Defining and Responding to the Insect Pest Management Needs of a “New” Crop: Industrial Hemp

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Colorado State University
What type of crop is hemp?
Hemp (broad sense)

Cultivars of *Cannabis* with low levels* of psychoactive compounds (THC).

* The magic number is 0.3% by dry weight. Don’t ask why.
There are at least 3 kinds of hemp crops from an Insect Management Perspective

- Hemp grown seed and/or fiber
  - Outdoor culture
- Hemp grown for CBD production
  - Outdoor culture
- Indoor culture of any Cannabis crop
Hemp Grown for Fiber and/or Seed

Produced by seeding

Plant populations are high
Hemp Grown for Fiber and Seed

Crop may be a mixture of separate female and male (dioecious) plants or may include monoecious plants.

Pollination (wind) is needed for seed production.
Hemp flowers may be a very heavily used by many kinds of bees as a pollen source late in the season.

Many species of native solitary bees.
Hemp can provide a major, late summer pollen resource for bees in agricultural areas.
Hemp grown for seed production with pollen producing male plants/flowers – potentially excellent resource for many pollinators

Hemp grown for extractable compounds (e.g. CBD) without male plants – not a potential pollen source
Hemp Grown for CBD/Flowers

Grown primarily for flowers, which are rich in CBD and other desired pharmaceutical compounds.

Desired product are large, unfertilized female flowers.
Historically most hemp grown for CBD has involved use of transplanted clones. With more stable genetics increasingly there is a shift to produce use of plants grown from seed, particularly feminized seed that produces all-female plants.
Hemp Grown for CBD (and other non-psychoactive compounds)

Typically grown by transplants, with early season indoor production

In-field plant populations are low
Hemp Grown for CBD

Plant form is a large, bushy plant that produces numerous flower buds for harvest.
Stages in Developing Insect Pest Management Systems for Industrial Hemp

- Descriptive Stage
- Development Stage
- Implementation Stage
What kinds of arthropods will we find associated with North American hemp in this new era? …and what is their association with the crop?
The only university-derived resources that give any mention of hemp insects in the United States date to the World War II period. The entomology details provided were cursory and appear to have little relevance to the present situation.
This book has very well summarized the information known about hemp pests, worldwide, prior to 2000.

There are very few references from North America sources.
What is a Hemp Insect?
What is a hemp insect?

Zygogramma disrupta – a leaf beetle of ragweed

Argus tortoise beetles pupating on hemp

Physiphora demandata – a commonly seen fly that develops on decaying OM

Western corn rootworm

Diamondback moth
An Unusual Insect Event in Hemp - 2018

A Lace Bug

Gargaphia sp.
A field of young hemp in southeastern Colorado was massively infested by a lace bug in early June. Adults of a *Gargaphia* sp. were found on essentially every plant.
Large numbers of eggs were laid on the plants
Some plant injury was observed on the lower leaves.
What happened?

Nothing. Eggs hatched but no nymphs developed.

A few adults were found on the plants for weeks.

The field as it was being readied for first harvest in September.
Several insects will be associated with ooze from wounds or infections of stems, stalks.

*Physiphora demandata*

*Bumble flower beetle*

*Green June beetle*
Hemp may support a diverse and robust complement of natural enemy species.
The most common lady beetles found in hemp fields are the Convergent lady beetle, the Multicolored Asian lady beetle, and the Sevenspotted lady beetle. *Coleomegilla maculata* is a common species in VA and TN.
Lady Beetle
Larvae
A very common insect in hemp fields and a generalist predator of many insects, including caterpillars.
A robust complex of natural enemies can be expected to be found in hemp when it is grown outdoors (particularly on flowering plants?)
Key Arthropod Pests of Indoor Grown Cannabis

- Hemp russet mite
- Onion thrips
- Twospotted spider mite
- Fungus gnats
- Cannabis aphid
- Rice root aphid
Twospotted spider mite
*Tetranychus urticae*
Broad mite injuries to pepper

Photographs courtesy of Janinine Spies, University of Florida

Broad mite
*Polyphagotarsonemus latus*
Onion Thrips

*Thrips tabaci*

Adult

Nymph

Extensive leaf injury by onion thrips

Leaf injury and nymphs
Darkwinged fungus gnats

*Bradysia* spp.
Rice root aphid
*Rhopalosiphum rufiabdominalis*

Massed aphids in roots of rice.
Photograph by Emily Luna.

Colonizing roots of hydroponically cultured cannabis

Winged forms caught on leaves

Wingless forms at base of plant
Hemp russet mite

_Aculops cannabicola_

Photograph courtesy of Karl Hillig
Cannabis Aphid

*Phorodon cannabis*
This is what I said in Extension programs last winter:

“Pests problems associated with outdoor grown hemp will *likely have little overlap* with those affecting it when the plant is grown in confined conditions. This is largely due to greater effects of natural controls in outdoor settings.”
This is what I had been saying in Extension programs:

“Pests problems associated with outdoor grown hemp will likely have little overlap with those affecting it when the plant is grown in confined conditions. This is largely due to greater effects of natural controls in outdoor settings.”

Two Hemp Pests that Can Occur in High Population on both Indoor and Outdoor Hemp Production

Cannabis aphid

Hemp russet mite

Photograph courtesy of Karl Hillig
Primary herbivore groups associated with outdoor grown hemp

- Associates of foliage
  - Defoliators
  - Sucking insects, mites
- Stem, stalk borers
- Flower/seed feeders
- Root feeders
Defoliators

Foliage associates

Caterpillars

Beetles

Grasshoppers
Various caterpillars chew leaves (and flowers?) of the plant *(defoliators)*

- **Yellowstriped armyworm**
- **Yellow woollybear**
- **Thistle caterpillar**
- **Variegated cutworm**
- **Zebra caterpillar**
- **Beet webworm**
Two late season “woollybear” caterpillars are common.
Leaf Feeding Beetles

Palestriped flea beetle

Western black flea beetle

Southern corn rootworm adult and damage
Japanese beetle?

Photograph by Hunter Konchan

Photograph by Steve Tomlins

Japanese beetle appears to have a decided preference for male flowers.

Likely an insignificant defoliator.
Grasshoppers (at least three species)
Stem feeding seems to cause the most injury by grasshoppers.

Twostriped grasshopper has particularly high damage potential.
Hemp response to hail injury can give some insight on how the crop may respond to grasshopper injuries.
Research questions: What is the relationship between leaf loss (defoliation) and yield? Do plant injuries affect production of important compounds produced by the crop (e.g. THC, CBD)?
Perhaps hail simulation trials can also answer questions about effects of insect defoliators in hemp.
Foliage Associates

Plant Fluid Feeders

Leafhoppers
Aphids
Thrips
Russet Mites

Various “bugs”
The most common fluid feeding insects that occur on the leaves

Plus some treehoppers, planthoppers, spittlebugs, true bugs, thrips

Aphids

Leafhoppers
Most surprising insect associated with the crop?

**Cannabis Aphid**

*Phorodon cannabis*
Hop aphid
Phorodon hamuli

Cannabis aphid
Phorodon cannabis
Cannabis aphid is newly describe from North America – but is very widely distributed in the U.S. and Canada.
Leafhoppers

Insects with sucking mouthparts that feed on leaves

Damage potential of Colorado species to crop: Negligible, at most
Newly identified insect-vectored pathogen of hemp – **beet curly top virus**

Beet curly top virus **is transmitted to plants by the beet leafhopper** (*Neoaliturus tenellus*)

Photograph courtesy of A.C. Magyarosy, Bugwood.org
Could potato leafhopper be a significant pest of hemp?

Potato leafhopper

*Empoasca fabae*

**Hopperburn injuries to potato (above) and maple (below)**

Jim Kalisch, University of Nebraska

David Shetlar, Ohio State University
Hopperburn of hemp
Hemp russet mite
*Aculops cannabicola*

This is most important as a pest of developing flower buds on CBD cultivars.
Stem/Stalk Boring Insects

European corn borer

Eurasian hemp borer

Photograph from the website of the Canadian Hemp Trade Alliance
European corn borer
*Ostrinia nubilalis*

European corn borer was pretty much the only insect mentioned in WWII-era publications.
How important is European corn bore to hemp in the modern era?
An insect that surprised me a lot when found in Colorado

Eurasian hemp borer
*Grapholita delineana*

This is most important to flower buds and developing seeds
Eurasian hemp borer stalk tunneling in hemp in Wisconsin. Photograph by Steve Tomlins.
Adults were found in fields from 5 of the 6 eastern Colorado counties visited in 2018. These constitute a known range extension to the west of 600+ miles. Recent reports of it in Western CO – from human assisted transfers.
Hemipteran seed/flower feeders

Some of these could be important for hemp crops grown for seed.
Several hemipterans ("true bugs") feed on flowers and developing seeds of hemp.

Stink bugs (4 species in Colorado)

Lygus bugs (2-3 species)
Hemipteran seed feeders

Species of interest where there is continuous culture of seed-producing crops?
Seed Feeding Bugs and Hemp

- Feeding concentrated on flowers and developing seed
- Potential damage
  - Aborted seed, damaged seed
- Significant damage??
Potential Pest Management Problem:

If we do have significant seed feeding insect pests on hemp.....

....how can they be managed without harming pollinators?
Chewing Insects that Damage Buds

- Corn earworm
- Eurasian hemp borer
Key Pests Emerging in Colorado Hemp Production

- Corn earworm
- Eurasian hemp borer
- Cannabis aphid
- Hemp russet mite
Cannabis Aphid

*Phorodon cannabis*
Cannabis Aphid

- *Cannabis* spp. are the only plants on which cannabis aphid can feed and develop (we think)
Sexual forms appear in late summer and eggs are laid on plants.

- Egg producing form female mating with winged male
- Winged male
- Egg producing form female with recently laid eggs
How will cannabis aphid survive between seasons in a place with hard freezing winters?

... mostly on indoor crops?
Feral hemp - and volunteers - could sustain significant numbers of cannabis aphid
Cannabis aphids were collected from volunteer hemp sampled in midMay.
Are there alternative crops for cannabis aphid? Is hops aphid a potential pest of cannabis?

Hop aphid
*Phorodon hamuli*

Cannabis aphid
*Phorodon cannabis*
Hemp russet mite

*Aculops cannabicipola*

Photograph courtesy of Karl Hillig
Is an upward leaf curl a symptom of hemp russet mite injury?
Yes – and no. Some cultivars seem to produce an upward leaf curl in response to hemp russet mites. Some do not.

Some genotypes normally produce upward leaf curling in the absence of mites.
Symptoms of hemp russet mite infestation on developing buds of hemp
Minute pirate bugs were the only species regularly observed that could credibly be considered a hemp russet mite predator.

But do they eat russet mites?
How does hemp russet mite survive outdoors through winter?

Mites were observed on a volunteer plant on June 18. The plant was next to the building used to dry the plants of the 2017 crop.

Is there some non-Cannabis living bridge host that allows survival between growing seasons????
Key Questions in Managing Hemp Russet Mite

• How does hemp russet mite survive outdoors between growing seasons?
• What natural controls help regulate populations of hemp russet mite in fields?
• How damaging is hemp russet mite to hemp (economic injury levels studies)?
• What products can be used to help manage hemp russet mite as economic thresholds are approached?
Eurasian Hemp Borer
*Grapholita delineana*
Volunteer hemp examined June 18 were infested with larvae in late stages of development.
Exterior symptom of stalk tunneling – leaf flagging
Late in the season larvae will often move into and destroy flower buds. Developing seed is also reported to be damaged.
The last stage larva changes from cream colored to pinkish, as do some other *Grapholita* species.
Serious damage to buds was observed in fields during 2018 in northeastern Colorado.
Eurasian Hemp Borer – Potential key pest of crop in eastern North America on cultivars grown for seed?

Photograph by Steve Tomlins
Traps containing available lures used to monitor three other *Grapholita* species (oriental fruitworm, cherry fruitworm, lesser appleworm) *failed to capture* *Eurasian hemp moth*.
Adults were found everywhere – in areas with no previous history of hemp....

There *must be* significant non-*Cannabis* host plants that can sustain this insect

Some knotweed (*Polygonum*)? Hops???????
Eurasian hemp borer larvae enter the plant shortly after egg hatch.

Key period of injury is concurrent with heavy visitation by pollinators in the seed crops.

What possible insecticides could manage this type of situation?

Chlorantraniliprole??
Most significant insect pest observed on hemp

Corn earworm  
*Helicoverpa zea*

Found on all types of hemp. Greatest damage potential to CBD forms of hemp.
Corn earworm shows wide range in coloring and patterning on hemp (as with most crops)
Corn earworm tunnels into and can extensively damage developing buds of hemp
At what plant growth stage is hemp attractive (and not attractive) to corn earworm?
Risk factor of corn earworm damage to hemp?

Maturing corn next to flowering hemp
In 2016 and 2018 corn earworm caused serious losses to CBD hemp in southeastern Colorado

One night’s light trap capture, September 8, 2016

Adults of the corn earworm
A fact sheet on Corn Earworm at the Hemp Insect Website

Corn Earworm

The insect that has shown the most potential to damage hemp in Colorado is the corn earworm (Helicoverpa zeae). This is one of the most widespread and commonly damaging insects in much of the United States, affecting both field crops and vegetable crops. Evidence of its importance is indicated by it having three accepted common names: corn earworm (when in corn), tomato fruitworm (when feeding on fruits of peppers, tomatoes, etc.), and bollworm (when feeding on cotton bolls).

In hemp the primary damage occurs when they tunnel into buds and developing seeds. Damage to hemp by corn earworm has potential to cause significant damage, particularly to crops grown for production of large buds to extract CBD or other pharmaceutical compounds. Potential damage to fiber or seed producing cultivars is likely to be minimal. Populations of this insect vary greatly from season to season in Colorado and will usually peak in hemp during late August and/or September.

Parts of Colorado include areas of the northern range of where corn earworm has historically been able to survive through winter (as a pupa in the soil). However, mild winters will allow this insect to persist in those areas. Infestations need to be controlled to prevent potential damage. There are a number of techniques available to control this insect.
Proposed Management Plan for Corn Earworm in Hemp

Background. Corn earworm (Helicoverpa zea) is a key pest of hemp grown in Colorado. Damage is caused by the larva (caterpillar) that tunnels through and destroys maturing buds. This insect is present every growing season in Colorado, where it may be found on a wide variety of crops and weed hosts. However, population size, and associated damage, can vary greatly from season to season and by location.

Traps (light, pheromone) can be used to capture the adult stage of this insect, a night flying moth. When used over a period of time these traps can provide information on in changes in abundance of the insect, with high trap captures being associated periods of peak egg laying on plants.

The insecticides that have the most potential to control corn earworm - and are allowable by the Colorado Department of Agriculture for use on cannabis crops – are certain strains of the microbial insecticide Bacillus thuringiensis (Bt). These are best applied at times coinciding with periods of peak egg laying by the adult moths and subsequent egg hatch, which occurs a couple of days after eggs are laid.

Use of Traps for Monitoring Corn Earworm

Two types of traps can be used to capture the night flying moths of the corn earworm, light traps or pheromone traps.

Basic design of a light trap uses a light, preferably UV, to attract insects that fly at night. The insects then hit a vane and are funneled into a collecting container below. Usually a killing agent (often a dichlorvos Pest-Strip) is placed in the collecting container to minimize damage to the collected insects, particularly damage to the delicate wings of moths, which may be torn by “June bugs” and other other active insects that come to these traps.

Light traps will capture a wide variety of insects, mostly various kinds of moths and beetles. Traps placed in crop fields, hedges or groves, may be used to monitor the number of insects that are of interest to this program.
Pheromone trap used to monitor corn earworm
Outline of Corn Earworm Management Program in Hemp

• Establish a program to monitor flights of adult corn earworms using pheromone traps
  – This should begin by midsummer to establish baseline of adult captures
  – Traps should be checked twice a week and the number of new moths recorded
Outline of Corn Earworm Management Program in Hemp

• If very high numbers of moths are discovered during flowering, treatment should be considered
  – *Bacillus thuringiensis var. aizawi*
    • Agree WG, XenTari Biological Insecticide
  – *Helicoverpa NPV*
    • *HelicoVex*
Colorado allowed insecticides that can be used to control corn earworm in hemp.

**Bacillus thuringiensis** *(aizawi strain)*

**Helicoverpa Nuclear Polyhedrosis Virus**
Pollinator use may complicate controls if there are insects that are pests of the crop during flowering.

Fortunately, the *Bacillus thuringiensis* (Bt) and HelicoVex products used for corn earworm are compatible with pollinators.
2018 Corn Earworm Monitoring Program

- Traps were provided to 7 growers (8 counties)
- In two sites (SE Colorado) high trap captures were noted in September
- At least 3 growers treated for corn earworm in 2018
The Pesticide Conundrum with Cannabis

• All registered pesticides *can only be legally applied* to sites (e.g., crops) consistent with label directions

• Presently the agency overseeing pesticide labeling (EPA) does not recognize cannabis as a crop site

*Are there pesticides that can be used on this crop now?*
State Responses to the Issue of Pesticide Use on Hemp (and other Cannabis spp. crops)

- Ignore the issue/Provide no guidance
- Allow no registered pesticides
- Provide vague guidelines of some kinds of registered pesticide products that might be allowable
- Provide a list of specific allowable products ("State Finesse")
2013 Washington State Finesse on the Subject of Pesticide Use on Cannabis

• Pesticides that require federal registration under Section 3 of FIFRA
  – Active ingredient is exempt from the requirements of food crop tolerance, and
  – Label has directions for use on unspecified food crops, including unspecified food crops grown as bedding plants
  – EPA and WSDA registration is required

• Section 25b minimum risk pesticides (exempt from federal registration)
This system provides a state-generated list of specific products that are allowed for use in production of Cannabis spp. crops in the state.
Criteria for Pesticides Allowed to be Used on Cannabis in Colorado

- Pesticides that require federal registration under Section 3 of FIFRA
  - Active ingredient is exempt from the requirements of food crop tolerance, and
  - Label has directions for use on unspecified food crops, including unspecified food crops grown as bedding plants
  - EPA and CDA registration is required
  - Pesticide is registered on tobacco

- Section 25b minimum risk pesticides (exempt from most federal registration)
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- **Section 25b minimum risk pesticides (exempt from most federal registration)**
Example of pesticide label with a very broadly described Crop Site

Labels written in this manner can be interpreted as allowing use on hemp

<table>
<thead>
<tr>
<th>CROPS (including but not limited to)</th>
<th>APPLICATION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes, lettuce, cucumbers, peppers, sweet corn, broccoli, cauliflower, cabbage; peas, beans, beets, celery, onions, garlic, leek, asparagus, okra, eggplant strawberries, grapes, escarole ornementals and flowers</td>
<td>Rate: 1.0 – 2.5 fl. oz. per acre</td>
<td>Repeat application as above every 6 – 8 sunny days (counting 2 partially sunny days as 1 sunny day) if monitoring indicates that reapplication is necessary. Lower rates (every 6 sunny days) may be used during vegetative stages of the crop or when tank mixed with other insecticides. When flowers, fruits or other harvested structures of the plant are present or when infestation becomes strong, use the higher rates. Sweet corn and corn: For very sunny regions (e.g., California), use 0.5 to 1.25 fl. oz./acre every 3 days; for less sunny regions, use 1 to 2.5 fl. oz./acre every 6 to 8 days. Cover the whole larval hatching period of the treated generation until harvest.</td>
</tr>
<tr>
<td>Cotton, alfalfa, soybeans, peanuts, potatoes, corn, wheat, sweet potatoes, tobacco, sunflowers, sugar beets, sorghum, floriculture, and border plants</td>
<td>Method: Sprayer, Aircraft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment: Sprayer, Sprinkler Irrigation, Mist Sprayer</td>
<td></td>
</tr>
</tbody>
</table>
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- **Section 25b minimum risk pesticides (exempt from most federal registration)**
Criteria for Pesticides Allowed to be Used on Cannabis in Colorado

• Pesticides that require federal registration under Section 3 of FIFRA
• Section 25b minimum risk pesticides with food crop uses (exempt from most federal registration)
  – Must be registered with the state

Mostly sodium lauryl sulfate and soybean oil

Mostly geraniol

Rosemary oil

New miticide to add to your tool-box!
• Contact miticide that kills and repels two-spotted spider mites
• Covers the most common oil blights
In Colorado, the Colorado Department of Agriculture maintains a website of pesticides that may be applied to hemp grown within the state. Similar lists are produced by Washington, Oregon, Arizona, and Nevada.
Website page to access what Colorado Department of Agriculture considers to be *not allowable (= allowable)* for use on Cannabis in Colorado.

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Pesticides Allowed for Use on Cannabis

Each time we update the Cannabis pesticides list or have industry news we will send out an email blast and you can sign up here to be included. As of March 30, 2016 all past lists will be removed from the CDA website and updates will be made only to the list of approved pesticides that may be used in accordance with Pesticide Applicators’ Act Rule - Part 17.

The list developed by CDA is intended to assist Colorado Cannabis growers in identifying which pesticides can be used legally in accordance with the Pesticide Applicators’ Act and its Rules in the production of Cannabis (marijuana and industrial hemp). It is not an endorsement or recommendation to use these products in the production of Cannabis in Colorado. These products have not been tested to determine their health effects if used on Cannabis that will be consumed and thus the health risks to consumers is unknown. By including products on this list, therefore, CDA make no assurances of their safety or effectiveness when used on Cannabis and is not responsible or liable for any such use.

To view or download the current list, click the link below:

- Pesticides allowed for use in Cannabis production in accordance with the PAA Rule: Effective June 29th, 2016
  - PDF
  - Excel

- This link provides a list of products that have been removed from the list of pesticides that may be used on Cannabis. These products were either removed from the list prior to the effective date of the rule or were removed as a result of them not meeting the rule criteria as of March 30th, 2016.
  - Excel

- Selected Examples of pesticides that cannot be used in marijuana production January 13 2016
  - PDF

Products added since the last update are now highlighted in red on the PDF version of the file. The Excel version has the date that each product was added and can be sorted or filtered by name, date, active ingredient, etc.
A page listing the current products that are allowed for use on all Cannabis (including hemp) grown in Colorado

Most all of the CDA allowable pesticides are also allowed in production of Certified Organic crops
Phases of Pesticide Use Regulation in Cannabis Production

• Phase I - “Wild West” Phase
• Phase II - State Finesse Phase
• Phase III - Normalization Phase
  – Cannabis is federally recognized as a crop
  – Cannabis is regulated as a normal crop
When hemp “grows up” as a crop, addressed by federal laws and regulations as are all other crops - how will the pesticides issues work out?

It will very likely vary by the type of hemp crop, and end use
For seeds, perhaps this would be considered under Crop Group 20 (Oilseeds, such as sunflower, cotton seed and canola/rape seed)

*For a strictly fiber grown crop?*
Hemp Grown for CBD

This poses some more serious registration problems
This poses some obvious registration problems.

This produces an extracted product that is consumed by humans, and in different manners (e.g., ingested, inhaled)
Hemp Grown for CBD

This poses some obvious registration problems.

This produces a product that is applied to humans, and in different manners.

Extraction methods used will affect potential for residues, and these must be studied.
You may wish to check out the **Colorado Hemp Insect Website** for periodic updates on this subject.

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**Insect Management Considerations in Hemp Production**

The Hemp Insect Website is designed to provide hemp producers a way to recognize and to better understand the insects, mites, and other “bugs” that are present when this crop is grown in North America.

The goals of the Hemp Insect Website are to:

1. Provide description of all insects and mites observed in production of hemp;
2. Provide information on the habits of all insects that are associated with hemp production.

At present the Hemp Insect Website does give particular attention to insects and mites that are present within the High Plains/Rocky Mountain area of the western United States. This is because, to date, the most extensive surveys of hemp insects have occurred in this region, mostly in Colorado from 2015 to the present. However, the goal of this website is to provide progressively more comprehensive treatment of insects associated with hemp production throughout North America. Submission of photos and inquiries about insects observed on hemp is encouraged from anywhere and the website should expand as the field of hemp insect pest management develops in the United States and Canada.

**Note:** This website is limited to insect issues involving hemp, defined as *Cannabis* grown for seed, fiber, or non-THC pharmaceutical products. *This is not a forum for marijuana Industrial hemp is not medical marijuana.*
Questions?