

The background of the slide is a close-up photograph of green hemp leaves. The leaves are serrated and have a prominent vein pattern. They are densely packed and fill the entire frame, creating a textured, natural background for the text.

Overview of Floral Hemp Fertility and Production in North Carolina

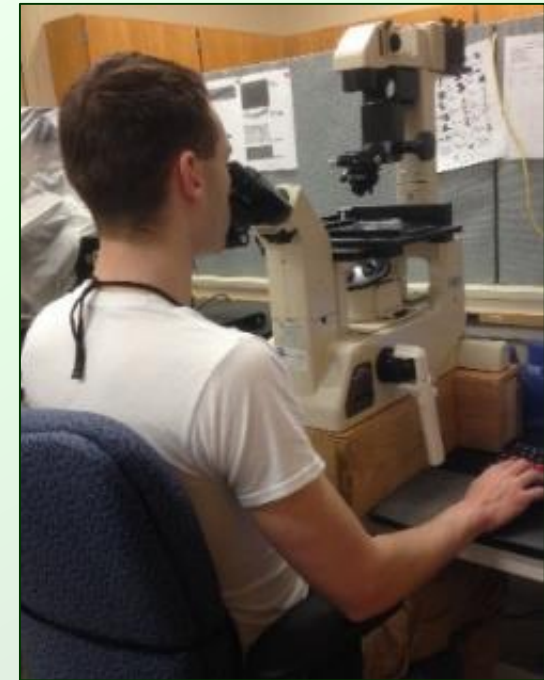
Michelle McGinnis, Ph.D.
NCDA&CS Agronomic Field Services Section Chief
NCSU Horticultural Science Adjunct Faculty

UVM Industrial Hemp Conference
February 20, 2020



Agronomic Services Division Laboratory Sections

- Soil Testing
- Nematode Assay
- Plant, Waste, Solution, & Media Analysis



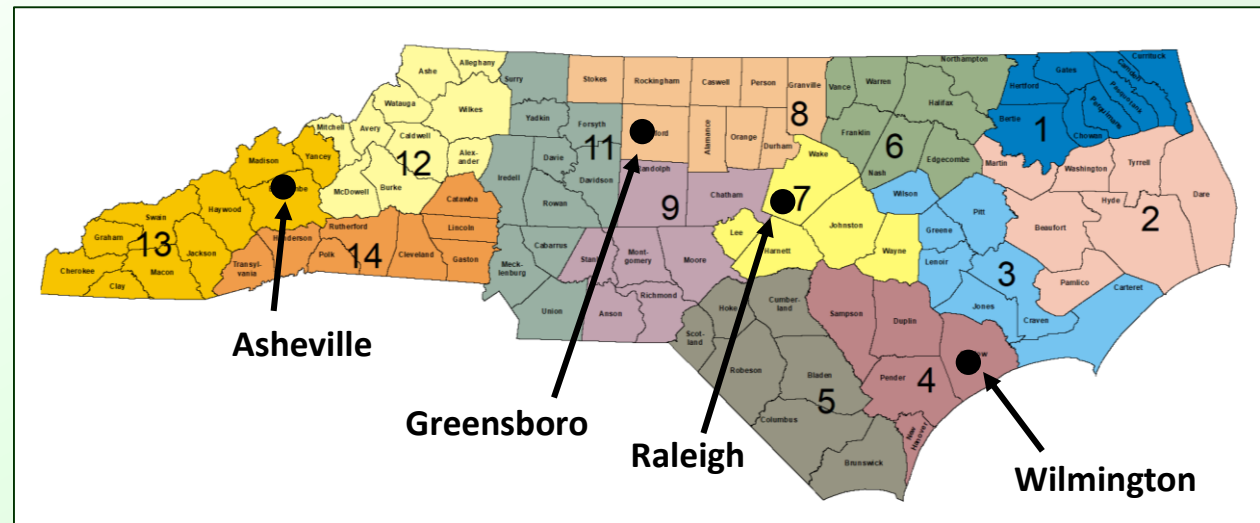


Agronomic Services Division Field Services Section

- Provide on-farm consultations
- Diagnose plant growth problems
- Advise to prevent or correct plant growth problems



Dr. Michelle McGinnis and 13 Regional Agronomists



Grown for seed, fiber, and flowers

- Seed/fiber

- Agronomic crop
- Seeds drilled or broadcasted
- Harvested with combine
- Male and female plants



- Flower (>95% licenses in NC)

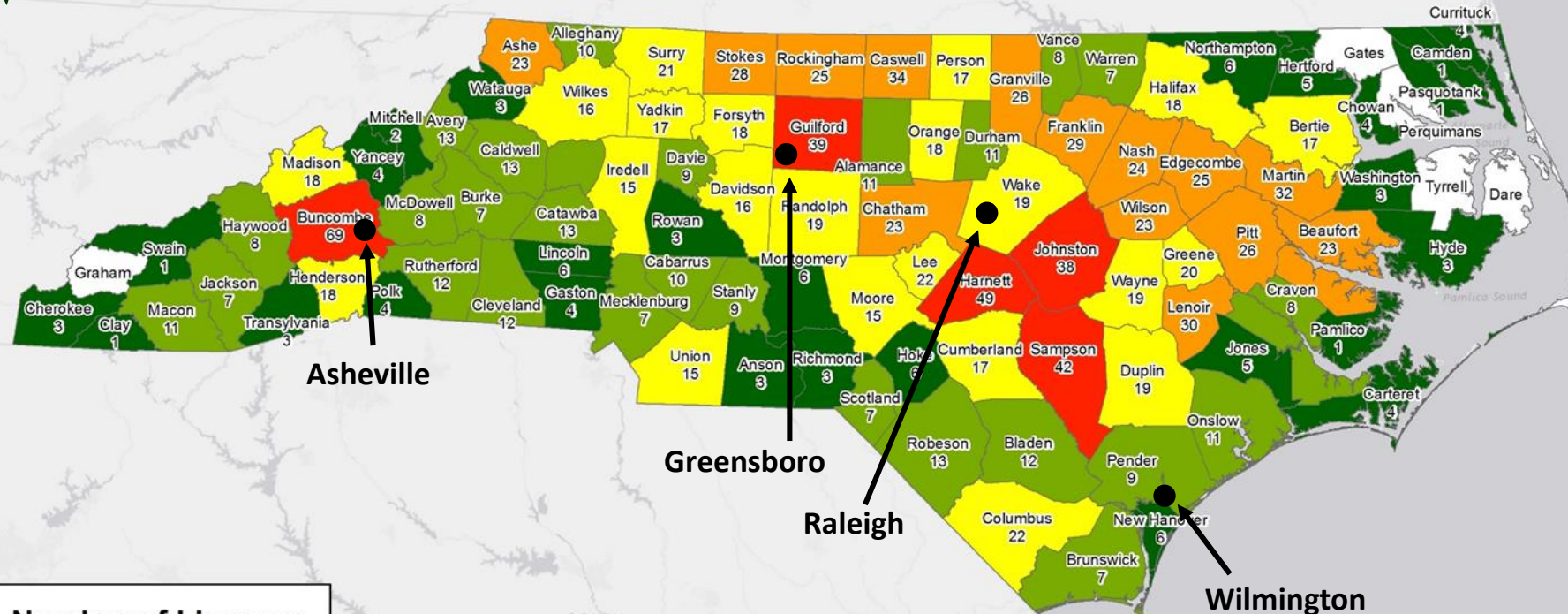
- Horticultural crop
- Plant greenhouse produced transplants
- Harvested by hand or mechanically
- Female plants



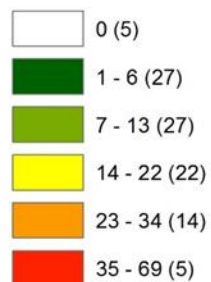


Total Number of Hemp Licenses by County 01/01/2020

Number of hemp licenses – 1,387
Floral hemp on 97% of the licenses




Number of Licenses



Steve Troxler
Commissioner

17,500 acres licensed (field production)
6,750,000 ft² licensed (GH production)



17,500 acres licensed (field production)
6,750,000 ft² licensed (GH production)



Why Floral Hemp?

- Hemp flowers contain cannabidiol (CBD)
 - as well as other cannabinoids
- CBD has been reported to help with
 - Chronic pain
 - Anxiety and depression
 - Neurological disorders (epilepsy)
 - Arthritis and inflammation
 - Overcoming opioid addiction

How to take CBD

- **Topical application** (*oil, lotion, etc.*)
 - CBD extracted from dried hemp flowers and incorporated into cosmetics
- **Inhalation** (*smoking & vaping*)
 - CBD inhaled from fresh hemp flowers
- **Ingestion** (*soft gels, tea, gummies, etc.*)
 - Fresh or extracted CBD
 - CBD infused food and beverage is illegal



CBD comes from trichomes

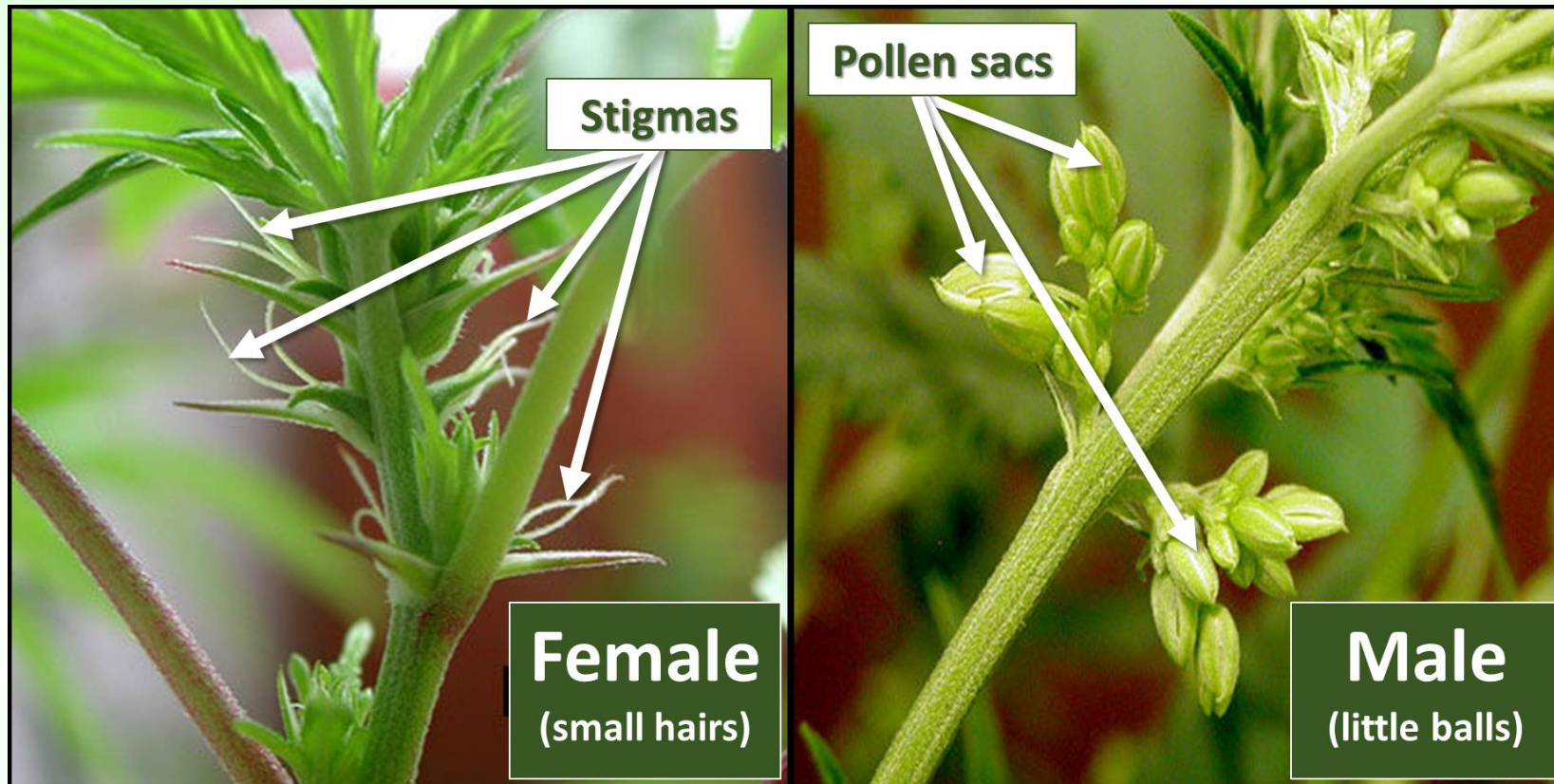
Trichomes

- Glandular hairs
- Contain CBD
- Only on female flowers
- Will not fully develop if flowers are pollinated (produce seeds)



Hemp plants are either male or female (dioecious)

Determine plant sex at the pre-flowering stage



Grow female clones or remove males
before pollination to maximize CBD production



DECISIONS BEFORE GROWING FLORAL HEMP

- **Planting.** Direct seed or transplants? Cultivar?
- **Direct seed.** Feminized seed or non-feminized seed?
- **Greenhouse produced transplants.** Female clones, feminized seedlings, non-feminized seedlings? Purchase or grow your own?
- **Production environment.** Outdoors, controlled (greenhouse or warehouse), protected (hoop house)?
- **Outdoor production.** Open bed, plasticulture, container?

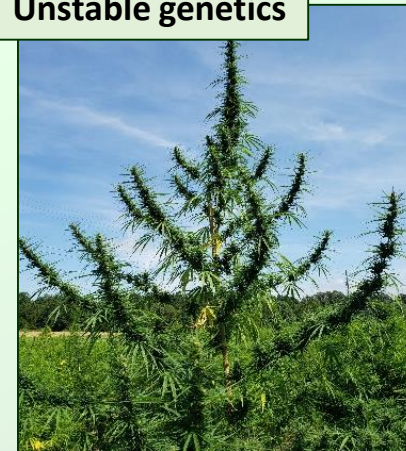
SEED (Direct-Seed or Transplant)

- Genetics not stable
- Feminized seed (may have >20% males)
- Non-feminized seed (50% male)
- Prevent seed formation by culling males
- Genetics improving
- Industry seems to be moving from clones to seedlings

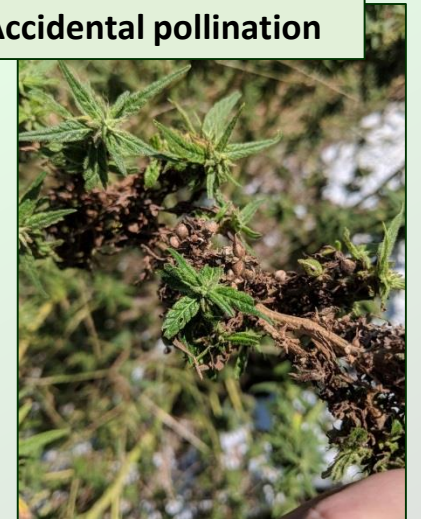
Poor germination (direct seeded)



Unstable genetics



Accidental pollination



TRANSPLANTS (Clones vs Seedlings)

- Female Clones

- Vegetative propagation - cuttings from female stock plants
- Relatively uniform phenotype
- Stock (mother) plant maintenance
- ~\$5/transplant

- Feminized Seedlings

- Sexual (seed) propagation
- Tend to have unstable genetics (characteristics not uniform)
- Can have 20-30% male plants (need to cull males)
- No certifying agencies
- ~\$1/transplant

Seedling



Female mother plants



Rooted cuttings



Scout to cull males



ENVIRONMENT (Outdoor, Greenhouse, Hoop House)

- Depends on your current infrastructure
- Most varieties are photoperiodic short days plants (flowering occurs when periods of light are less than periods of dark)
 - Outdoor or protected (hoop house): Flowering occurs ~6 wks after summer solstice (late-Jul, mid-Aug)
 - Controlled (greenhouse): Flower initiation can occur anytime with artificial light manipulation



FLORAL HEMP – FIELD



Plastic
(like strawberries or tomatoes)



Open fields / bare ground
(like tobacco)

Plasticulture Production

June 2018
Forsyth County
Plastic – They were experimenting with various methods of row middle control
Drip irrigation/fertigation



August 2018
Guilford County
Plastic – No row middle weed control
Drip irrigation/fertigation



July 2018
Chatham County
Plastic – No row middle weed control
Drip irrigation/fertigation



- Irrigation – Drip
- Weed control – Plastic (row middles a challenge)
- Nitrogen 80-150 lb/ac
- Split (50 lb N/ac pre-plant; remainder fertigated throughout season)

Open Bed Production

July 2018
Harnett County
Bare ground – Weed control with cultivation
Overhead irrigation



July 2018
Chatham County
Bare ground – Weed control with cultivation
No irrigation



July 2018
Franklin County
Bare ground – Weed control with mulched middles
Overhead irrigation

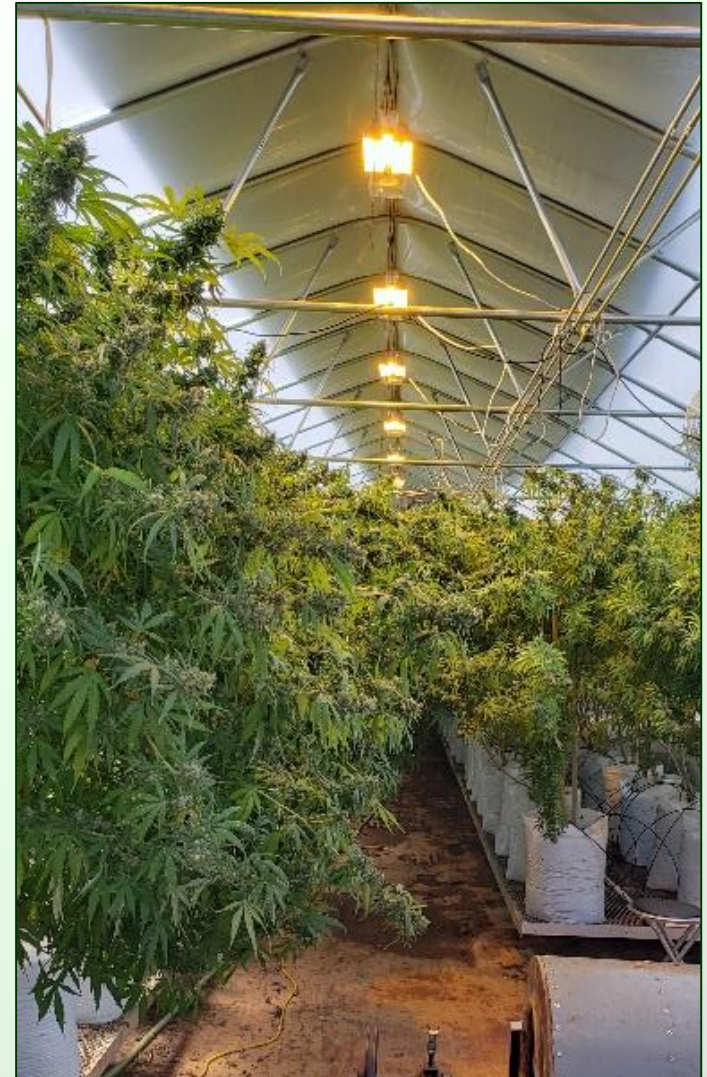


- Irrigation – Drip or none
- Weed control – Cultivate (late season a challenge)
- Nitrogen 80-150 lb/ac
- Split (50% pre-plant; 50% ~4 weeks after transplant)

FLORAL HEMP – GREENHOUSE



Containers. Fertigation. Lights



FLORAL HEMP – HIGH TUNNEL



Photo credit: Dr. Sanjun Gu
Horticulture Extension Specialist NCA&T



Photo by Debbie Roos

- Grow in soil or containers
- Irrigation – Drip
- Fertilize pre-plant or thru drip
- No heat source or grow lights

2019 NCSU Cultivar Trials

Visit <https://industrialhemp.ces.ncsu.edu/> for 2019 Hemp Strain Testing Results

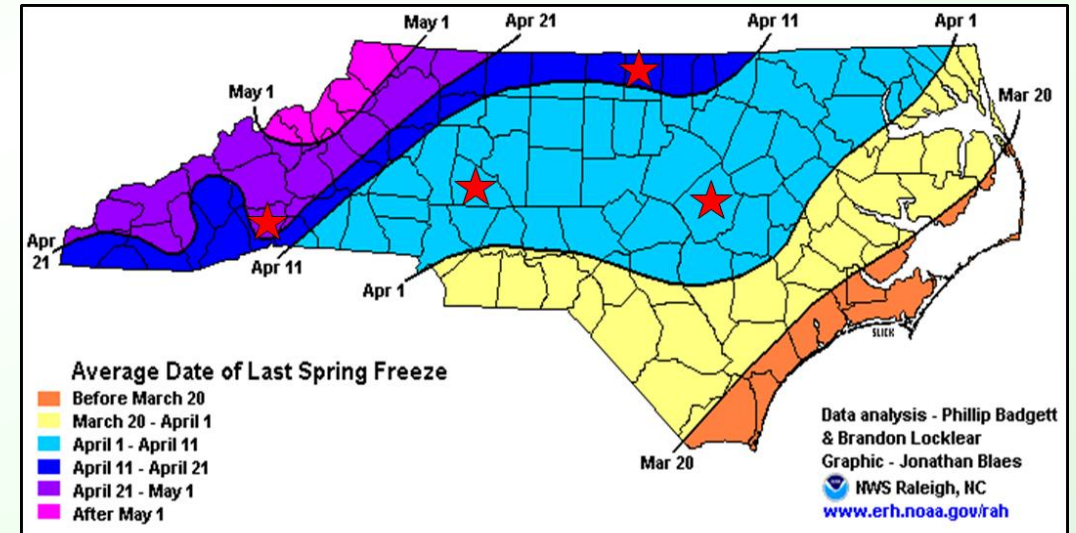
Varieties*	Floral Yield (lb/plant)**	Total THC (%)	Total CBD (%)
Boax	>1.5	0.6 - 0.8	13 - 16
Suver Haze	>1.5	0.6 - 0.7	13 - 15
Cherry Wine	1-1.5	0.4 - 0.6	10 - 15
Sweeten	1-1.5	0.2 - 0.7	6.0 - 16
T1	0.5-1	0.3 - 0.6	7.0 - 12

* Varieties among the top 10 cultivars grown in NC

** Bucked (de-stemmed dry yield)

TAKE HOME MESSAGE

Test for THC during flower production and harvest before you go hot!!!



<https://industrialhemp.ces.ncsu.edu/>

NC STATE EXTENSION

COUNTY CENTERS TOPICS GIVE NOW

Hemp

Meet Our Staff

Events

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Production
Insect & Disease Management Planting
Sources (Seeds, Clones, Transplants)

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Attorneys & Law Firms Banks &
Financial Institutions CPAs and
Accountants ...


E-Mail Newsletter

Agent Resources

Publications & Factsheets

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an EXPERT

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Search

Events

FEB 19 WED

Winter Vegetable Conference
Wed Feb 19 - Thu Feb 20
12 hours away

FEB 24 MON

Small Farms AgriShop
Mon 2/24 8:30 AM - 4:30 PM
6 days away


FEB 25 TUE

Regional Hemp Production Meeting
Tue Feb 25
6 days away

FEB 25 TUE

AgriShop
Tue Feb 25
6 days away

News and Updates



2019 North Carolina Hemp Strain Testing Results
North Carolina Hemp Strain Testing Results are finally here! Hemp strains were tested in four locations last year including ...

Buying and Selling Hemp Seed in NC
2/11/2020- There are many people getting involved in the hemp industry who are new to agriculture. They may not ...

How and When to Request THC Testing in NC
UPDATED 2/10/2020 – Dr. Michelle McGinnis, Field Services Section Chief with the Agronomic Division, and Kathy Bowers, Hemp Sampling Coordinator, ...



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- **Outdoor production.** Open bed, plasticulture container?



Planting Date in North Carolina

- Overall, most growers seemed to plant early-May through late-June
- Some planted mid-April; a few planted in late at mid-August
- In 2019, the late planting date (early July) appeared to reduce yields in at the Mountain Horticulture Crops and Piedmont Research Stations compared to the May and June plantings.

Planting date, spacing, mulching, pruning, and cultivar studies conducted by Drs. Jeanine Davis and Angela Post (NC State University) in 2018 and 2019 and will be conducted by Drs. Jeannine David and David Suchoff (NC State University) in 2020



Spacing (In-Row and Between-Row)

- 4-6 in-row on 4-6 foot centers
- Lessons learned in 2018
 - In-row spacing
 - Between row spacing
- Depends on variety, planting date, harvest date, planting equipment, harvest equipment



Clip / finger
planter



Water wheel planter



Carousel planter

Planting date, spacing, mulching, pruning, and cultivar studies conducted by Drs. Jeanine Davis and Angela Post (NC State University) in 2018 and 2019 and will be conducted by Drs. Jeannine David and David Suchoff (NC State University) in 2020

Weed Control

Open beds

- In-Row: Cultivation
- Between-Row: Cultivation



Plasticulture

- In-Row: Plastic
- Between Row: Mechanical, live mulch, dead mulch, hand work



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Staking / Pruning / Topping

- Questions based on marijuana production model
- Lessons learned in 2018
- In summary, little if any yield increase
- Labor intensive

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E-Mail Newsletter

Plant Resources

Publications & Factsheets

ask
an EXPERT

Now on Twitter

Now on Twitter

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Moving on to Fertility and Plant Nutrition

NCDA Soil Test Recommendations

Based on University of Kentucky guidelines

Target pH

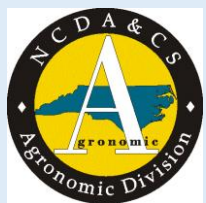
- 6.2 for mineral soil
- 5.5 for mineral-organic soil
- 5.0 for organic soil

Nitrogen rate*

- 50 lb/A for fiber
- 100-150 lb/A for seed/grain
- No recommendation for flower

Phosphorus and potassium* rates (based on soil test results)

- Phosphorus (P_2O_5)
 - 0 lb/A at P-Index of 70
 - 150 lb/A at P-Index of 0
- Potassium (K_2O)
 - 0 lb/A at K-Index of 80
 - 150 lb/A at K-Index of 0



*Dr. Michelle McGinnis (NCDA Agronomic Division), Drs. Matthew Vann, Keith Edmisten, David Suchoff, and Ms. Maggie Short (NC State University) are currently evaluating N and K rate effects on yield and cannabinoid concentrations and developing plant leaf tissue sufficiency ranges

GH Floral Hemp Nitrogen Management (Containers)

FIGURE 2:

RECOMMENDED FERTILIZATION RATES BASED ON CANNABIS PLANT GROWTH

DEVELOPMENT STAGE	FERTILIZER RATE (PPM N)
Early Vegetative	100 to 125
Late Vegetative	150 to 200
Peak Flowering	200 to 225
Pre-Harvest	100 to 150

© BRIAN WHIPKER



Excerpt from NCSU's: Whipker, Brian, J. Smith, P. Cockson, and H. Landis. 2018. *Cannabis Tips: 10 Building Blocks to Plant Nutrition*. Cannabis Business Times.

< <https://www.cannabisbusinesstimes.com/article/10-building-blocks-to-plant-nutrition/> >

GH Floral Hemp EC Management

FIGURE 3:

RECOMMENDED POURTHRU ELECTRICAL CONDUCTIVITY (EC) LEVELS BASED ON CANNABIS PLANT GROWTH

DEVELOPMENT STAGE	TOP IRRIGATION (mS/cm)	SUB-IRRIGATION OR CAPILLARY MAT (mS/cm)
Early Vegetative	1.0 to 1.5	0.67 to 1.0
Late Vegetative	1.5 to 2.0	1.0 to 1.3
Peak Flowering	2.0 to 2.5	1.3 to 1.7
Pre-Harvest	1.5 to 2.0	1.0 to 1.3

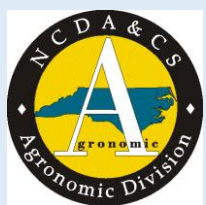
VALUES VARY WITH IRRIGATION METHOD. (TOP VERSUS SUB-IRRIGATION)

© BRIAN WHIPKER



Plant leaf tissue nutrient analysis*

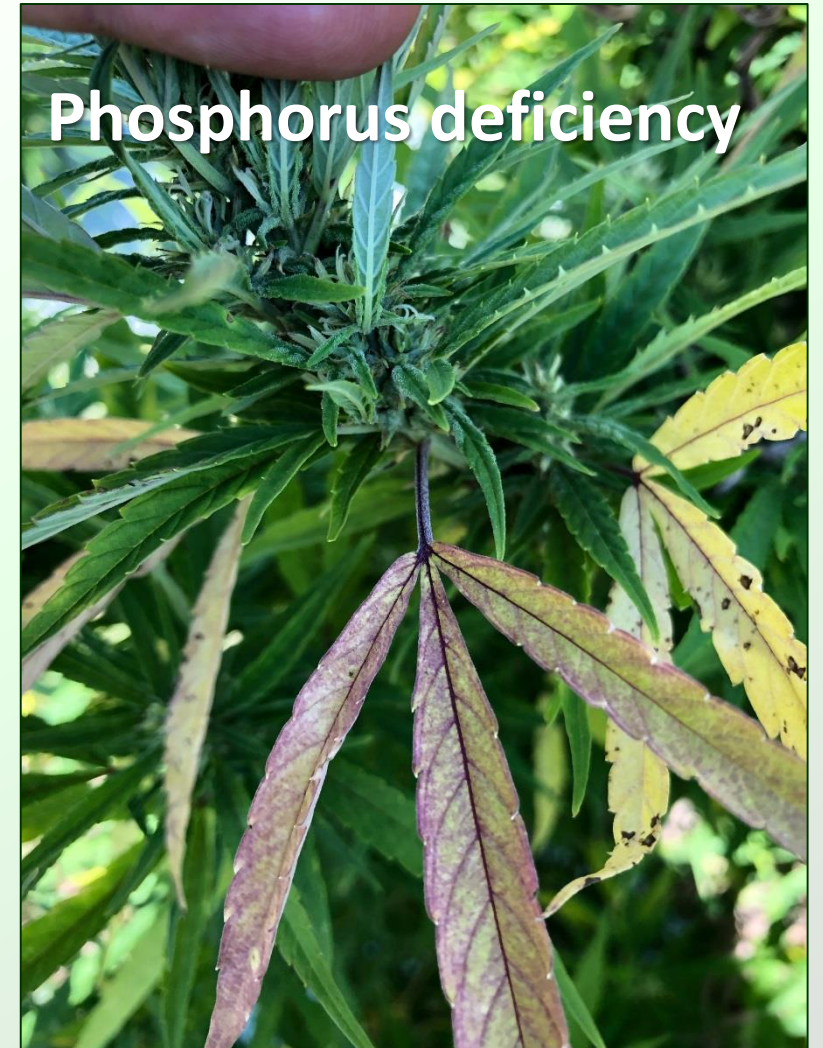
- Excellent tool to manage in-season fertility
- Diagnostic tool to help identify cause(s) of plant growth problems
- Results compared to crop specific target nutrient ranges of the most recently mature leaves (MRML)
- Lab reports indicate if nutrients are sufficient, low/deficient, or high/excessive



*Dr. Michelle McGinnis (NCDA Agronomic Division), Drs. Matthew Vann, Keith Edmisten, David Suchoff, and Ms. Maggie Short (NC State University) are currently evaluating N and K rate effects on yield and cannabinoid concentrations and developing plant leaf tissue sufficiency ranges



Plant leaf tissue nutrient analysis



Collecting representative plant leaf tissue samples



Collect the most recently mature leaf (MRML) or the most recently expanded leaf. It is generally the 3rd to 5th leaf down from the growing point.

For hemp, collect 1-2 MRMLs from 20-30 plants growing in like conditions (30-40 leaves is ideal).

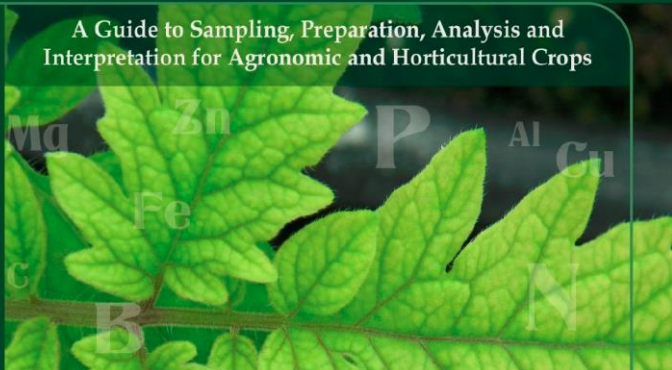
Compare lab results to crop specific target nutrient ranges

- No sufficiency ranges for hemp
- Survey ranges in Plant Analysis Handbook* used as guidelines by most labs and advisors

*Bryson, G.M, and H.A. Mills (Eds). 2014. *Plant analysis handbook IV e-edition. A guide to sampling, preparation, analysis, and interpretation for agronomic and horticultural crops*. Athens, GA: Macro-Micro Publishing Inc.

Plant Analysis Handbook IV

A Guide to Sampling, Preparation, Analysis and Interpretation for Agronomic and Horticultural Crops



Edited by
Gretchen M. Bryson
Harry A. Mills

SCIENTIFIC NAME		<i>Cannabis sativa</i>	
COMMON NAME		Cannabis	
COLLECTED FROM		Production nursery	
PLANT PART		25 mature leaves from new growth	
SEASON		Vegetative prior to flowering	
DATA TYPE		Survey Range	
CULTIVARS USED			
Macronutrients		Micronutrients	
	%		ppm
N	3.3 - 4.76	Fe	100 - 150
P	0.24 - 0.49	Mn	41 - 93
K	1.83 - 2.35	B	56 - 105
Ca	1.47 - 4.42	Cu	5 - 7.1
Mg	0.4 - 0.81	Zn	24 - 52
S	0.17 - 0.26	Mo	0.5 - 1.5



Compare lab results to crop specific target nutrient ranges

- Sufficiency Ranges—established through yield based studies replicated over space and time
- Survey Ranges—established based on observational data; believed to approximate the critical values for deficiency or toxicity however additional research under a wide range of growing ranges is required to verify this assumption



Compare lab results to crop specific target nutrient ranges

Nutrient	Survey Range (%)*
N	3.30 - 4.76
P	0.24 - 0.49
K	1.83 - 2.35
Ca	1.47 - 4.42
Mg	0.40 - 0.81
S	0.17 - 0.26

Nutrient	Survey Range (ppm)*
Fe	100 - 150
Mn	41 - 93
Zn	24 - 52
Cu	5 - 7
B	56 - 105
Mo	0.5 - 1.5

*Bryson, G.M, and H.A. Mills (Eds). 2014. *Plant analysis handbook IV e-edition. A guide to sampling, preparation, analysis, and interpretation for agronomic and horticultural crops*. Athens, GA: Macro-Micro Publishing Inc.

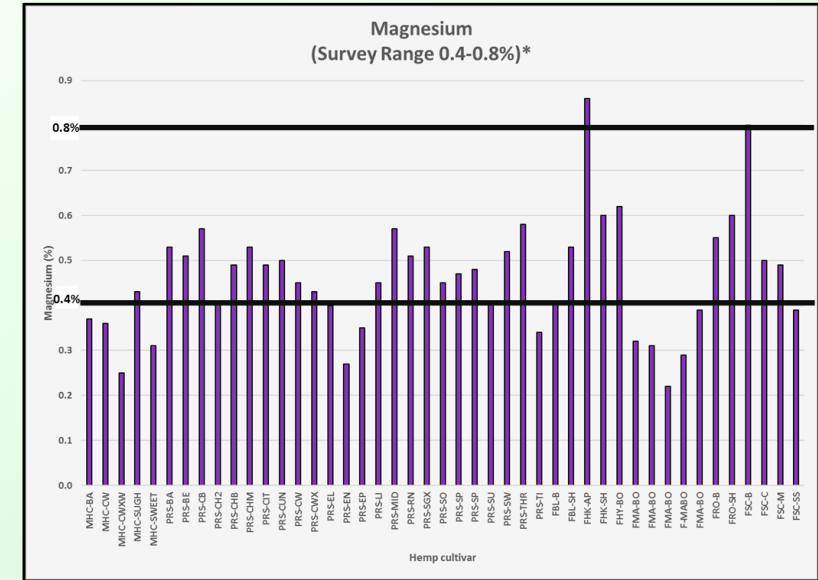
NCDA is conducting a hemp leaf tissue nutrient survey

- **Fine-tune published nutrient survey ranges to cultivars and environments specific to North Carolina**
- **Compare plant tissue nutrient concentration of 29 floral hemp varieties grown over a broad range of locations and fertility management practices**
- **Compare plant tissue nutrient concentrations to the Plant Analysis Handbook IV survey ranges**





Magnesium survey range 0.4-0.8%

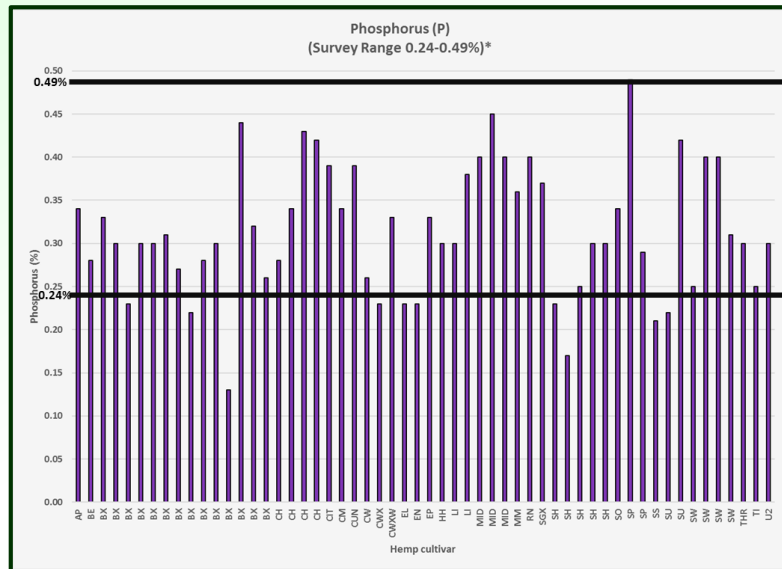


Ranges too high??

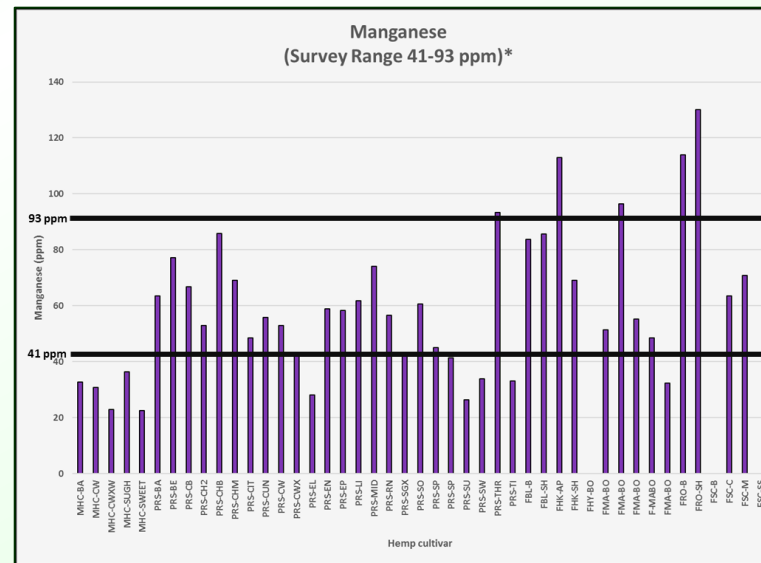


Leaf Tissue Nutrient Survey

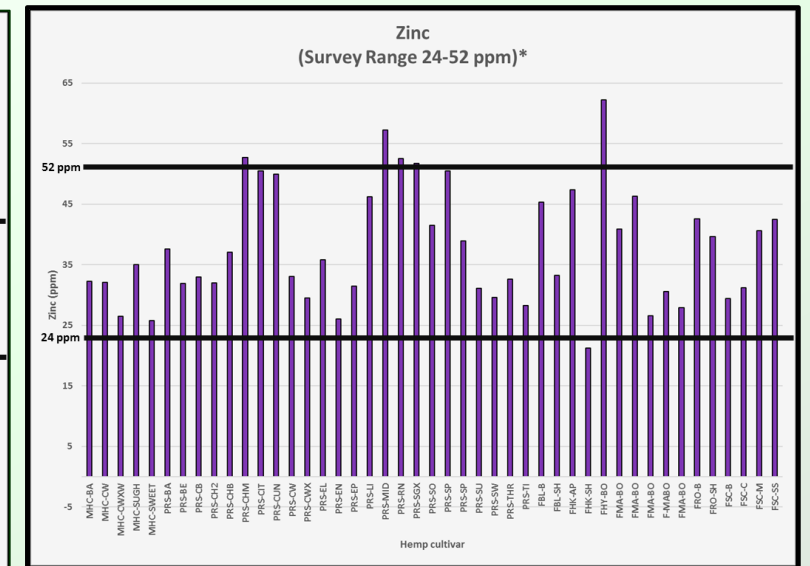
Phosphorus survey range 0.24-0.49%



Manganese survey range 41-93 ppm



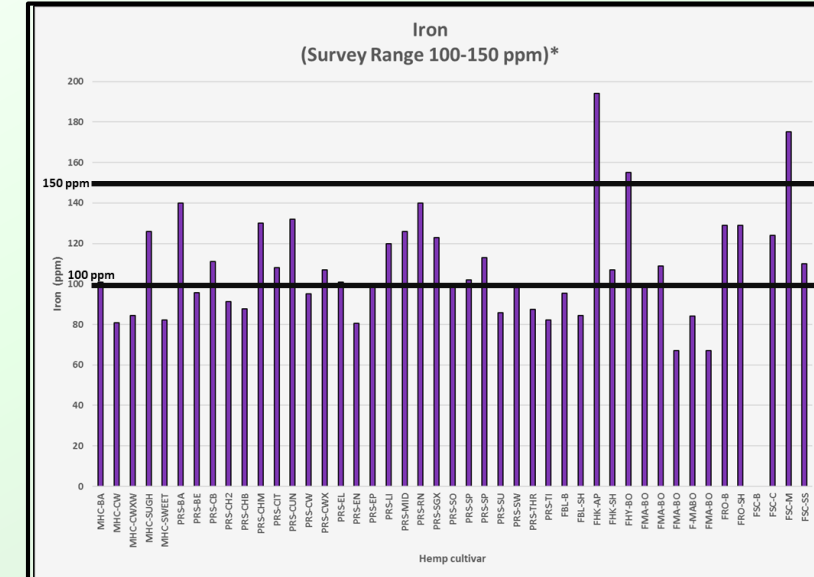
Zinc survey range 24-52 ppm



Ranges reasonable??



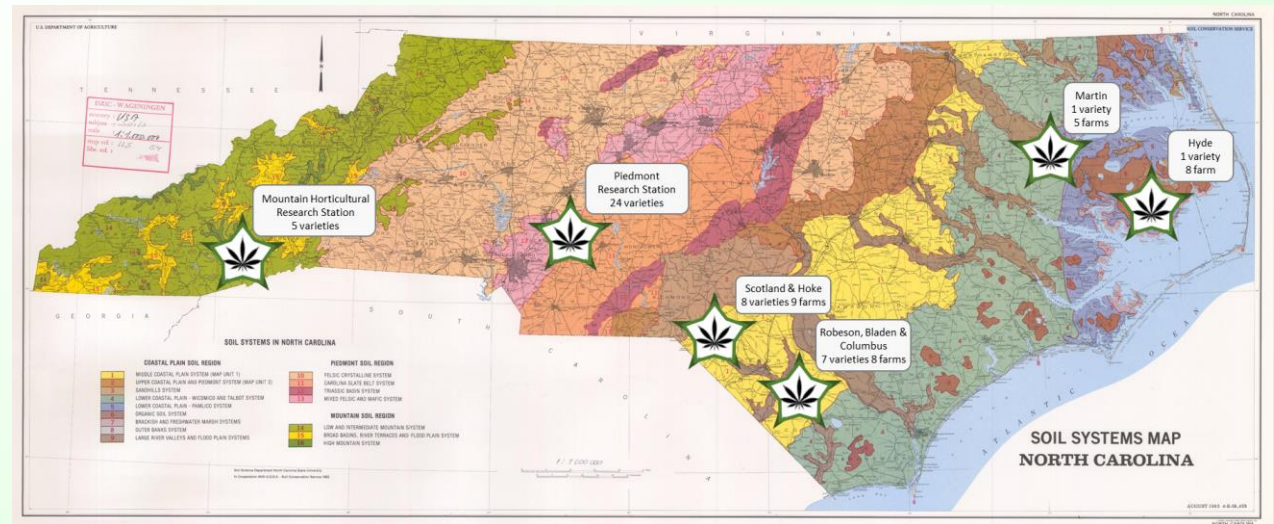
Iron survey range 100-150 ppm



Ranges too narrow??

Plant nutrient survey in 2020

- Expand across the state
- NCSU Extension cultivar trials in the coastal plain as well as piedmont and mountains
- Commerical farms
 - Different varieties
 - Different fertility programs
- Out-of-state samples
 - If interested, contact me
 - Michelle.Mcginnis@ncagr.gov





Other NCSU Resources from Brian Whipker and Whipker Research Team

- Nov 2018. <https://www.cannabisbusinesstimes.com/article/media-matters/>
- Dec 2018. <https://www.cannabisbusinesstimes.com/article/10-building-blocks-to-plant-nutrition/>
- March 2019. <https://www.cannabisbusinesstimes.com/article/new-research-results-optimal-ph-for-cannabis/>
- April 2019. <https://www.cannabisbusinesstimes.com/article/optimizing-electrcal-conductivity-ec/>
- May 2019. <https://www.cannabisbusinesstimes.com/article/yellowing-leaves/>
- June 2019. <https://www.cannabisbusinesstimes.com/article/magnesium-part-of-a-balanced-cannabis-diet/>
- July 2019. <https://www.cannabisbusinesstimes.com/article/upper-leaf-chlorosis/>
- Aug 2019. <https://www.cannabisbusinesstimes.com/article/troubleshoot-nutrient-problems-before-they-occur/>
- Sept 2019. <https://www.cannabisbusinesstimes.com/article/balancing-the-nutrient-equation-cannabis-cultivation/>
- Oct 2019. <https://www.cannabisbusinesstimes.com/article/alkalinity-control-for-container-grown-cannabis/>
- Nov 2019. <https://www.cannabisbusinesstimes.com/article/prevent-solve-nutrition-problems-cannabis-leaf-tissue-analysis/>
- Dec 2019. <https://www.cannabisbusinesstimes.com/article/10-tips-to-identify-cannabis-pests/>
- Cockson, P.; Landis, H.; Smith, T.; Hicks, K.; Whipker, B.E. Characterization of Nutrient Disorders of *Cannabis sativa*. *Appl. Sci.* **2019**, *9*, 4432. <https://www.mdpi.com/2076-3417/9/20/4432>



TAKE HOME MESSAGE

- We have learned a lot in 2018 and 2019
 - NCSU Research
 - Commercial growers
- There is still a lot to learn
 - Variety is the top issue
 - Fertility
 - Optimal N and K rates on yield and cannabinoid
 - Optimal B rate for yield and cannabinoids
 - BMPs for disease and insect prevention and control



Questions?

Michelle McGinnis, Ph.D.
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