Introduction

- Incorporating cattle into cover crops quicker economic return on investment in seed (Franzluebbers et al., 2007; Drewnoski et al., 2018)
- Selecting plant species difficult with all the options
- Operations have specific goals
  - No one-size fits all plans
Integrated Crop-Livestock Systems

• “Encourage sustainable farming and generate positive interactions between crops and livestock with environmental and economic benefits” Allen et al., 2007

• Benefits:
  • Reduce risk of raising single product
  • Increase water infiltration
  • Resist soil erosion
  • Build soil organic carbon
  • Manure from livestock increases within-farm nutrient cycling = less synthetic fertilizers

Summarized by Maughan, 2009

Issues with cattle grazing crops

• Compaction??
• Water
• Fencing
• Toxicities
Why integration of cattle and covers on operations

### Cattle Performance

<table>
<thead>
<tr>
<th>Measure</th>
<th>Tillage¹</th>
<th>Winter CC²</th>
<th>Summer CC²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calf daily gain (lb/hd/d)</td>
<td>CT</td>
<td>4.61</td>
<td>1.81*</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>5.00</td>
<td>2.05*</td>
</tr>
<tr>
<td>Cow daily gain (lb/hd/d)</td>
<td>CT</td>
<td>0.55</td>
<td>2.00</td>
</tr>
<tr>
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<td>NT</td>
<td>2.98</td>
<td>2.16</td>
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<tr>
<td>Cow/calf pair daily gain (lb/hd/d)</td>
<td>CT</td>
<td>3.17*</td>
<td>3.22</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>4.32*</td>
<td>3.64</td>
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<tr>
<td>Calf gain (lb/a)</td>
<td>CT</td>
<td>157*</td>
<td>206</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>213*</td>
<td>230</td>
</tr>
<tr>
<td>Cow gain (lb/a)</td>
<td>CT</td>
<td>38*</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>149*</td>
<td>77</td>
</tr>
<tr>
<td>Cow/calf pair gain (lb/a)</td>
<td>CT</td>
<td>182*</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>312*</td>
<td>289</td>
</tr>
</tbody>
</table>

¹ CT = conventional till and NT = no-till  
² Summer grain (Sorghum 2002-2004) or corn (2005) and winter cover crop (Rye)  
³ Winter grain (Wheat) and summer cover crop (pearl millet)  
* Indicates difference in tillage treatment
## Economics - $/acre

<table>
<thead>
<tr>
<th>System</th>
<th>Tillage</th>
<th>Grazing</th>
<th>Total Cost</th>
<th>Crop Value</th>
<th>Calf gain value</th>
<th>Total crop and calf value</th>
<th>Net return over variable costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum (corn) + rye</td>
<td>CT</td>
<td>Ungrazed</td>
<td>159.62</td>
<td>122.13</td>
<td>0.00</td>
<td>122.13</td>
<td>-37.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>160.00</td>
<td>131.75</td>
<td>117.57</td>
<td>249.32</td>
<td>89.32</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>Ungrazed</td>
<td>160.59</td>
<td>153.13</td>
<td>0.00</td>
<td>153.13</td>
<td>-7.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>159.16</td>
<td>117.50</td>
<td>159.66</td>
<td>277.16</td>
<td>118.00</td>
</tr>
<tr>
<td>Wheat + pearl millet</td>
<td>CT</td>
<td>Ungrazed</td>
<td>122.96</td>
<td>100.17</td>
<td>0.00</td>
<td>100.17</td>
<td>-22.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>118.58</td>
<td>103.25</td>
<td>154.31</td>
<td>257.56</td>
<td>138.98</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>Ungrazed</td>
<td>129.71</td>
<td>95.50</td>
<td>0.00</td>
<td>95.50</td>
<td>-34.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grazed</td>
<td>127.75</td>
<td>97.83</td>
<td>172.35</td>
<td>270.18</td>
<td>142.43</td>
</tr>
</tbody>
</table>

No cost associated for fence in this analysis

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## K-State 1 yr Study

- Lyndon, KS
- Fescue versus cocktail cover crop
  - Hay, mineral, corn/distillers supplement
  - Fescue – 8 lbs/hd/d and Cocktail 5 lb/hd/d
- Wheat – cover crop – soybean
- Turn out Nov. 18 remove Feb. 10
- Shrank body weight on an off pasture
Raw Results

<table>
<thead>
<tr>
<th>Item</th>
<th>Fescue</th>
<th>Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. head</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Initial weight</td>
<td>457</td>
<td>460</td>
</tr>
<tr>
<td>Final weight</td>
<td>602</td>
<td>626</td>
</tr>
<tr>
<td>Total gain</td>
<td>145</td>
<td>166</td>
</tr>
<tr>
<td>Average daily gain</td>
<td>1.63</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Cattle Economics

**Fescue**
- Supplement: $0.72/hd/d
- Fescue rental: $0.75/hd/d
- Hay/mineral: $19.88/hd

**Feeding cost:** $140.42/hd
- Sale wt: 602 pounds
- Sale value: $878.92

$35.26 lower cost in covers
$35.04 more in sale value
$70.30/hd advantage to the covers

**Covers**
- Supplement: $0.43/hd/d
- CC cost: $0.61/hd/d
- Hay/mineral: $19.88/hd

**Feeding cost:** $105.16/hd
- Sale wt: 626 pounds
- Sale value cattle: $913.96
What do we know about covers as an annual forage?

Type and common cool season annuals

Fall/Winter
- Grasses
  - Rye, barley, oat, triticale, wheat, rye, ryegrass
- Broadleafs
  - Brassicas, buckwheat
- Legumes
  - Winter pea, clovers

Summer
- Grasses
  - Sorghums, sudans, millets, corn, teff
- Broadleafs
  - Sunflowers, buckwheat
- Legumes
  - Sunn hemp, forage soybeans
What do we plant?

- Perennial systems diversity is the best (Gunter et al., 2012; Gadberry et al., 2015; Keyser et al., 2016)
  - Bermuda/bahiagrass pastures addition of wheat+ryegrass, wheat+ryegrass+red clover, wheat+ryegrass+white clover+crimson clover
  - Calf weaning weight greater – cow effects no difference
- Legumes in meadow or tall fescue cattle gains improved (Schaefer et al., 2014)
- In an already diverse perennial pasture – addition of 3, 5, or 8 additional plant species did not affect cattle performance (Tracy and Faulkner, 2006)

What do we plant?

- Annual forages – few head to head between grass only and mixture
- Florida study addition of triticale into ryegrass did not improve cattle gains and was more expensive (Vendramini et al., 2016)
- Gains: Oat-ryegrass mixture = rye-ryegrass-oat mixture > rye-ryegrass mixture (Mullenix et al., 2012)
- Gains: Wheat = wheat+radish (Farney et al., unpublished)
  - $P = 0.12$ but gains are 0.50 lb/d lower with wheat+radish
  - Grain yield reduced with radish
Average Hay Quality of 2012 Winter Forages

<table>
<thead>
<tr>
<th>Crop</th>
<th>% Crude Protein Dry Basis</th>
<th>% TDN Dry Basis</th>
<th>NO₃ ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassica</td>
<td>29</td>
<td>80</td>
<td>2736</td>
</tr>
<tr>
<td>Cereal</td>
<td>25</td>
<td>72</td>
<td>2435</td>
</tr>
<tr>
<td>Brome/fescue</td>
<td>21</td>
<td>57</td>
<td>817</td>
</tr>
</tbody>
</table>

Fall cereals will typically have 150 lbs/acre of dry matter forage for every inch of top growth
- 6” tall rye would have 900 lbs/acre usable forage

In an open graze situation cattle will utilize ~50% of the forage
- So only 450 lbs/acre of forage will be consumed
Brassicas

- Brassicas are a highly productive and high quality forage
  - Turnips
  - Radish
  - Hybrid brassica
- Good utilization on crop fields for fall and winter grazing when fields would remain fallow otherwise
- Brassicas are >80% water, so maintaining a dry roughage in their diet is important

Brassica

- Brassica forage quality is very high ranging from 17-22% protein
  - Turnip bulb protein content ranges from 12-15%
- Cattle will generally seek out the cereal before utilizing the turnip tops
Brassica Quality

- Livestock devour brassica forage more rapidly following a hard freeze (28°F)
  - Digestibility increases significantly

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Protein</th>
<th>ADF</th>
<th>NDF</th>
<th>NEM</th>
<th>TDN</th>
<th>RFV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>(Mcal/lb) (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE</td>
<td>26.2</td>
<td>21.8</td>
<td>24.5</td>
<td>0.84</td>
<td>73.2</td>
<td>277.3</td>
</tr>
<tr>
<td>POST</td>
<td>25.0</td>
<td>17.8</td>
<td>20.0</td>
<td>0.90</td>
<td>77.9</td>
<td>352.3</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>-</td>
<td>1.65</td>
<td>1.5</td>
<td>0.03</td>
<td>1.9</td>
<td>23.9</td>
</tr>
</tbody>
</table>

Stamm, et al.

Legumes

- Incorporated into mixes for N-fixation

- Winter growth of legumes very low in most of KS studies
  - Also around the country (minus hairy vetch; Coombs et al., 2017)

- Do we need legumes from a cattle diet perspective?
  - Plenty of N (CP from cereal grasses and brassicas)
    - Dairy study milk yield, fat, protein same in ryegrass or ryegrass + Berseem clover, crimson clover, and Persian clover (Veiga et al., 2016)
  - What’s the difference in the amount of N contribution to the soil of plant vs cattle excretions?
Winter legume emerged or not

- Columbus study **NO** difference in winter cover if legume emerged or did not
  - Biomass
  - Crude protein
  - TDN
  - ADF
  - NDF
  - Carbon
  - Nitrogen
  - C:N

![Graph showing DM biomass by plant category (lb ac-1)]
Warm Season Types

- **Grasses**
  - Sorghums, millets, sudans, corn

- **Broadleaf**
  - Sunflower, buckwheat

- **Legumes**
  - Lespedeza, Cowpea, chickpea, soybean, mungbean, sun hemp, medics
### Summer cover mixtures

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Grass (lb/ac)</th>
<th>Collard (lb/ac)</th>
<th>Legume (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR sorghum</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRM sorghum + spring pea</td>
<td>10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>BMR sorghum + collard</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BMR sorghum + spring pea + collard</td>
<td>7</td>
<td>2.7</td>
<td>17</td>
</tr>
<tr>
<td>Collard</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage sorghum</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage sorghum + spring pea</td>
<td>10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Forage sorghum + collard</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Forage sorghum + spring pea + collard</td>
<td>7</td>
<td>2.7</td>
<td>17</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearl millet + spring pea</td>
<td>10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Pearl millet + collard</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Pearl millet + spring pea + collard</td>
<td>7</td>
<td>2.7</td>
<td>17</td>
</tr>
<tr>
<td>Spring forage pea</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunn hemp</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Summer cover crop treatments

<table>
<thead>
<tr>
<th>Single species</th>
<th>Multi-species mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage sorghum (Sorghum spp.)</td>
<td>Forage sorghum – sunflower</td>
</tr>
<tr>
<td></td>
<td>Forage sorghum – sunn hemp</td>
</tr>
<tr>
<td>Pearl millet (Pennisetum glaucum)</td>
<td>Pearl millet – sunflower</td>
</tr>
<tr>
<td></td>
<td>Pearl millet – sunn hemp</td>
</tr>
<tr>
<td>Sunflower (Helianthus annuus)</td>
<td>Forage sorghum – sunflower – sunn hemp</td>
</tr>
<tr>
<td></td>
<td>Pearl millet – sunflower – sunn hemp</td>
</tr>
<tr>
<td>Sunn hemp (Crotalaria juncea)</td>
<td>Forage sorghum – Pearl millet – sunflower – sunn hemp</td>
</tr>
</tbody>
</table>

![Graph showing pounds dry matter per acre for different treatments]
Methods

- Planted first of May
- Single species seeded at max recommended rate
- 2 species – each plant was seeded at 50% of max rate
- 3 species – each plant was seeded at 33% of max rate
- 5 species – each plant was seeded at 20% of max rate

- Plant emergence data
- Graze 1st harvest 45 DAP, then every 28 days
- Hay harvested when 1st seedhead emerged
- Silage harvested when grasses were ~30% DM
- Quality (NDF, ADF, in vitro, CP, nitrates, minerals)
- Composition
- Individual plant species composition
Biomass All Treatments $P < 0.001$

Harvest time biomass

- **Graze**: 2500 kg/ha (b)
- **Hay**: 2000 kg/ha (c)
- **Silage**: 4500 kg/ha (a)

Biomass based on number of plants

- **One**: 3500 kg/ha (b)
- **Two**: 3000 kg/ha (a)
- **Three**: 2500 kg/ha (ab)
- **All**: 4000 kg/ha (a)
2020 Warm Season grasses

- Still analyzing quality
- Still have to analyze final cutting information
- Wheat in this plot so will have grain yield
- Included weed rings for weed suppression/emergence counts

Cattle preference for annual forages
Preference study – pre-freeze

- Grew 8 plant species of fall/winter covers
  - Austrian winter pea
  - Winter barley
  - Bayou Kale
  - Trophy rape
  - Graza forage radish
  - Impact collard
  - Purple top turnip

- Offered plants for 2 consecutive days
  - Grazing occurred pre-freeze
  - Recorded order consumed (1st, 2nd, 3rd, ....)

Selectivity rank – pre-freeze

![Chart showing selectivity rank for different plants](chart.png)

- Plant type: $P < 0.001$
- Day: $P = 0.47$
- Plant x Day: $P = 0.63$
Preference study – summer

- Grew 8 plant species of fall/winter covers
  - Pearl millet
  - Mungbean
  - Okra
  - Sunflower
  - BMR forage sorghum
  - Safflower
  - Sunn hemp
  - Sorghum-sudan

- Offered plants for 2 consecutive days
- Recorded order consumed (1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}....)

Selectivity rank – summer annuals

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Ordinal Rank</th>
<th>Plant Type</th>
<th>Ordinal Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage Sorghum</td>
<td>a</td>
<td>Sorghum Sudan</td>
<td>b</td>
</tr>
<tr>
<td>Pearl Millet</td>
<td>b</td>
<td>Sunflower</td>
<td>c</td>
</tr>
<tr>
<td>Sunn Hemp</td>
<td>c</td>
<td>Okra</td>
<td>d</td>
</tr>
<tr>
<td>Mungbean</td>
<td>d</td>
<td>Safflower</td>
<td>d</td>
</tr>
</tbody>
</table>

Plant type: $P < 0.001$

Day: $P = 0.93$

Plant x Day: $P = 0.04$

1BMR variety Forage Sorghum
2SorGrow – sorghum-sudan
3Black Oil Sunflower

** $P < 0.05$
* $P < 0.10$
Preference study – post-freeze

- Grew 8 plant species of fall/winter covers
  - Austrian winter pea
  - Winter barley
  - Rapeseed
  - Graza forage radish
  - Winter oat
  - Purple top turnip
  - Common vetch

- Offered plants for 2 consecutive days
  - Grazing occurred post-freeze
  - Recorded order consumed (1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd},...)

Selectivity rank – winter post-freeze

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Ordinal Rank</th>
<th>Plant Type</th>
<th>Ordinal Rank</th>
<th>Plant Type</th>
<th>Ordinal Rank</th>
<th>Plant Type</th>
<th>Ordinal Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat</td>
<td>a</td>
<td>Barley</td>
<td>a</td>
<td>Common vetch</td>
<td>b</td>
<td>Graza Radish</td>
<td>b</td>
</tr>
<tr>
<td>Winter Pea</td>
<td>b</td>
<td>Rapeseed</td>
<td>b</td>
<td>Turnip</td>
<td>c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Plant type: $P < 0.001$
- Day: $P = 0.97$
- Plant x Day: $P = 0.23$
How do we use annual forages for cattle?

Know purpose - Cattle

• Are gains a priority
  • Might need to include supplement
• Is maximizing land a priority
• What class of animal maximizes the acreage
Winter Annuals and Cows

• Cow requirements, especially if dry, pregnant is much, much lower than what is offered by the winter annuals
Winter Annuals and Cows

• Issues
  • Too much body condition
  • Inefficiency in production system
  • Loss of potential revenue

• Practices to manage for this:
  • Short term grazing on high quality forage
  • Combination paddock

Short term grazing

• Allow cows a couple of hours/d to graze high protein, high energy forage at least 3x/week
  • This is also know as limit grazing wheat pasture

• Oklahoma State University study
  • Allowed cows to graze wheat pasture for 4 hours 3x/week (Fall-calving herd)
  • Rest of the time cows where on native hay
  • From calving to weaning cows on this system performed exceptional
Combination paddock

- Portion of pasture is corn/milo stalks or perennial pasture the other portion is cereal grain or brassica
  - Planting corners of circles with high quality forage
  - Fencing both types of forage
  - Flying on brassicas or cereal grains into residue??
- Cattle will consume a combination of residue and high quality forage
- Cows maintain appropriate body condition
- Removes the need for supplemental protein on residues
How much high quality pasture need??

- Really for spring cows don’t need anything other than corn stalks for 1st month of grazing
- If only want to fence once – determine was maximal acreage is needed for the highest nutrient requirement period and multiply by days (90 d)
  - Cow needs 1.14 ac of cocktail and 1.93 ac of stalks
- Fall cows for 90 d
  - Cow needs 1.51 ac of cocktail and 2.18 ac of stalks
Weaned Calves

- Most of the time, we still are offering too much protein (much higher than requirements)
- Need another source of dry forage/feed
- Maximize gain potential want to make protein to energy ratio optimal
- Maximize gain = maximum dry matter intake

Value of winter cover crops - stockers

- Nebraska data showed that calf gains are VERY variable with cover crop mixtures
- Over 10 studies
  - ADG ranged from 0.8 lb/d up to 2.3 lb/d
  - Same cocktail in back-to-back years
    - 2.3 lb/d one year and 1.3 lb/d next year
Calf gains on cereal grains

<table>
<thead>
<tr>
<th>Cereal type</th>
<th>Cattle Type</th>
<th>Gain</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat</td>
<td>Heifer</td>
<td>1.96</td>
<td>North Dakota</td>
</tr>
<tr>
<td>Barley</td>
<td>Heifer</td>
<td>1.96</td>
<td>North Dakota</td>
</tr>
<tr>
<td>Barley</td>
<td>Heifer</td>
<td>1.75-1.96</td>
<td>South Dakota</td>
</tr>
<tr>
<td>Barley</td>
<td>Steers</td>
<td>3.0</td>
<td>Canada</td>
</tr>
<tr>
<td>Oat</td>
<td>Steers</td>
<td>2-3.5</td>
<td>Canada</td>
</tr>
<tr>
<td>Rye</td>
<td>Steers</td>
<td>2.25-2.6</td>
<td>Canada</td>
</tr>
<tr>
<td>Triticale</td>
<td>Steers</td>
<td>1.7-2.4</td>
<td>Canada</td>
</tr>
<tr>
<td>Wheat</td>
<td>Steers</td>
<td>1.87</td>
<td>Canada</td>
</tr>
<tr>
<td>Oat-Ryegrass</td>
<td>Steers</td>
<td>3.06</td>
<td>Alabama</td>
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<td>1.96</td>
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<tr>
<td>Ryegrass-triticale</td>
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Grazing Weaned Calves  Data - Eric Mousel
Figure 4: Calf average daily gain on dual-purpose wheat with or without radish (averaged over two years)
Farney and Sassenrath, unpublished

Figure 5: Dual-purpose wheat yield averaged over two years with or without radish and with or without grazing. Letters with different superscripts differ $P < 0.05$.
Farney and Sassenrath, unpublished

Grazing systems with covers
Warm-season systems

- Year 1 of 3
- Fescue
  - 2 pastures – stocked 1 ac/hd – March to November
- Sorghum-sudan Fescue
  - 2 pastures rotationally grazed in 3 paddocks
  - Stocked 0.67 ac/hd – March to July ("mowing fescue")
  - Drilled 25 lb/ac sorghum-sudan May 26
  - Stocked 1 ac/hd – July to November
- Crabgrass
  - 3 pastures rotationally grazed in 2 paddocks stocked 1 ac/hd
- Bermudagrass
  - 3 pastures rotationally grazed in 2 paddocks stocked at 0.8 ac/hd
On-going project

• On-farm project converting 160 acres of cropland into a year-long annual forage grazing system
  • Summer 2020 start
    • Teff, sorghum-sudan, crabgrass
  • Supported 110 cows May – mid-September
    • 46 spring pairs and 65 fall cows

• Capture stocking rate, water runoff, and cow performance data during this transition

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Questions