Model description

Iowa Landscape Design MADSS: Nevada Fuelshed

This Multi-Atttribute Decision Support System (MADSS) was built by Oak Ridge National Laboratory (ORNL) to evaluate the relative sustainability of four alternative landscapes considered by the Antares-led Iowa Landscape Design project consortium for the US Department of Energy (DOE) BioEnergy Technologies Office (BETO). The model was built using quantitative results from ArcGIS analyses of the 50-mile fuelshed area around a commercial cellulosic biorefinery located in Nevada, Iowa. The analyses were based on subfield-scale results output from combinations of Profit Zone Manager (PZM) calculations for 2013-2016 and 7 AgSolver management scenarios developed by EFC Systems and provided to Antares Group LLC.

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Attribute tree

Attribute	Description
Landscape Sustainability	Aggregation of indicators derived from AgSolver runs prepared for the Antares Iowa Landscape Design project.
├─**Environmental Indicators**	Measurements related to biodiversity habitat, soil quality and water quality
│ ├─Biodiversity	Additional grassland acres for birds and pollinators; includes switchgrass plantings and Conservation Reserve Program (CRP) grasses
│ ├─**Soil Quality**	Indicators of soil quaility
│ │ ├─Soil condition	Soil conditioning index (SCI)
│ │ └─**Soil retention**	Avoided soil erosion by wind and water (total tons)
│ │ │ ├─water erosion	Tons of soil eroded by water across the area on an annual basis
│ │ │ └─wind erosion	Tons of soil eroded by wind across the area on an annual basis
│ └─Water quality	Reduced levels of nitrate leaching (pounds NO3 avoided in water bodies)
└─**Socioeconomic Indicators**	Measures related to feedstock availability, management inputs and climate change
├─**Biomass availability**	Feedstock availability for food and fuel
│ ├─corn grain	Average yield of corn harvested from 2013-2016
│ ├─corn residues	Corn stover removed from fields with slopes < 5% and average corn yields >= 165 bu/acre
│ ├─switchgrass	Switchgrass harvested from perennial fields (tons/acre)
│ └─rye cover crop	Rye cover crop planted on top of corn
├─**Climate change**	Net carbon loss and/or sequestration
│ ├─soil carbon	Net change in soil organic carbon (SOC) in pounds/year
│ └─methane emissions	CH4 released from agricultural fields (net flux in in pounds/year)
└─Fertilizer application	Volume of ammonia added to fields through injection (lbs NO3)

Scales

Attribute	Scale
Landscape Sustainability	**adverse impacts**; mixed results; status quo; ***some benefit***; ***mulitiple benefits***
├─**Environmental Indicators**	**declining environmental conditions**; mixed environmental conditions; ***improving environmental conditions***
│ ├─Biodiversity	no grassland added; ***switchgrass plantings***; ***switchgrass plantings + CRP acres***
│ ├─**Soil Quality**	**deteriorating soil quailty**; stable soil quality; ***improving soil quality***
│ │ ├─Soil condition	**negative SCI value**; ***positive SCI value***; ***SCI value > 0.5***
│ │ └─**Soil retention**	current soil erosion rate; ***reduction in wind OR water erosion***; ***reduction in wind AND water erosion***
│ │ ├─water erosion	current soil erosion rate; ***up to 25% reduction***; ***25-50% reduction***; ***> 50% reduction***
│ │ └─wind erosion	current soil erosion rate; ***up to 25% reduction***; ***25-50% reduction***; ***> 50% reduction***
│ └─Water quality	**current leaching rate**; up to 25% reduction; ***25-50% reduction***; ***> 50% reduction***
└─**Socioeconomic Indicators**	**increased costs to stakeholders**; mixed results for stakeholders; status quo; ***stakholder benefit***; ***multiple stakeholder benefits***
├─**Biomass availability**	**decreased food availability**; status quo (no cellulosic bioenergy); ***feedstock available for food & fuel***
│ ├─corn grain	**decreased corn yield**; average corn yield; ***increased corn yield***
│ ├─corn residues	no stover removals; ***30% stover removal***; ***45% stover removal***
│ ├─switchgrass	no switchgrass plantings; ***switchgrass plantings***
│ └─rye cover crop	no cover crop; ***cover crop***
├─**Climate change**	**worsening GHGs**; mixed results; status quo; ***improving GHGs***
│ ├─soil carbon	**loss of soil carbon**; ***increase in soil carbon***; ***carbon sequestered***
│ └─methane emissions	**increased emissions**; status quo
└─Fertilizer application	**increased fertilizer use**; average fertilizer use; ***decreased fertilizer use***

Landscape Sustainability

Aggregation of indicators derived from AgSolver runs prepared for the Antares Iowa Landscape Design project.

1. **adverse impacts**
2. mixed results
3. status quo
4. ***some benefit***
5. ***mulitiple benefits***

Environmental Indicators

Measurements related to biodiversity habitat, soil quality and water quality

1. **declining environmental conditions**
2. mixed environmental conditions
3. ***improving environmental conditions***

Biodiversity

Additional grassland acres for birds and pollinators; includes switchgrass plantings and Conservation Reserve Program (CRP) grasses

1. no grassland added	No switchgrass plantings or additional CRP acres
2. ***switchgrass plantings***	Switchgrass planted on clustered low ROI acres
3. ***switchgrass plantings + CRP acres***	Switchgrass planted on clustered low ROI acres; remaining low ROI acres enrolled in CRP

Soil Quality

Indicators of soil quaility

1. **deteriorating soil quailty** based on SCI and erosion rates
2. stable soil quality based on SCI and erosion rates
3. ***improving soil quality*** based on SCI and erosion rates

Soil condition

Soil conditioning index (SCI)

1. **negative SCI value** Loss of soil organic matter
2. ***positive SCI value*** Increase in soil organic matter
3. ***SCI value > 0.5*** Large increase in soil organic matter

Soil retention

Avoided soil erosion by wind and water (total tons)

1. current soil erosion rate tons of soil eroded under basecase conditions
2. ***reduction in wind OR water erosion*** tons of sediment eroded relative to basecase
3. ***reduction in wind AND water erosion*** tons of sediment eroded relative to basecase

water erosion

Tons of soil eroded by water across the area on an annual basis

1. current soil erosion rate tons of soil eroded under basecase conditions
2. ***up to 25% reduction*** tons of sediment eroded relative to basecase
3. ***25-50% reduction*** tons of sediment eroded relative to basecase
4. ***> 50% reduction*** tons of sediment eroded relative to basecase

wind erosion

Tons of soil eroded by wind across the area on an annual basis

1. current soil erosion rate tons of soil eroded under basecase conditions
2. ***up to 25% reduction*** tons of sediment eroded relative to basecase
3. ***25-50% reduction*** tons of sediment eroded relative to basecase
4. ***> 50% reduction*** tons of sediment eroded relative to basecase

Water quality

Reduced levels of nitrate leaching (pounds NO3 avoided in water bodies)

1. **current leaching rate** pounds of NO3 leached under basecase conditions
2. up to 25% reduction pounds of NO3 leached relative to baseline
3. ***25-50% reduction*** pounds of NO3 leached relative to baseline
4. ***> 50% reduction*** pounds of NO3 leached relative to baseline

Socioeconomic Indicators

Measures related to feedstock availability, management inputs and climate change

1. **increased costs to stakeholders** includes food insecurity and/or increased climate change contributions
2. mixed results for stakeholders
3. status quo
4. ***stakholder benefit***
5. ***multiple stakeholder benefits*** includes feedstock diversity, GHG reductions, and/or reduced inputs

Biomass availability

Feedstock availability for food and fuel

1. **decreased food availability** marked decrease in corn yields and/or acres
2. status quo (no cellulosic bioenergy) all modeled acres allocated to corn/soy rotation
3. ***feedstock available for food & fuel*** switchgrass and stover removals integrateed with corn/soy

corn grain

Average yield of corn harvested from 2013-2016

1. **decreased corn yield**
2. average corn yield average bushels/acre across modeled area
3. ***increased corn yield***

corn residues

Corn stover removed from fields with slopes < 5% and average corn yields >= 165 bu/acre

1. no stover removals
2. ***30% stover removal***
3. ***45% stover removal***

switchgrass

Switchgrass harvested from perennial fields (tons/acre)

1. no switchgrass plantings all acres left in traditional corn/soy rotation
2. ***switchgrass plantings*** switchgrass replacing corn on clustered low ROI lands

rye cover crop

Rye cover crop planted on top of corn

1. no cover crop no rye planted over corn
2. ***cover crop*** rye cover crop assumed to yield 4000 lb/acre

Climate change

Net carbon loss and/or sequestration

1. **worsening GHGs** lower SOC & larger CH4 release
2. mixed results opposite trends between SOC & methane emissions
3. status quo no change from basecase values
4. ***improving GHGs*** increased SOC & smaller CH4 release

soil carbon

Net change in soil organic carbon (SOC) in pounds/year

1. **loss of soil carbon** total net change in SOC is negative across the area
2. ***increase in soil carbon*** net positive change in SOC across the area
3. ***carbon sequestered*** magnitude of net SOC gain more than offsets magnitude of net loss under basecase

methane emissions

CH4 released from agricultural fields (net flux in in pounds/year)

1. **increased emissions** Larger release of methane across the modeled land area
2. status quo Basecase methane emission levels

Fertilizer application

Volume of ammonia added to fields through injection (lbs NO3)

1. **increased fertilizer use** larger volume of NH3 relative to basecase
2. average fertilizer use basecase NH3 volume
3. ***decreased fertilizer use*** smaller volume of NH3 relative to basecase

Functions

Attribute	Rules	Defined	Determined	Values
Landscape Sustainability	15/15	100.00%	100.00%	adverse impacts:4,mixed results:3,status quo:2,some benefit:4,mulitiple benefits:2
├─**Environmental Indicators**	36/36	100.00%	100.00%	declining environmental conditions:4,mixed environmental conditions:15,improving environmental conditions:17
│ ├─Biodiversity				
│ ├─**Soil Quality**	9/9	100.00%	100.00%	deteriorating soil quailty:3,stable soil quality:1,improving soil quality:5
│ │ ├─Soil condition				
│ │ └─**Soil retention**	16/16	100.00%	100.00%	current soil erosion rate:1,reduction in wind OR water erosion:6,reduction in wind AND water erosion:9
│ │ ├─water erosion				
│ │ └─wind erosion				
│ └─Water quality				
└─**Socioeconomic Indicators**	36/36	100.00%	100.00%	increased costs to stakeholders:11,mixed results for stakeholders:13,status quo:2,stakholder benefit:5,multiple stakeholder benefits:5
├─**Biomass availability**	36/36	100.00%	100.00%	decreased food availability:12,status quo (no cellulosic bioenergy):4,feedstock available for food & fuel:20
│ ├─corn grain				
│ ├─corn residues				
│ ├─switchgrass				
│ └─rye cover crop				
├─**Climate change**	6/6	100.00%	100.00%	worsening GHGs:2,mixed results:2,status quo:0,improving GHGs:2
│ ├─soil carbon				
│ └─methane emissions				
└─Fertilizer application				

Tables

	Environmental Indicators	Socioeconomic Indicators	Landscape Sustainability
	70%	30%	
1	**declining environmental conditions**	<=status quo	**adverse impacts**
2	<=mixed environmental conditions	**increased costs to stakeholders**	**adverse impacts**
3	**declining environmental conditions**	>=***stakholder benefit***	mixed results
4	***improving environmental conditions***	**increased costs to stakeholders**	mixed results
5	mixed environmental conditions	mixed results for stakeholders:status quo	status quo
6	mixed environmental conditions	>=***stakholder benefit***	***some benefit***
7	***improving environmental conditions***	mixed results for stakeholders:status quo	***some benefit***
8	***improving environmental conditions***	>=***stakholder benefit***	***mulitiple benefits***

	Biodiversity	Soil Quality	Water quality	Environmental Indicators
	17%	51%	33%	
1	no grassland added	deteriorating soil quailty	<=up to 25% reduction	declining environmental conditions
2	no grassland added	<=stable soil quality	current leaching rate	declining environmental conditions
3	<=*switchgrass plantings*	deteriorating soil quailty	current leaching rate	declining environmental conditions
4	*	deteriorating soil quailty	>=*25-50% reduction*	mixed environmental conditions
5	no grassland added	stable soil quality	up to 25% reduction	mixed environmental conditions
6	*	*improving soil quality*	current leaching rate	mixed environmental conditions
7	>=*switchgrass plantings*	deteriorating soil quailty	>=up to 25% reduction	mixed environmental conditions
8	>=*switchgrass plantings*	>=stable soil quality	current leaching rate	mixed environmental conditions
9	*switchgrass plantings + CRP acres*	deteriorating soil quailty	*	mixed environmental conditions
10	*switchgrass plantings + CRP acres*	*	current leaching rate	mixed environmental conditions
11	*	>=stable soil quality	>=*25-50% reduction*	*improving environmental conditions*
12	*	*improving soil quality*	>=up to 25% reduction	*improving environmental conditions*
13	>=*switchgrass plantings*	>=stable soil quality	>=up to 25% reduction	*improving environmental conditions*

	Soil condition	Soil retention	Soil Quality
	86%	14%	
1	negative SCI value	*	deteriorating soil quailty
2	*positive SCI value*	current soil erosion rate	stable soil quality
3	>=*positive SCI value*	>=*reduction in wind OR water erosion*	*improving soil quality*
4	*SCI value > 0.5*	*	*improving soil quality*

	water erosion	wind erosion	Soil retention
	50%	50%	
1	current soil erosion rate	current soil erosion rate	current soil erosion rate
2	current soil erosion rate	>=*up to 25% reduction*	*reduction in wind OR water erosion*
3	>=*up to 25% reduction*	current soil erosion rate	*reduction in wind OR water erosion*
4	>=*up to 25% reduction*	>=*up to 25% reduction*	*reduction in wind AND water erosion*

	Biomass availability	Climate change	Fertilizer application	Socioeconomic Indicators
	40%	23%	37%	
1	**decreased food availability**	**worsening GHGs**	*	**increased costs to stakeholders**
2	**decreased food availability**	<=status quo	<=average fertilizer use	**increased costs to stakeholders**
3	<=status quo (no cellulosic bioenergy)	**worsening GHGs**	<=average fertilizer use	**increased costs to stakeholders**
4	<=status quo (no cellulosic bioenergy)	<=status quo	**increased fertilizer use**	**increased costs to stakeholders**
5	**decreased food availability**	>=mixed results	***decreased fertilizer use***	mixed results for stakeholders
6	**decreased food availability**	***improving GHGs***	*	mixed results for stakeholders
7	*	***improving GHGs***	**increased fertilizer use**	mixed results for stakeholders
8	>=status quo (no cellulosic bioenergy)	**worsening GHGs**	***decreased fertilizer use***	mixed results for stakeholders
9	***feedstock available for food & fuel***	**worsening GHGs**	*	mixed results for stakeholders
10	***feedstock available for food & fuel***	*	**increased fertilizer use**	mixed results for stakeholders
11	status quo (no cellulosic bioenergy)	mixed results:status quo	average fertilizer use	status quo
12	status quo (no cellulosic bioenergy)	mixed results:status quo	***decreased fertilizer use***	***stakholder benefit***
13	status quo (no cellulosic bioenergy)	***improving GHGs***	average fertilizer use	***stakholder benefit***
14	***feedstock available for food & fuel***	mixed results:status quo	average fertilizer use	***stakholder benefit***
15	>=status quo (no cellulosic bioenergy)	***improving GHGs***	***decreased fertilizer use***	***multiple stakeholder benefits***
16	***feedstock available for food & fuel***	>=mixed results	***decreased fertilizer use***	***multiple stakeholder benefits***
17	***feedstock available for food & fuel***	***improving GHGs***	>=average fertilizer use	***multiple stakeholder benefits***

	corn grain	corn residues	switchgrass	rye cover crop	Biomass availability
	70%	13%	17%	0%	
1	**decreased corn yield**	*	*	*	**decreased food availability**
2	>=average corn yield	no stover removals	no switchgrass plantings	*	status quo (no cellulosic bioenergy)
3	>=average corn yield	*	***switchgrass plantings***	*	***feedstock available for food & fuel***
4	>=average corn yield	>=***30% stover removal***	*	*	***feedstock available for food & fuel***

	soil carbon	methane emissions	Climate change
	43%	57%	
1	**loss of soil carbon**	*	**worsening GHGs**
2	>=***increase in soil carbon***	**increased emissions**	mixed results
3	>=***increase in soil carbon***	status quo	***improving GHGs***

Average weights

Attribute	Local	Global	Loc.norm.	Glob.norm.
Landscape Sustainability				
├─**Environmental Indicators**	70	70	53	53
│ ├─Biodiversity	17	12	14	8
│ ├─**Soil Quality**	51	35	43	23
│ │ ├─Soil condition	86	30	86	20
│ │ └─**Soil retention**	14	5	14	3
│ │ │ ├─water erosion	50	3	50	2
│ │ │ └─wind erosion	50	3	50	2
│ └─Water quality	33	23	42	22
└─**Socioeconomic Indicators**	30	30	47	47
├─**Biomass availability**	40	12	36	17
│ ├─corn grain	70	9	77	13
│ ├─corn residues	13	2	14	2
│ ├─switchgrass	17	2	9	2
│ └─rye cover crop	0	0	0	0
├─**Climate change**	23	7	30	14
│ ├─soil carbon	43	3	60	8
│ └─methane emissions	57	4	40	6
└─Fertilizer application	37	11	33	15

Evaluation results

Attribute	Basecase	Improved Management	Landscape Design A	Landscape Design B
Landscape Sustainability	**adverse impacts**	mixed results	***some benefit***	***mulitiple benefits***
├**Environmental Indicators**	**declining environmental conditions**	***improving environmental conditions***	***improving environmental conditions***	***improving environmental conditions***
│ ├Biodiversity	no grassland added	no grassland added	***switchgrass plantings***	***switchgrass plantings + CRP acres***
│ ├**Soil Quality**	**deteriorating soil quailty**	***improving soil quality***	***improving soil quality***	***improving soil quality***
│ │ ├Soil condition	**negative SCI value**	***positive SCI value***	***positive SCI value***	***SCI value > 0.5***
│ │ └**Soil retention**	current soil erosion rate	***reduction in wind AND water erosion***	***reduction in wind AND water erosion***	***reduction in wind AND water erosion***
│ │ ├water erosion	current soil erosion rate	***25-50% reduction***	***25-50% reduction***	***> 50% reduction***
│ │ └wind erosion	current soil erosion rate	***> 50% reduction***	***> 50% reduction***	***> 50% reduction***
│ └Water quality	**current leaching rate**	up to 25% reduction	***> 50% reduction***	***> 50% reduction***
└**Socioeconomic Indicators**	**increased costs to stakeholders**	**increased costs to stakeholders**	mixed results for stakeholders	***multiple stakeholder benefits***
├**Biomass availability**	status quo (no cellulosic bioenergy)	status quo (no cellulosic bioenergy)	***feedstock available for food & fuel***	***feedstock available for food & fuel***
│ ├corn grain	average corn yield	***increased corn yield***	***increased corn yield***	***increased corn yield***
│ ├corn residues	no stover removals	no stover removals	***30% stover removal***	***45% stover removal***
│ ├switchgrass	no switchgrass plantings	no switchgrass plantings	***switchgrass plantings***	***switchgrass plantings***
│ └rye cover crop	no cover crop	no cover crop	***cover crop***	***cover crop***
├**Climate change**	**worsening GHGs**	**worsening GHGs**	mixed results	mixed results
│ ├soil carbon	**loss of soil carbon**	**loss of soil carbon**	***increase in soil carbon***	***carbon sequestered***
│ └methane emissions	status quo	status quo	**increased emissions**	**increased emissions**
└Fertilizer application	average fertilizer use	**increased fertilizer use**	**increased fertilizer use**	***decreased fertilizer use***