Agricultural Research Service

USDA

Updates on National Action Plan Infection Prevention and Goals 1 – 5

PACCARB
September 13-14, 2017, Washington, D.C.
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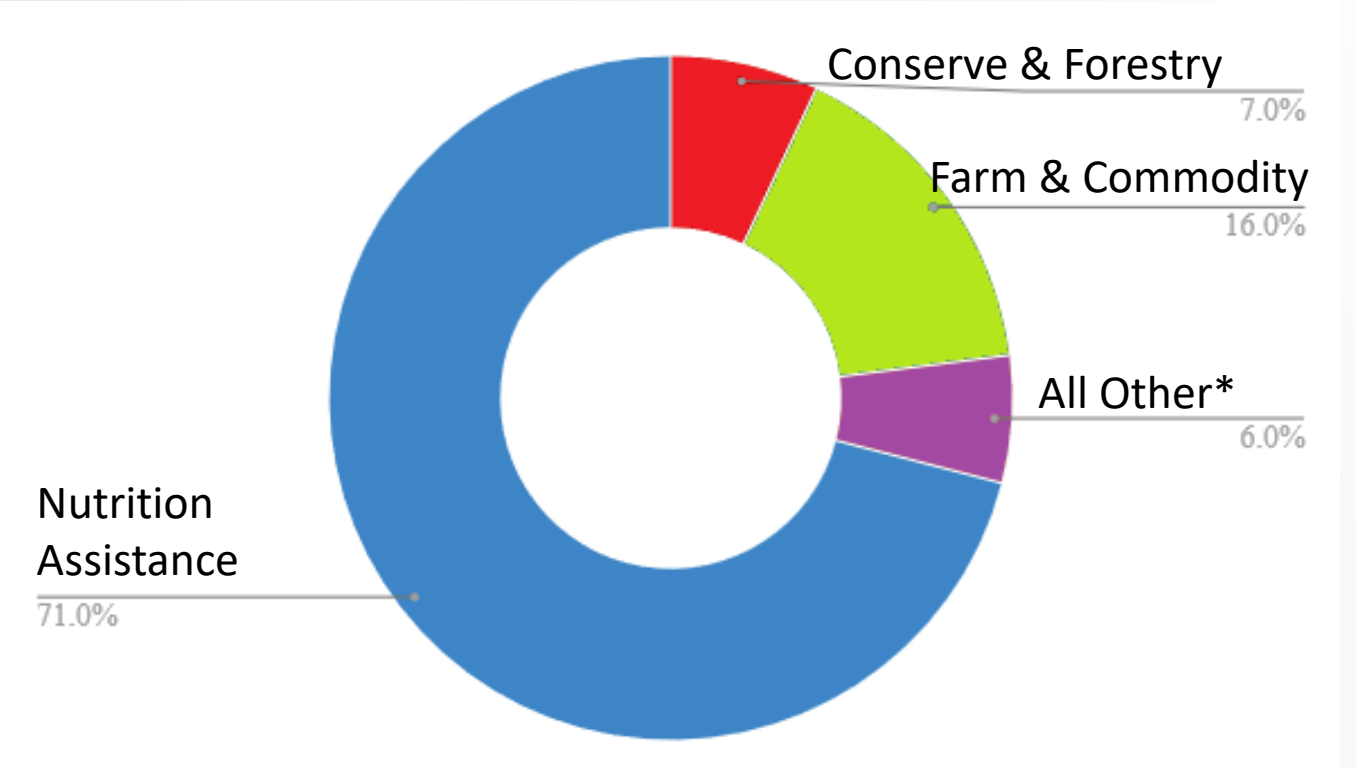
ARS is the intramural research arm of USDA

USDA 2017 Outlays

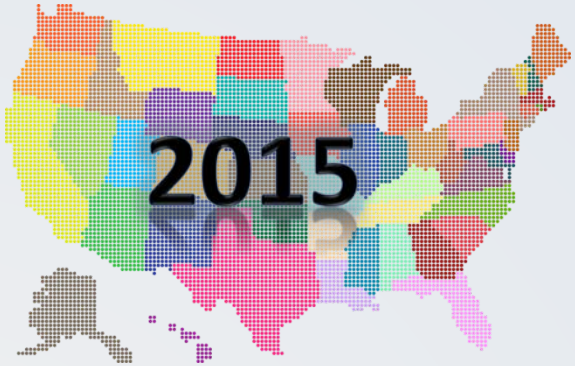


*Includes Rural Development, Research, Food Safety, Marketing and Regulatory, and Departmental Management

ARS FY 2017 AMR estimate is $13M

ARS Locations

23,000 deaths/yr



$55 Billion health system costs & lost productivity

2013 CDC Threat Report

10 million deaths/yr

$100 trillion lost global production

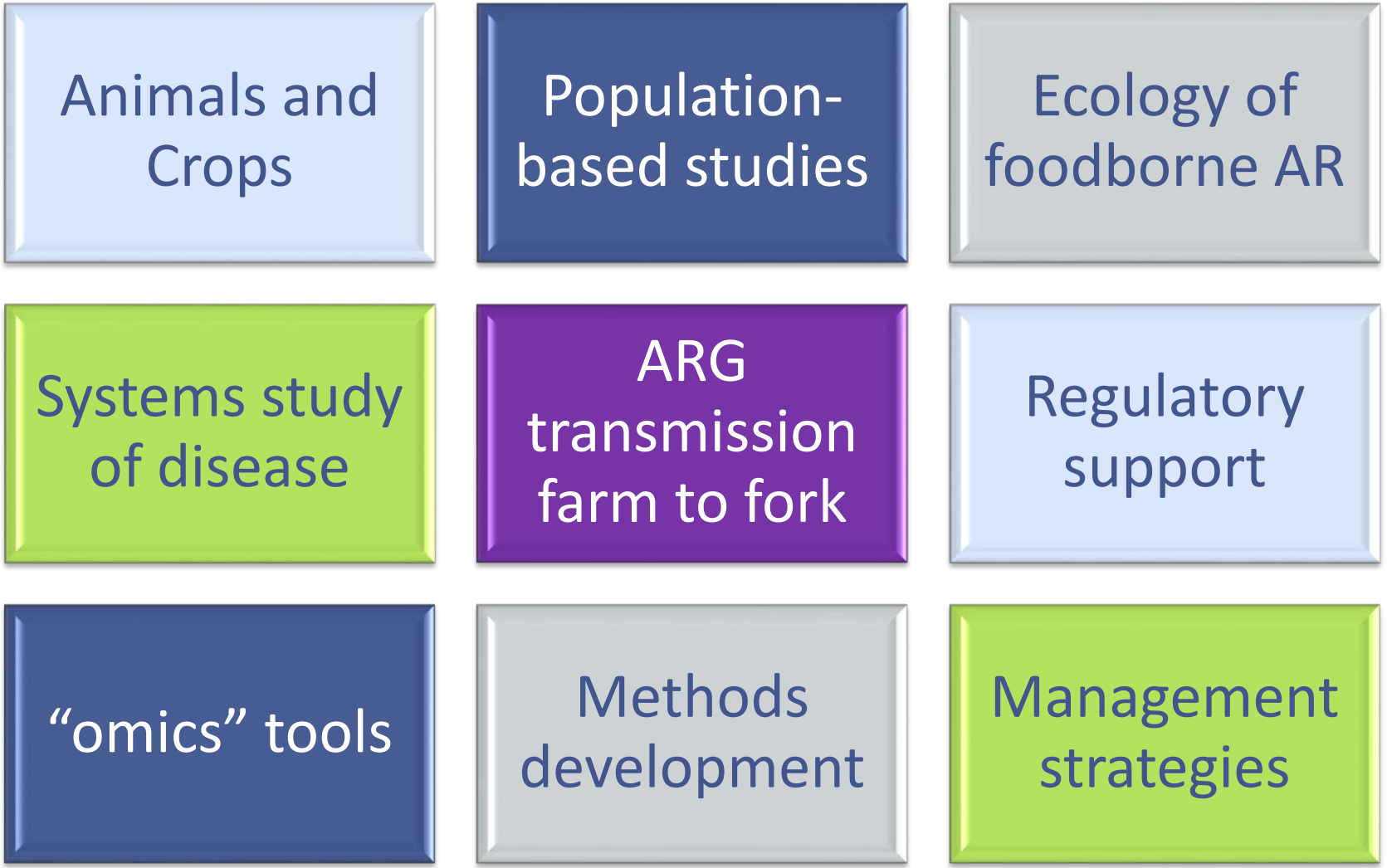
2014 O'Neill Review on AMR

CARB Report Goals

ARS Research addresses CARB Goals

1. Slow the Emergence of Resistant Bacteria and Prevent the Spread of Resistant Infections.

ARS AR Research



Examples of ARS AR research

- **Dairy cattle studies**
  - Found high levels of generic *E. coli* and *Salmonella* (Foodborne pathogen) in manure
    - Small percentage AMR positive– most pan-susceptible
    - Young calves tended to have higher levels of AMR than older cows-still investigating
  - Studies are being done by Dr. Jo Ann Van Kessel and Bradd Haley, BARC, MD

Examples of ARS AR research

- **Manure Management**
  - Development and implementation of woodchip bioreactors, reduce transport of tested antibiotic drugs 70-80%
  - Hydrothermal carbonization eliminates 100% of antibiotic resistant bacteria and their genes.
  - Studies done by Dr. Tom Moorman in IA and Dr. Thomas Ducey in SC.

Examples of ARS AR research

- **Crops and fruits**
  - Biological control of the bacterial disease fire blight of pear and apple
  - Evaluating uptake of antibiotics from irrigation water in lettuce

  - Studies done by Dr. Virginia Stockwell in OR and Dr. Clinton Williams in AZ

ARS Research addresses CARB Goals

2. Strengthen National One-Health Surveillance efforts to Combat Resistance.

ARS Provides Research Support

NARMS

National Antimicrobial Resistance Monitoring System

Food and Drug Administration • Centers for Disease Control and Prevention • United States Department of Agriculture

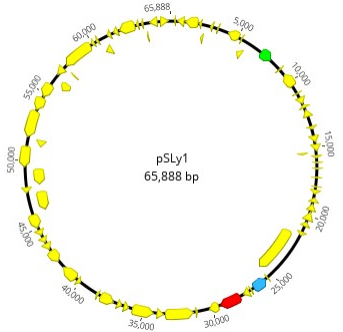
FDA CDC USDA

Example of ARS AR Research Support

ARS screened hundreds of NARMS isolates for the colistin resistance gene mcr-1

88 Turkeys
395 cattle
167 Chickens
395 Swine

- Colistin (a.k.a. polymyxin E) is effective against Gram-negative bacteria but is toxic in humans, so is held in reserve.
- Colistin is <u>not</u> used in animals for human consumption in the US, but is used in China and parts of Europe.
- mcr-1 gene (red) found on plasmid from swine isolate.



ARS Research addresses CARB Goals

3. Advance Development and Use of Rapid and Innovative Diagnostic Tests for Identification and Characterization of Resistant Bacteria.

Sequence-based AMR Detection < $2/Sample

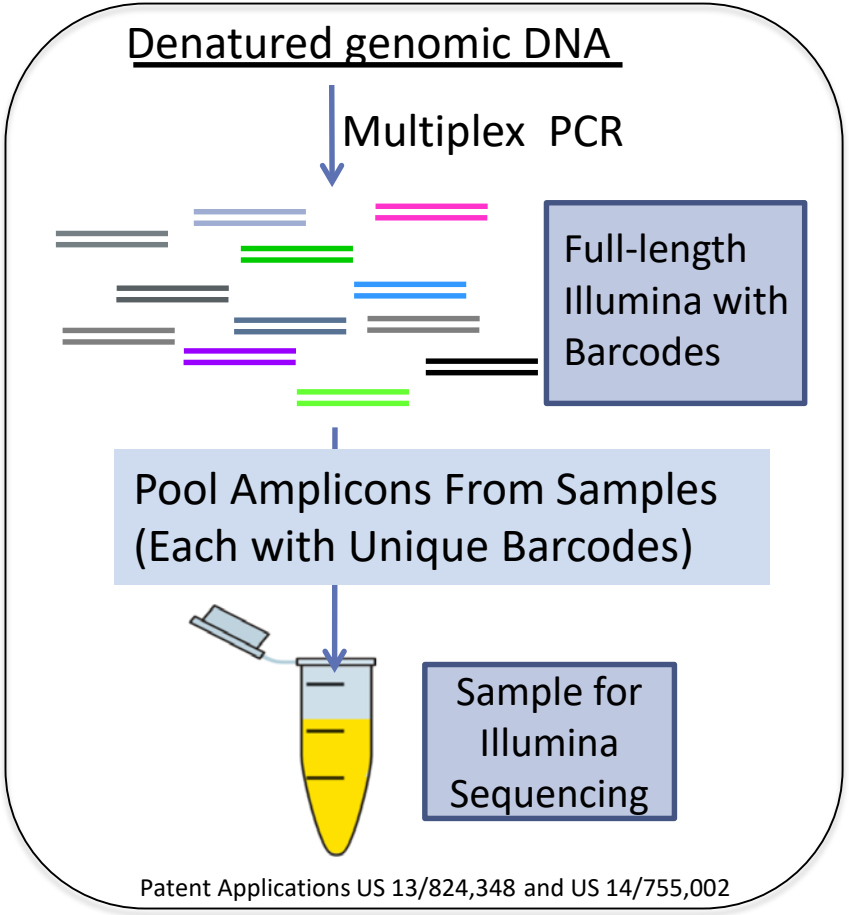
Multi-gene ID

Pipeline for sample ID, gene ID, and determining gene relatedness

Ability to mix-and-match genes of interest

Apply to different samples

Rapid, affordable assay



- Studies led by Dr. Jim Wells, and Dr. Amanda Lindholm-Perry, NE

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Impact of spatiotemporal, environmental, and wildlife factors on AR and pathogens at watershed scale (34,000 acres)

Migratory waterfowl and other wildlife

Pest flies and mosquitoes

Soil, water, feces

Studies led by Dr. Elaine Berry, NE

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ARS Research addresses CARB Goals

4. Accelerate Basic and Applied Research and Development for New Antibiotics, Other Therapeutics, and Vaccines.

ARS ATA Research

Vaccines

Brockmeier
Vaccine platforms in swine

Jenkins
Coccidiosis in chicken

Swayne/Afonso
Avian influenza/ Newcastle vaccine for poultry

Microbial Products

Anderson
Phage to reduce Salmonella in cattle

Carroll
Yeast to reduce impacts of Bovine resp disease & liver abscess in cattle

Phyto-chemicals

Donoghue
Plant products to reduce Salmonella & Campy in poultry

Welker
Pre-biotic Chinese tea additive for disease resist. & growth in farmed fish.

Immune-derived products

Lillehoj
CD molecules and cytokines to control disease in poultry

Lunney
Cytokines to improve swine health

Chemicals, enzymes

Dungan
Copper footbaths in dairies

Aksoy
Chitosan to control disease in fish

Anderson
Sodium chlorate to improve livestock food safety

4.1 Conduct research to enhance understanding of environmental factors

Resistance is closely linked to *Infectious Disease*

Resistance = RESIDUES BACTERIA GENES

Examples of ARS AR research

- **Swine**
  - Microbial ecology, pathogens and antibiotic resistance in three swine management systems
    - Sow, Nursery, and Finisher Farm manure
    - *tet*, *erm*, and intI genes in all systems
    - Finisher farms were significantly different
    - Management affects antibiotic resistance
  - Studies were done by Dr. John Brooks in MS

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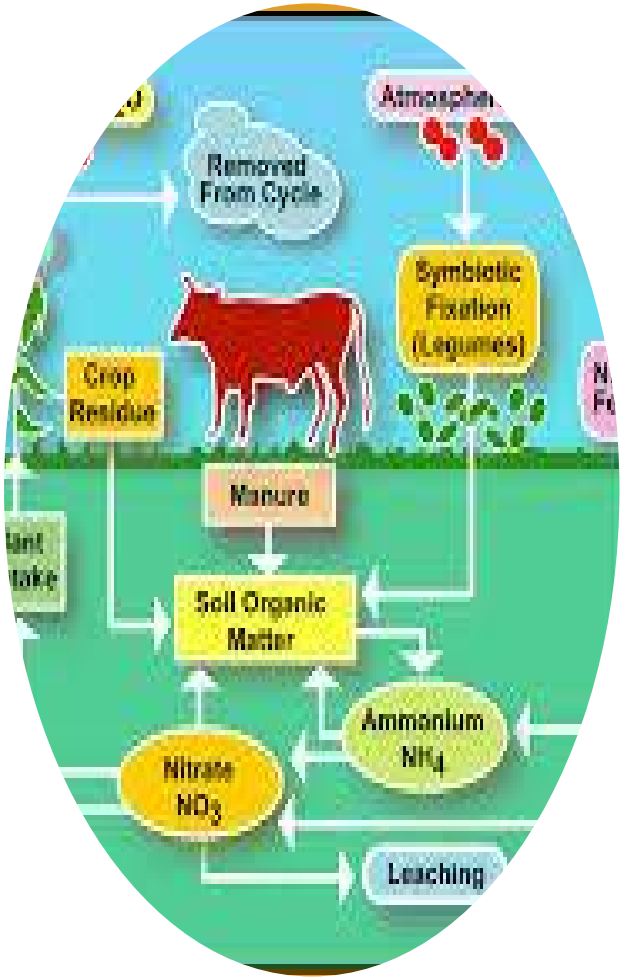
Examples of ARS AR research

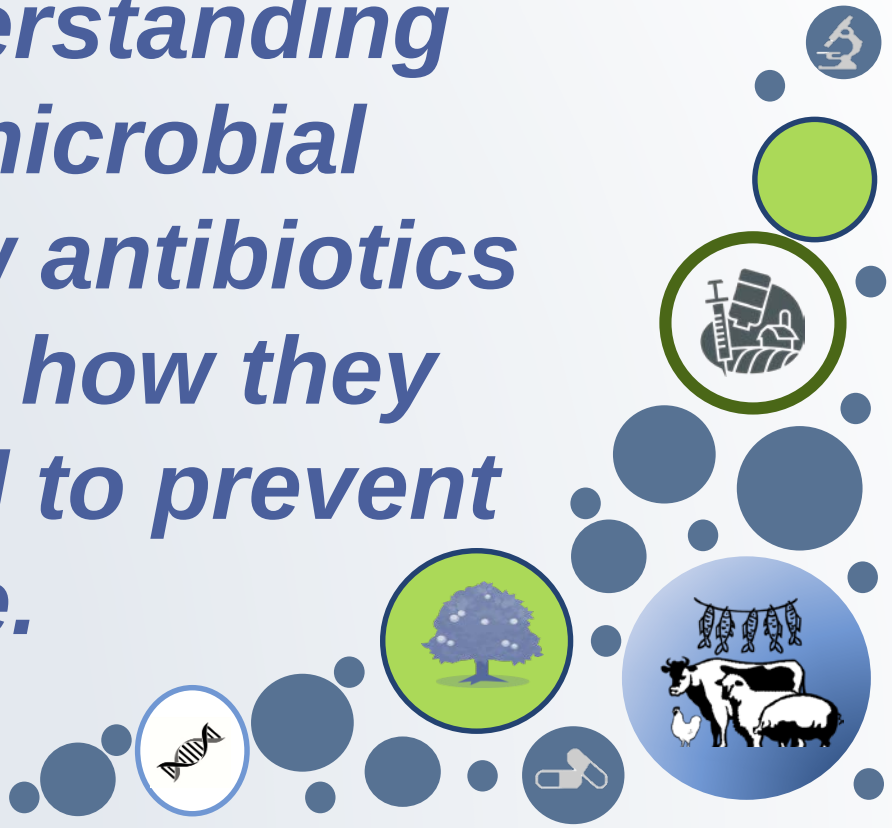
- Measuring impacts of manure-borne antibiotic drugs on bacterial nutrient cycling (nitrogen, carbon)
  - Role of different soil types on transport of drugs and persistence of antibiotic resistance genes.

- Studies performed by Dr. Daniel Miller in NE



Dan.Miller@ars.usda.gov

4.2 Increase research focused on understanding the nature of microbial communities, how antibiotics affect them, and how they can be harnessed to prevent disease.



Probing ecology of AMR in soil

Image: A. Kelley, USDA Natural Resources Conservation Service

Measuring antibiotic resistance in ungrazed prairie soils, Nebraska

Characterizing “baseline” resistance in soils

Researchers can use innovations and new technologies—including whole genome sequencing, metagenomics, and bioinformatic approaches—to develop next-generation tools to strengthen human and animal health,

NAP for CARB page 5

Comparing resistance across ecosystems

Antarctic **28%**

Cattle **45%**

Sargasso Sea **24%**

46% **52%** **48%**

Humans

Chicken **63%**

Soil **45%**

Tracking ARGs through animals and farms

Which bacteria from beef cattle feces are most likely to be carrying antibiotic resistance genes?

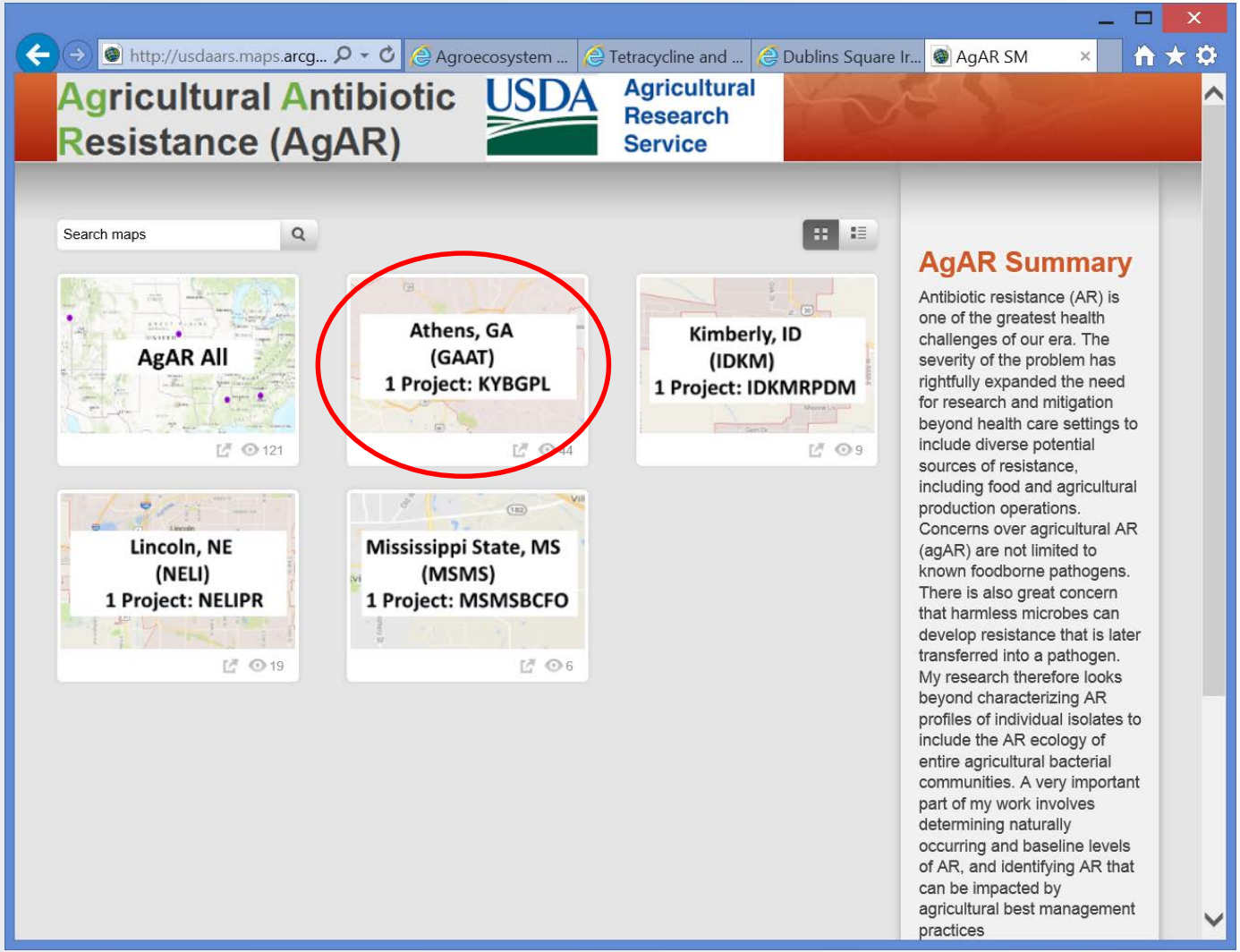
Bacteroides sp. (43%)
Clostridium sp. (15%)

ARS Research addresses CARB Goals

5. Improve International Collaboration and Capacities for Antibiotic-resistance Prevention, Surveillance, Control, and Antibiotic Research and Development.

New efforts to share ARS data

ARS AgAR Database online soon



ARS AgAR Database online soon

Athens, Georgia

USDA-ARS

Description | Methods | Experimental Design | Query

Cook Experimental Design JEQ 43:1546-1558

https://dl.sciencesocieties.org/publications/jeq/abstracts/43/5/1546

Rep 1 | Rep 2 | Rep 3 | Rep 4

Rep 1 | Rep 2 | Rep 3 | Rep 4

Rep 1 | Rep 2 | Rep 3 | Rep 4

Rep 1 | Rep 2 | Rep 3 | Rep 4

6 m

3 m

Randomized complete block design

Three cores were collected at each time point for each plot and combined for 1 soil analysis per plot per time point

Year 1 Sample Collection (d post litter app)

D0, D1, D2 D4
D7, D15, D21
D35, D42, D57
D84, D148

Year 2 Sample Collection (d post litter app)

D0, D1, D2 D4
D7, D15, D21
D35, D42, D57

Green plots = tilled using conventional rotary tiller (CT)

Blue plots = no till (NT)

Soil

Transported to laboratory on ice

Homogenized

E. Coli and Enterococci Counts

Bulk soil DNA isolation

Campy, Listeria, Salmonella enrichment

qPCR for Enterococcus, Bacteroides, Clostridia, E. coli, C. Jejuni, Salmonella.

qPCR for ARGs tet(W), sull, strpB

Nutrient Analysis was conducted before application.

Agricultural Research Service AgAR Network

Antibiotic Drugs ● Resistant Bacteria ● Resistance Genes

Agricultural Antibiotic Resistance

An Environmental Component of a "One Health" approach

Long term goal: Provide data that reveals the details of how, and at what rate bacteria and genes move back and forth between animals and humans through agricultural systems (soil, water, air, wildlife, insects, and food).

Connecting scientists, providing results

Epidemiology

Tracking drugs, bacteria, and genes while determining baseline levels so that the impact of agricultural best management practices can be accurately evaluated. How long do specific types of genes persist in agricultural samples? What conditions increase or decrease the likelihood of a successful transfer in manure, soil, and water?

Manure Management

Manure is how the drugs, bacteria, and genes from animals first enter the environment. It links the animals with soil, water, air, and food.

Remediation

How effective are current manure management practices at reducing or eliminating resistant bacteria and their genes? Can we identify environmental critical control points? What new procedures can we develop to remediate resistance on the farm and in the environment?

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