NITROGEN FIXATION POTENTIALS OF THREE NATIVE LEGUME SPECIES

Caitlyn Barton

Dr. Joseph Hendricks

Photo Credit: The

Pine Forests

- Pine forestry is one of the most important industries in the southeastern U.S.
- Pine forests also provide habitat for wildlife species, including many protected species in this region.

Photo Credit: Best Life Birding

Photo Credit: The Nature Conservancy

Photo Credit: iNatrualist

Photo Credit: The Nature Conservancy

Fire

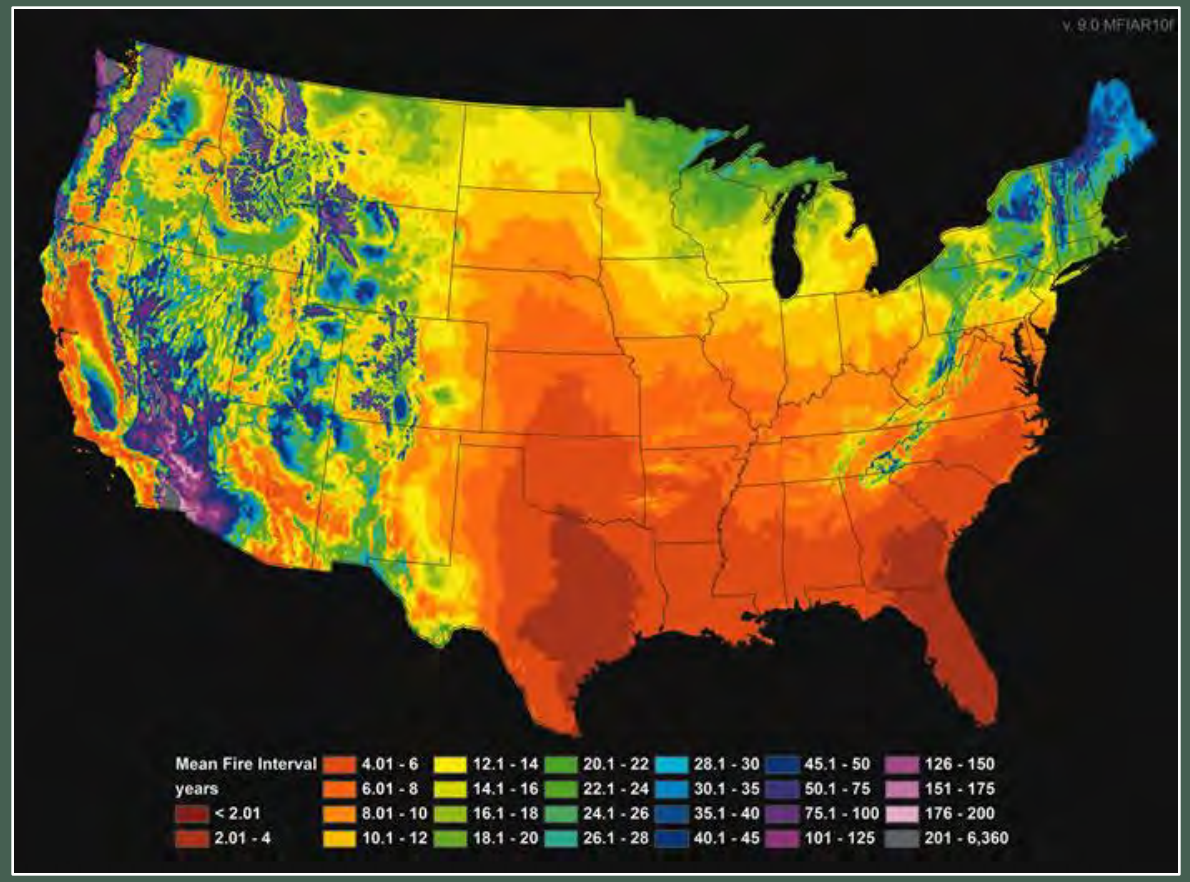


Photo Credit: Wildfire Today

- Pine forests evolved under the influence of low intensity fires ignited by lightning.
- These fires don't occur naturally anymore, so we now simulate them with prescribed burning.

Prescribed Burning

- One of the most important tools used in the management of pine forests in the SE.
- Cost efficient, highly effective, and provides many benefits.

Suppress Hardwoods

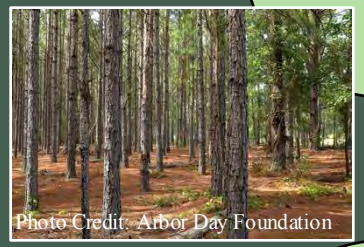


Photo Credit: Arbor Day Foundation

Control Diseases


Photo Credit: University of Minnesota


Photo Credit: CTIF

Improve Habitats


Photo Credit: TCPalm

Reduce Fuels


Photo Credit: Urban Forest Dweller

Burning Concerns

- While prescribed fire is a valuable management tool, it can result in a loss of some nutrients.
- In particular, nitrogen (N) in organic forms is readily volatilized to the atmospheric N_2 gas, which is not useable by most plants.
- Many soils are already deficient in N, so this is a problem.

Photo Credit: Kin.

Legumes

Photo Credit: CGTN.

- Prescribed burning promotes the growth of legumes!
- Some species have nodules on their roots, which allows them to cycle N_2 from the atmosphere back into the soil.
- This process, called N_2-fixation, has the potential to replenish N lost during burning.
- However, the growth and N_2-fixation potentials of native legumes have not been thoroughly assessed.

Objectives

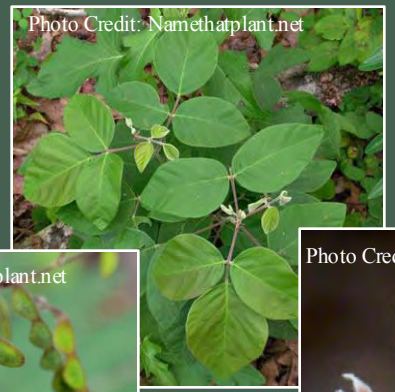
For three dominant native perennial legume species, assess:

1. above-ground growth patterns,
2. above- vs. below-ground biomass production,
3. foliar N concentration and retranslocation rates,
4. N_2-fixation rates, and
5. techniques to measure N_2-fixation in field settings.

Methods - Plants

Desmodium laevigatum

Desmodium marilandicum



Desmodium viridiflorum

Methods - Plants

Asclepias tuberosa

Methods - Soils

Collected soil from the 0-10 cm horizon in a pine forest.

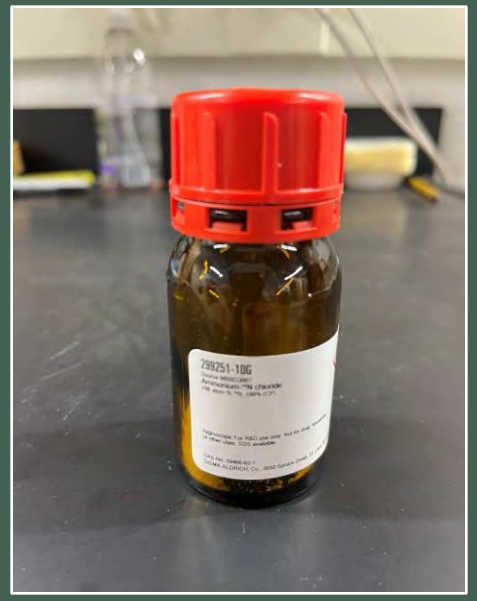
Sieved soil to remove organic matter & rocks.

Coarse organic matter & rocks (left) and soil (right).

Methods - Soils

Homogenized soil.

+



^{15}N isotope solution.

=

^{15}N enriched soil which was allowed to incubate for three months.

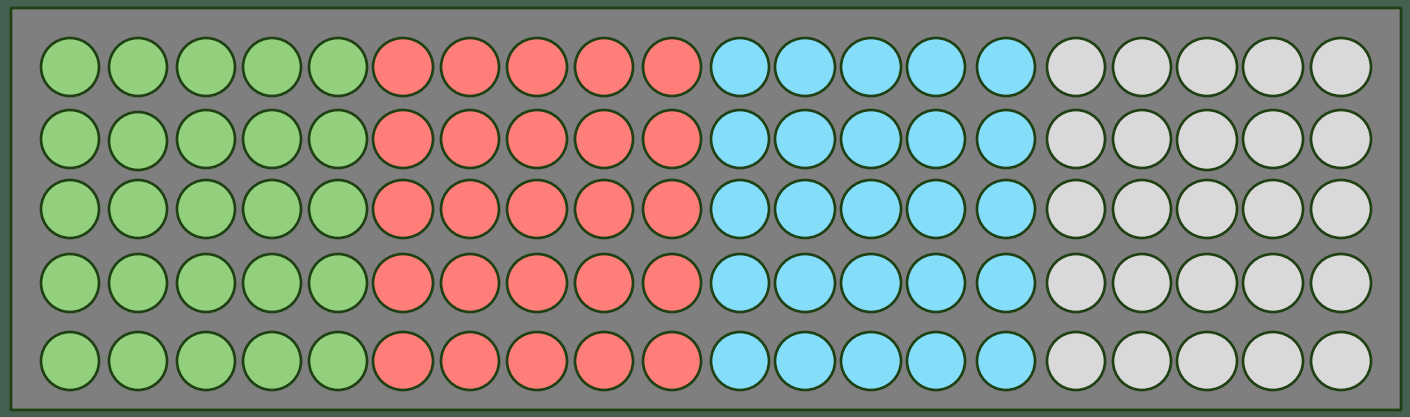
Methods – Experimental Design

Experimental unit: 2.25L pot.

100 Pots were filled with labeled soil and seed for each species.

Seeded pots were placed in a shade tent and watered daily.

Methods – Experimental Design



Desmodium laevigatum

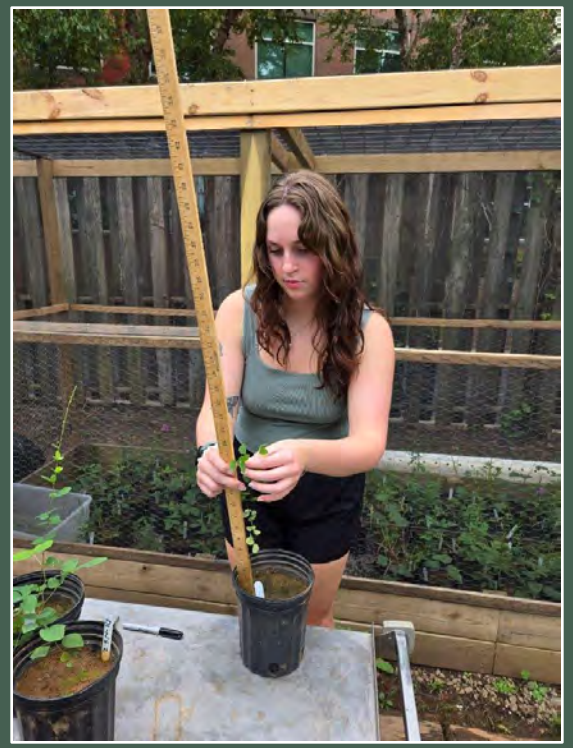
Desmodium marilandicum

Desmodium viridiflorum

Asclepias tuberosa

Shade tent

Methods – Dependent Variables

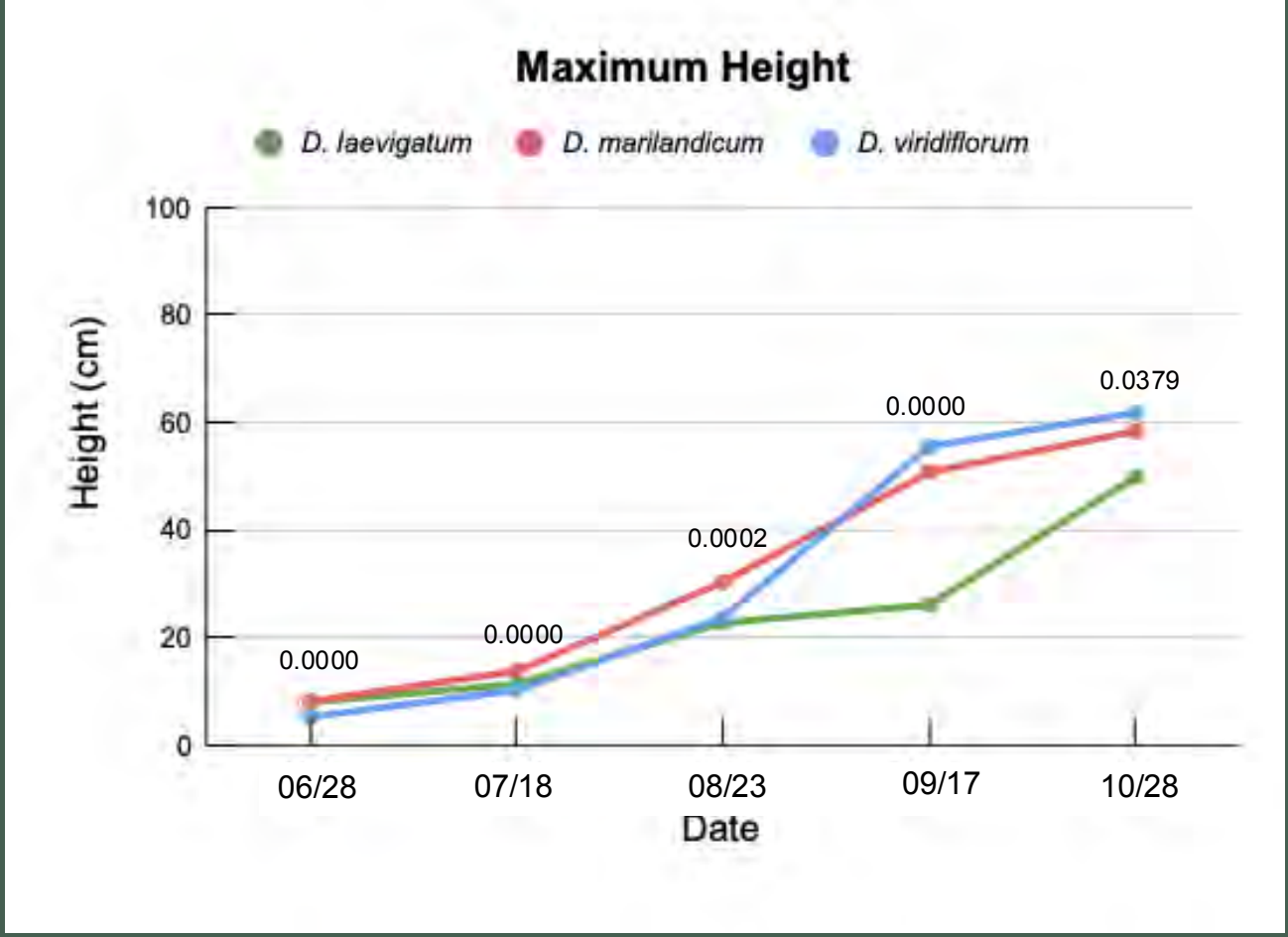


Measured maximum height & number of leaflets on each plant monthly.

Collected pre-senescent leaf samples from each plant in September.

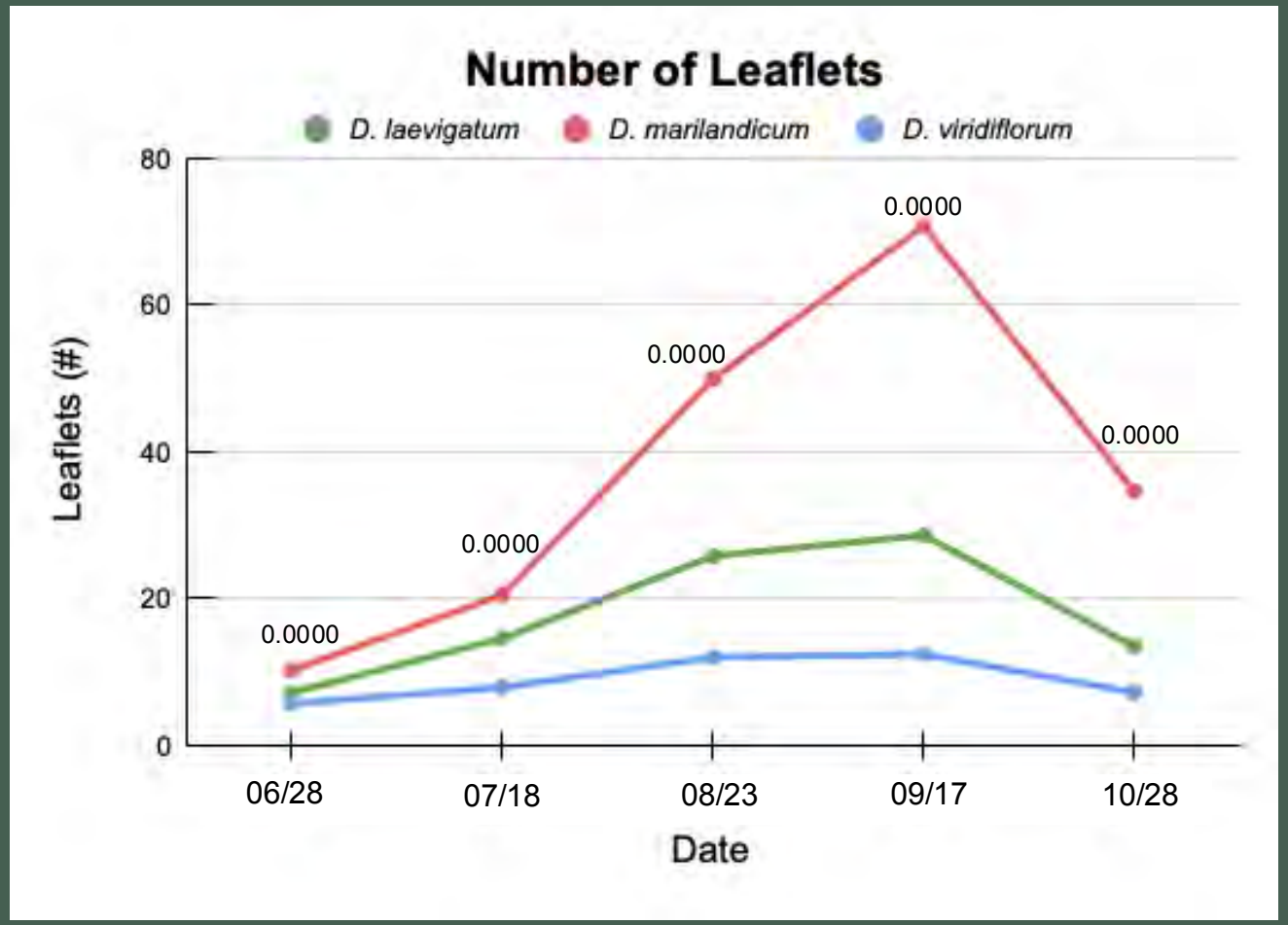
Collected senescing leaves as they dropped from plants from September – November.

Results - Above-Ground Growth



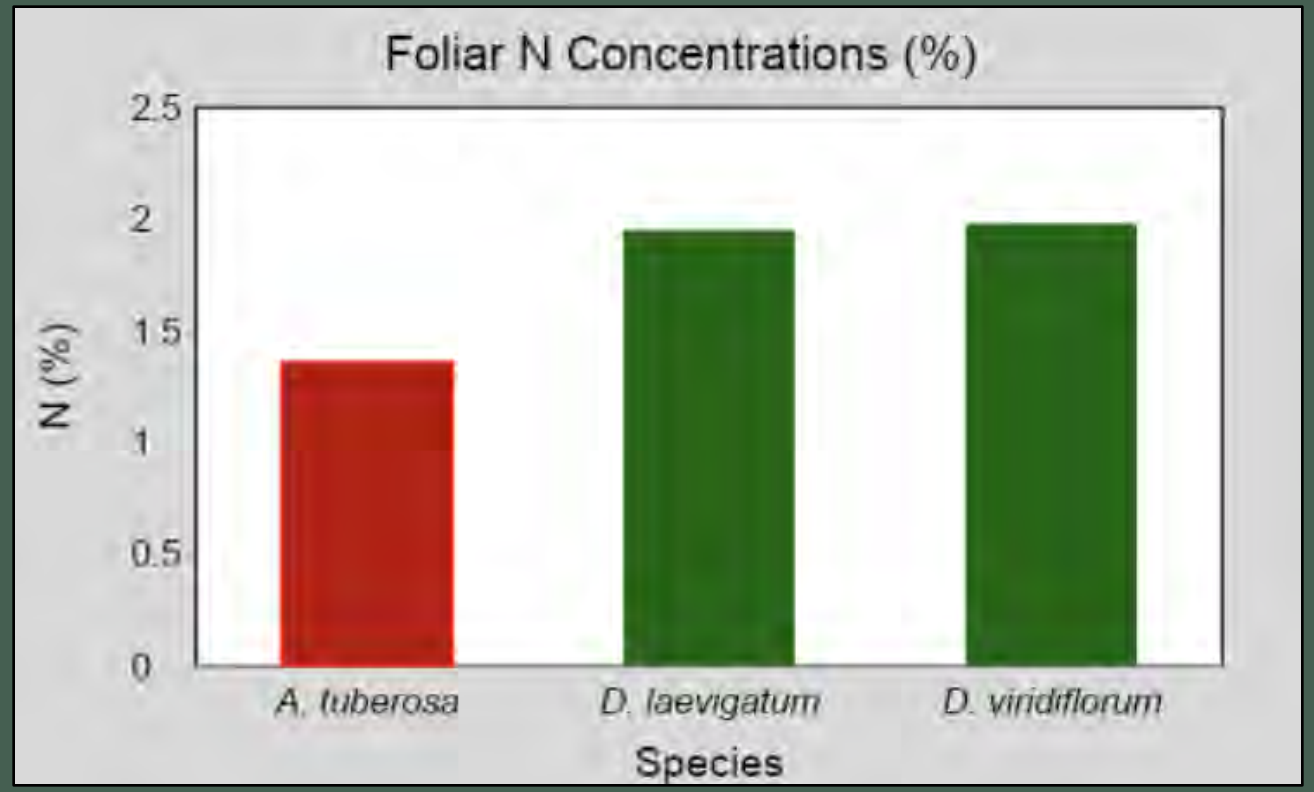
- Significant differences among species on each date.
- *D. viridiflorum* started significantly shorter and ended up the tallest – significantly higher than *D. laevigatum*.
- Maximum height: *D. viridiflorum* 61.7 cm.

Results - Above-Ground Growth



- Significant differences among species on each date.
- *D. marilandicum* produced more leaflets than other two species.
- *D. viridiflorum*, which was the tallest, consistently had fewer leaflets throughout the assessment.

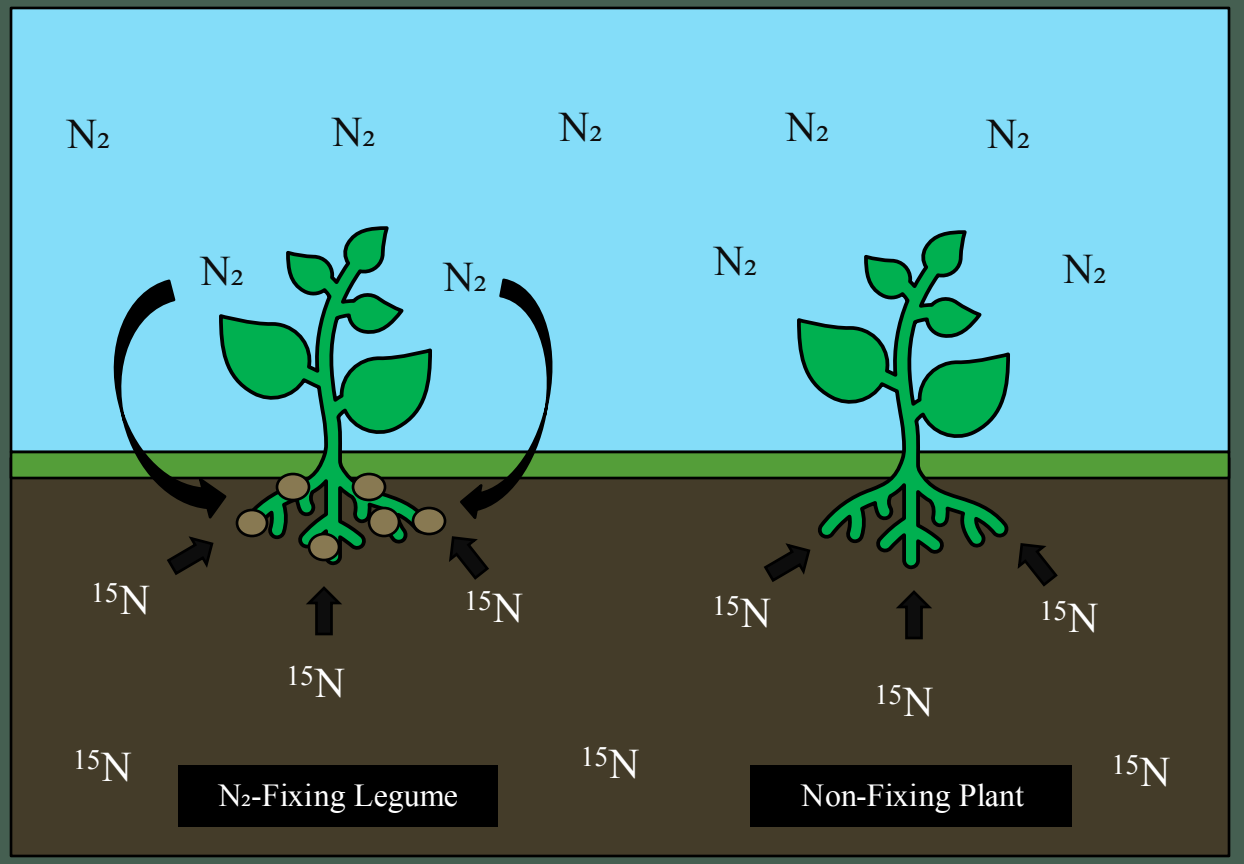
Results – Foliar N%



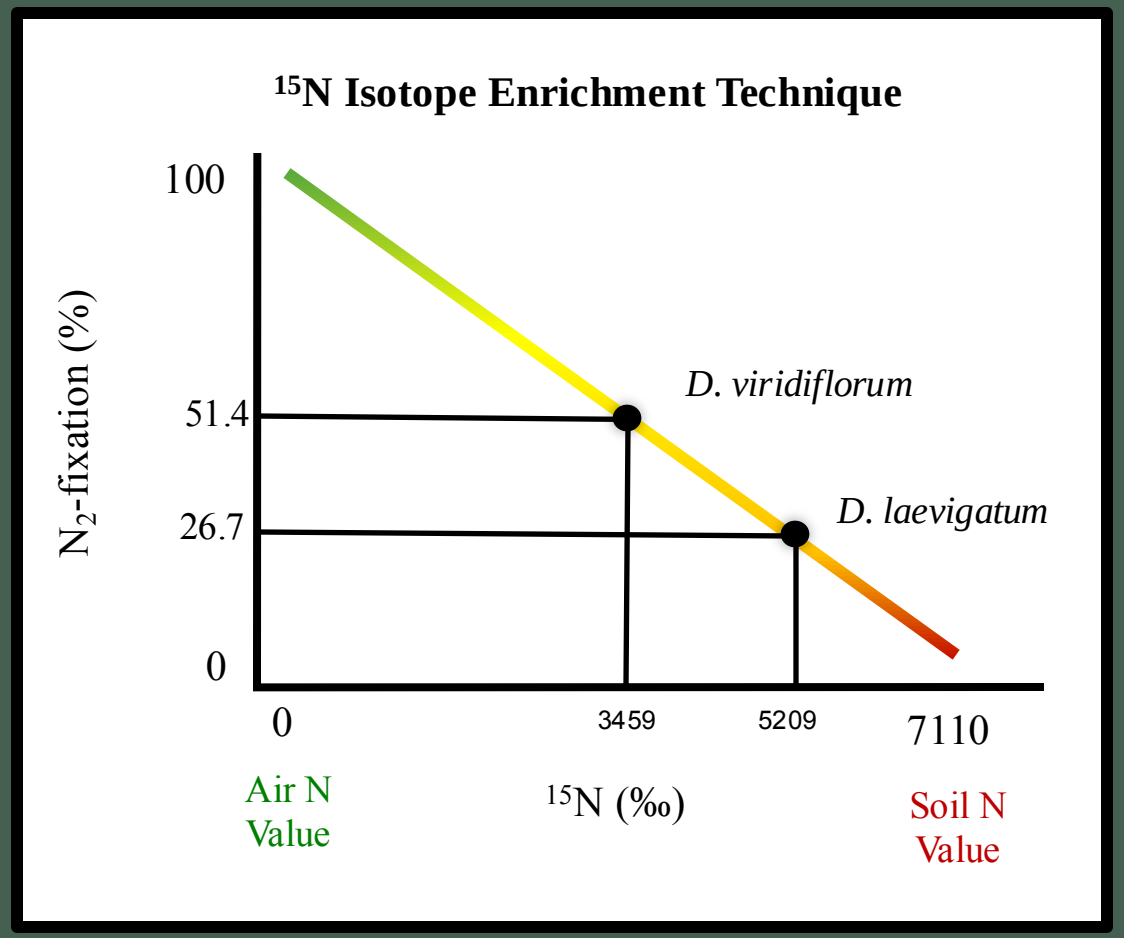
- *D. laevigatum* and *D. viridiflorum* had higher N% compared to *A. tuberosa*.
- Shows that they have higher N concentrations, but not necessarily from N_2-fixation.

Results – N_2-Fixation

- Soil was enriched with high levels of ^{15}N, which both the legume species and the reference species were able to use.
- This allowed for the quantification of how much N the legume species accessed from the atmosphere, if any.



Results – N_2-Fixation



- Non-fixing reference species had a ^{15}N concentration of 7110.
- *D. laevigatum* had a ^{15}N value of 5209, translating into a 26.7% derived via N_2-fixation.
- *D. viridiflorum* had a ^{15}N value of 3459, translating into a 51.4% derived via N_2-fixation.

Implications

- These preliminary results indicate that the *Desmodium* species have high growth potentials in shaded environments representative of pine forest understories.
- These species also had relatively high foliar N concentrations compared to the non-legume reference species.
- Approximately 25 – 50% of the legume foliar N was “new” N derived by N_2-fixation.
- These results suggest that native legumes may mitigate N losses due to prescribed burning in SE pine forests.
- Future studies should focus on assessing the rate and controls of legume N_2-fixation in natural settings.


QUESTIONS?

Credits

Title Slide Photo: https://www.nature.org/en-us/about-us/where-we-work/united-states/north-carolina/stories-in-north-carolina/history-of-longleaf-pine/
RCW Photo: https://birdwatchingnc.com/tag/red-cockaded-woodpecker/
Indigo Snake Photo: https://www.nature.org/en-us/get-involved/how-to-help/animals-we-protect/eastern-indigo-snake/
Pocket Gopher Photo: https://www.inaturalist.org/guide_taxa/273212
Gopher Tortoise Photo: https://www.nature.org/en-us/get-involved/how-to-help/animals-we-protect/gopher-tortoise/
Fire Map Photo: https://wildfiretoday.com/2015/06/04/historic-fire-frequency-1650-to-1850/
Pine Forest Photo: https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/piney-grove-preserve/
Mixed-Pine Forest Photo: https://www.capegazette.com/article/dying-pine-trees-sea-level-rise-or-pine-beetles/144720
Prescribed Burn Photo: https://ctif.org/news/prevention-control-using-back-fire-combat-wildfire
Brown Spot Photo: https://extension.umn.edu/plant-diseases/brown-spot-needle-blight
Leaf Litter Photo: https://www.urbanforestdweller.com/its-called-leaf-litter-but-its-not-garbage-six-reasons-to-leave-the-leaves/
Open Understory Photo: https://www.arborday.org/stories/long-leaf-pine.cfm
Woodpecker Photo: https://www.tcpalm.com/picture-gallery/news/2024/08/29/red-cockaded-woodpeckers-seen-in-pine-forests-in-jonathan-dickinson/74994203007/
Burning Leaf Litter Photo: https://www.kin.com/blog/wildfires-in-florida/
Root Nodule Photo: https://news.cgtn.com/news/2019-12-12/Why-do-legumes-have-nodules-on-their-roots--MmxlxHWkda/index.html
Laevigatum Photo: https://illinoisbotanizer.com/plants/desmodium-laevigatum/
Laevigatum Seed Photo: http://www.namethatplant.net/gallery_compari.shtml?compare=loments%20of%20Desmodium%20species
Marilandicum Photo: https://gobotany.nativeplanttrust.org/species/desmodium/marilandicum/
Marilandicum Flower Photo: https://wildflowersearch.org/search?&tsn=25809
Marilandicum Seed Photo: https://vaplantatlas.org/index.php?do=plant&plant=2707&search=packera
Desmodium Photo: http://www.namethatplant.net/plantdetail.shtml?plant=454
Tuberosa Photo: https://budburst.org/plants/90