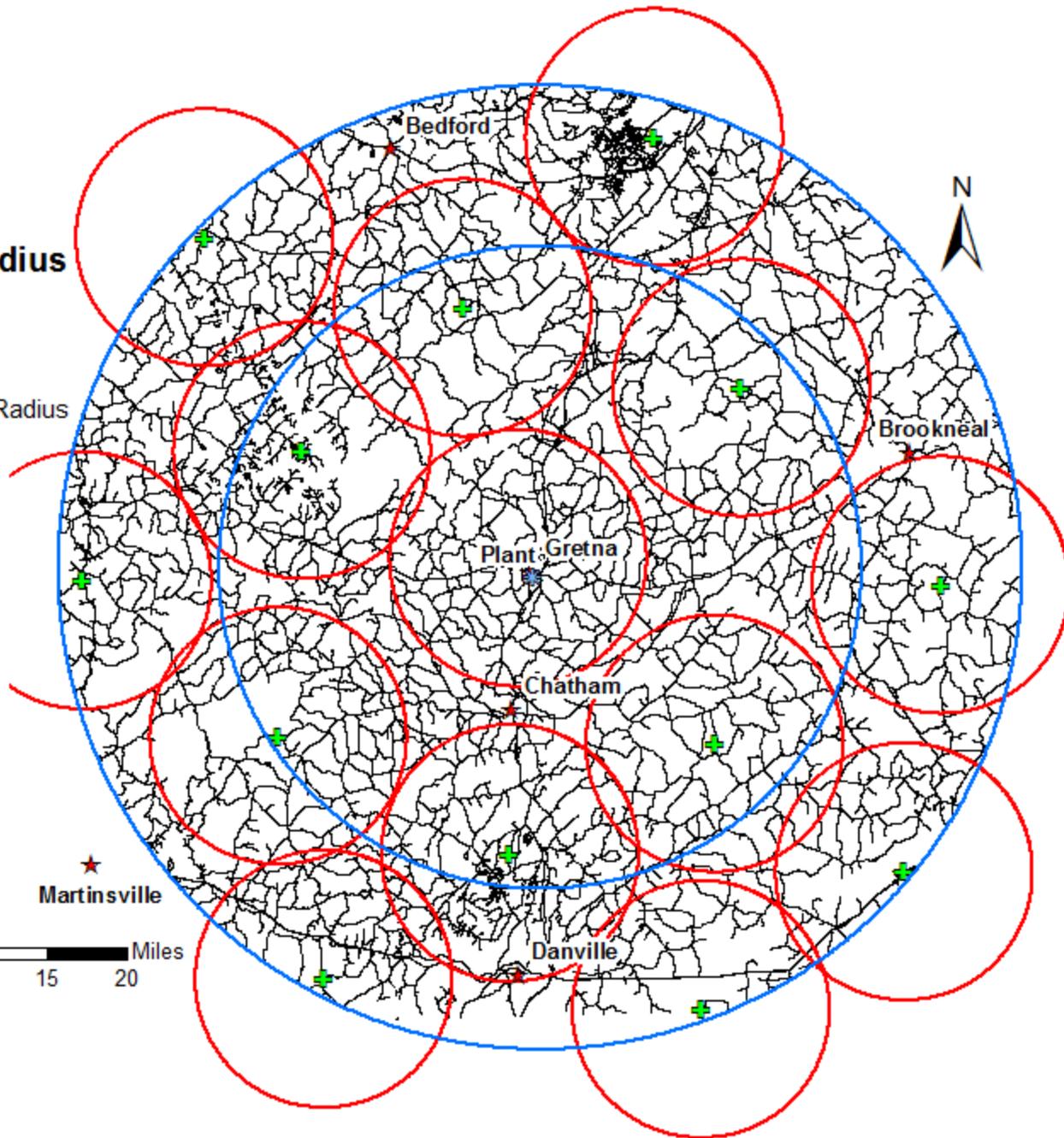Brookneal

Plant Gretna

Chatham

★ Martinsville

Danville

N

Miles
0 2.5 5   10   15   20

30-mi Radius

❋ Plant

✚ SSLs

▭ 8-mi Radius

Bedford

Brookneal

Plant Gretna

Chatham

Martinsville

Danville

Miles
0   2.5   5   10   15   20

N

Highway Hauling

Suppose I have a crew of two workers loading the truck

How many bales do these two workers need to load in a 10-h workday to have a labor productivity of 13.5 ton/h?

13.5 ton/h x 2 workers x 10 h/d = 270 ton/d

$$\frac{270\ \text{ton/d x 2000 lb/ton}}{900\ \text{lb/ton}} = 600\ \text{bales/d}$$

Can two workers load 600 5-ft diameter round bales on trucks in a 10-h workday?

Biomass Logistics Consortium

- 3 companies
- 3 universities

Goal: Develop equipment to load 480 bales in a 10-h workday

$$\frac{480 \text{ bales/d} \times 900 \text{ lb/bale}}{2000 \text{ lb/ton}} = 216 \text{ ton/d}$$

$$\frac{216 \text{ ton/d}}{10 \text{ h/d}} = 21.6 \text{ ton/h}$$

$$\frac{216 \text{ ton/d}}{2 \text{ workers}} = 10.8 \text{ ton/h}$$

Or 20% less than the baler operator

Labor: $20/h

Baling: $1.48/ton

In-field hauling: $1.48/ton

Loading: $1.85/ton

Suppose I want the truck driver to have a labor productivity of 13.5 ton/h

Truck load is 32 bales

$$\frac{32 \times 900\,\text{lb/bale}}{2000\,\text{lb/ton}} = 14.4\,\text{ton/load}$$

$$\frac{14.4\,\text{ton/load}}{13.5\,\text{ton/h}} = 1.07\,\text{h/load}$$

1. 10 min to load
2. 10 min to unload
3. Average road speed 45 mph

How far can I haul?

I can haul about 25 mi from the SSL to the bioenergy plant, if I want the truck driver to have a labor productivity of 13.5 ton/h