PASA
Sustainable Agriculture

Grazing Dairy Environmental Footprint Study

Results and interpretation of the Integrated Farming Systems Model (IFSM) output for 8 Master Grazier dairy farms in Pennsylvania, bench-marked against the "typical", confinement model Pennsylvania dairy

Dairy farms that graze their herds on deep-rooted, perennial pastures improve soil health, water quality, animal welfare and, often, profitability. While many grazing dairy farmers report their methods produce less soil erosion and nutrient runoff than confined dairy herds—while generating better quality milk at lower production costs—it's challenging to develop a holistic account of the environmental and economic footprints of grazing dairies.

In 2018, PASA partnered with the USDA Agricultural Research Service and grazing dairies enrolled in the Dairy Grazing Apprenticeship to conduct whole-farm environmental and economic assessments of grazing dairy farms. By employing the Integrated Farming Systems Model (IFSM), we were able to simulate flows of energy, nutrients, and dollars through a working dairy farm, based on input numbers provided by Master Graziers and Apprentices regarding their particular farm operations. These numbers included variables describing the farm's milk production, cropping and grazing practices, and infrastructure. The table below compares IFSM output for eight grass-based dairy farms in Pennsylvania, four of which feed an all-grass ration, the other four of which include some grain in the milking herd's diet. The table also benchmarks these grazing dairies against a "typical" Pennsylvania confinement dairy.

	100% Grass or Hybrid, Grass-Based Farms								"Typical"
	H	H	G	G	H	H	G	G	Farm
Total fam area, acres	150	620	210	443	264	100	363	300	220
Grass area, acres	100	500	210	370	264	100	327	300	0
Other crop area, acres	50	120	0	73	0	0	36	0	220
Number of cows	95	240	85	80	43	26	133	85	100
Number of heifers	45	200	45	30	31	18	44	60	80
Annual milk production, lb FPCM/cow	15011	13200	6700	9691	11270	13915	9341	6461	19497
Land use, acre/animal	1.07	1.41	1.62	4.03	3.57	2.27	2.05	2.07	1.22
Hay and silage produced, ton DM	240	1024	149	319	196	110	354	349	693
Grazed forage consumed, ton DM	233	432	330	196	68	110	458	196	0
Forage bought/sold, ton DM	27	64	23	-22	6	-44	68	40	0
Concentrate fed, ton DM	230	464	3	3	64	43	6	3	310
Feed consumed, lb/animal/day	28.6	24.7	21.3	24.7	24.7	27.3	27.4	22.2	30.5
Ammonia volatilized, lb N/ac	71.9	37.7	42.8	13.4	11.3	39.9	25.7	38.1	50.4
Nitrate leached, lb N/ac	7.9	30.8	26.7	22.7	28.1	30.4	13.5	78.5	42.8
N denitrified, lb N/ac	10.4	15.6	8.4	8.3	6.7	13.5	10.2	19.5	14.8
N runoff, lb N/ac	0.5	0.4	0	0.7	0.3	0.4	0.8	2.0	1.5
P runoff, lb P/ac	0.4	0.5	0.1	0.8	0.3	0.2	0.4	0.1	1.2
Soil P accumulation, lb P/ac	4.9	8.5	6.9	3.8	3.0	0	2.3	8.9	1
Energy use, Mbtu/lb FPCM	0.79	1.26	0.67	1.25	1.72	0.69	0.71	1.03	0.82
Carbon footprint, lb CO2e/lb FPCM	0.99	1.18	1.30	1.50	1.27	1.19	1.28	1.85	1.00
Production cost, $/ac	2222	1367	900	477	575	748	747	760	1375
Production cost, $/cwt	23.37	26.75	33.21	27.25	31.34	20.68	21.83	41.51	15.52
Net return to management & labor, $/ac	242	205	99	112	108	238	495	137	554
Net return to management & labor, $/cwt	2.54	4.00	3.65	6.40	5.88	6.57	14.45	7.51	6.26

Table Notes:
1: Data for the Typical Farm were derived from USDA surveys of the PA industry.
2: "Fat and Protein Corrected Milk" is a calculation that normalizes milk with different butter fat and protein contents onto a comparable basis.
3. CO2e are "carbon dioxide equivalents." Different greenhouse gases have different potentials to trap heat and energy in the atmosphere. IFSM takes all of the greenhouse gases emitted by a farm (including carbon dioxide, methane, and nitrous oxides) and weights them all on a common basis of the atmospheric warming caused by one molecule of carbon dioxide.
4. 100% grass-fed dairies are signified by 'G' in the Farm Name row; hybird operations are signified by 'H'.

Study Highlights:

Some key findings are that compared to the "Typical PA Farm" grazing dairies generally:

- Produce substantially less milk per cow and per acre.
- Use less fossil fuel energy per unit milk.
- Reduce nitrogen leaching into waterways.
- Substantially cut phosphorus runoff.
- Have more total greenhouse gas emissions per unit milk.
- Show mixed economic performance.

The larger greenhouse gas emissions may surprise many of the Master Graziers in this group, who generally take pride in practicing excellent environmental stewardship. The larger greenhouse gas emissions can be attributed to the fact that cows on a high forage data emit substantially more methane (a powerful greenhouse gas). However, while the IFSM model does account for methane fermentation in the cow's rumen, it does not take into account carbon sequestered into the soil, which will tend to be substantially greater on grasslands than on crop fields.

Because the IFSM cannot capture soil health dynamics, and because we know many graziers pride themselves on excellent soil stewardship, we are continuing our research work on these farms by including them in our ongoing soil health research study**.** For this research, we'll visit each farm for soil sampling and return detailed soil health data using the Cornell Soil Health test and other indicators. Using these data, we will be able to incorporate a more complete greenhouse gas budget (accounting for stored soil carbon) into the IFSM assessments, as well as get a nuanced picture of soil health outcomes on grazing dairies.

Contact Aaron de Long (814-349-9856, aaron@pasafarming.org) to discuss further the information shared in this fact sheet.