Marcellus Design

The Sullivan County Design Charette
The Pennsylvania State University
Landscape Architecture
2013

Sustainable Watershed

"Sustainable development is the master balance of meeting our own needs without jeopardizing the future generations' ability to do the same." - Light of Mine

Problem Statement:

The goal of the sustainable watershed project is to design a watershed that is **sustainable on three levels; Energy, Food, and Water**. If a self-sustaining watershed can be achieved, this area could act as a model for surrounding watersheds to reach the same level of independence.

Sustainable initiatives bring many benefits. A sustainable food practices turns the focus to local markets, **improving the local economy**. Sustainable energy creates a local industry that is **cleaner for the environment**. This ensures a brighter future for generations to come.

Energy

Sustainable energy is a viable option for this watershed. It means a cleaner environment and a reliable energy source that will be renewable for generations to come.

Food

Through focusing on sourcing food within the watershed, farmers will be able to maintain and improve their livelihoods in addition to bringing their community members closer to the land. Furthermore, local food sources tend to be less intensive on the environment, leading to a greener future.

Water

The key goal is to move the water through the watershed as natural as possible while preserving the quality. The water should act as though the watershed is not impacted by the development occurring there.

"The Endless Mountains" Personal Image

Gas Compression Station Personal Image

Historic Precedents

This is not the first time that Sullivan county has witnessed an rush of change due to the nation's demands for energy. Over the past 200 years and more, Sullivan County has experienced both the timber rush and the rise of coal. Now, this pattern seems to be reoccurring with natural gas.

Once these industries faltered, the sources of income for those who worked for them disappeared. This caused a "Boom and Bust" pattern for the population and economy of northeastern Pennsylvania.

Timber:

Between the 1760's and 1890's, the demand for charcoal and wood caused more than four million acres to be harvested multiple times. The Civil War, in addition to the need for coal mine supports and railroad ties only exacerbated the demand for lumber from northern Pennsylvania. By 1900, over 60% of Pennsylvania's forests were gone. The first forest commissioner, Joseph Rothrock, called this area the "Pennsylvania Desert".

Fortunately, over the past century substantial action by the government has allowed for about 60% of Pennsylvania's land to be covered once more with forest. (ExplorePAHistory.com "Penn's Woods")

ExplorePAHistory.com "Penn's Woods"

Circa 1890.

ExplorePAHistory.com "Overview"

The "Pennsylvania Desert", Circa 1920.

Anthracite Coal:

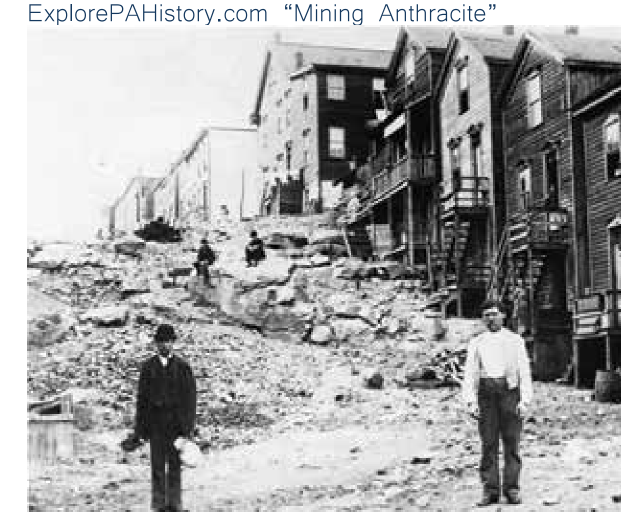
By the Civil War, coal was emerging as the primary source of energy for the burgeoning Industrial revolution. In order to access the mines and have a large supply of workers, coal barons rapidly raised many company-owned "patch towns" where the workers lived in over-crowded situations. Eventually, striking workers and the Great Depression hit gave the fatal blow, when cities and other industries to look for more affordable fuels, such as electricity, oil and gas.

With the decline of jobs in the anthracite industry, families and younger generations left northeast Pennsylvania, causing a localized economic depression due to a "painful deindustrialization process that many Pennsylvania towns and cities continue to experience". (ExplorePAHistory.com "Mining Anthracite")

ExplorePAHistory.com "Mining Anthracite"

Young Mine Workers, Circa 1910.

ExplorePAHistory.com "Mining Anthracite"



Workers in a "Patch Town", Circa 1900.

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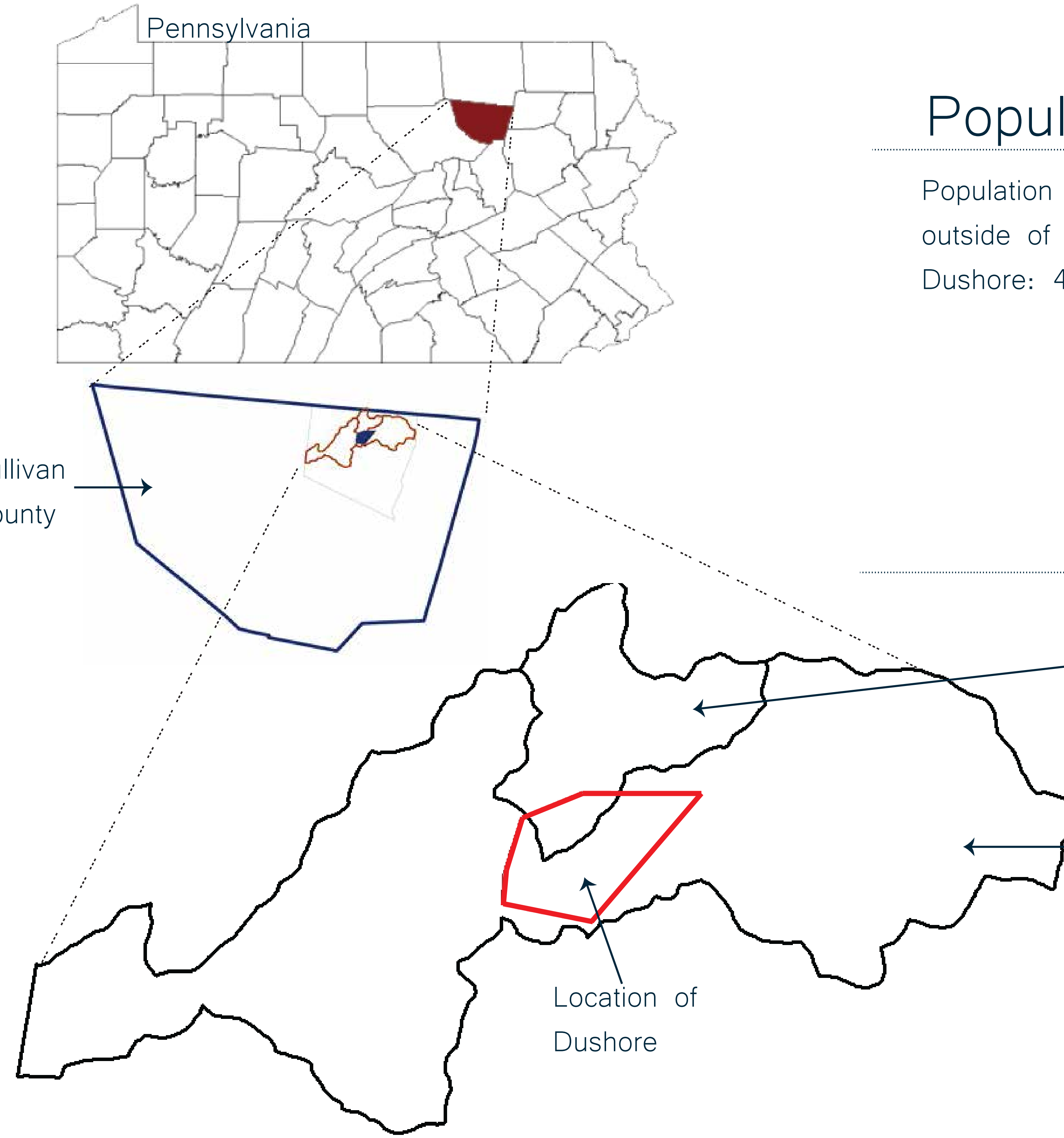
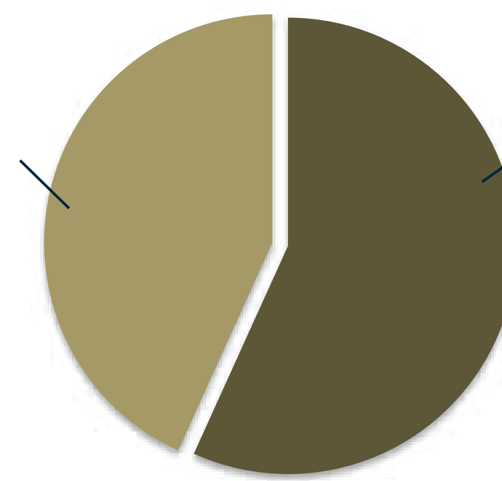
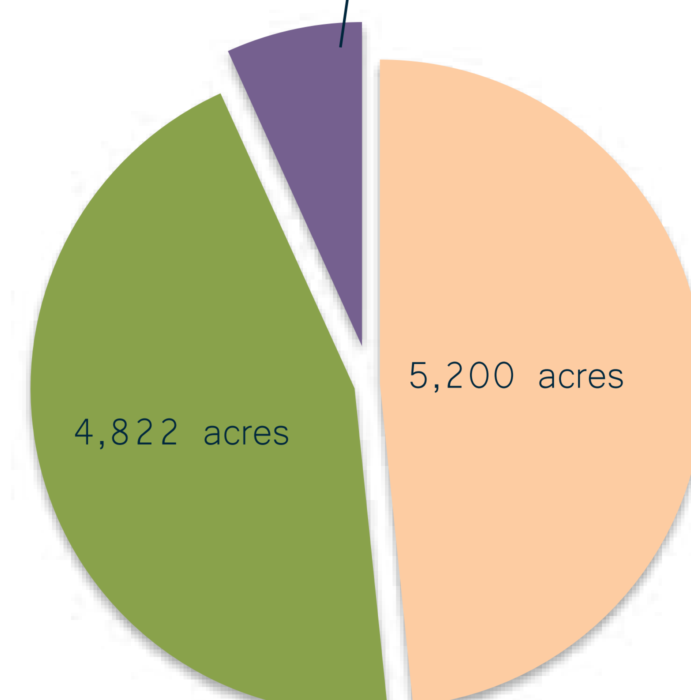
These watersheds were chosen for the sustainable watershed project because of their **proximity to a town center**, and the existing and future **gas industry** infrastructure that threatens visual, environmental, and social aspects.



Population: 1,071 people



Acres: 10,752 acres



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Renewable Energy: A Cleaner and Sustainable Future

15,600,000 kWh/year consumed within the Marsh Run and Little Loyalsock Watershed

Renewable Energy

"Resources that rely on fuel sources that restore themselves over short periods of time and do not diminish." - EPA

This is the amount of energy that is consumed annually within these two small watersheds. What if this energy need could be produced within the boundaries of these watersheds? By looking at the benefits and drawbacks of each renewable energy source, the cost, area it takes up, and environmental impacts, we can design a master plan that utilizes these sources to the best of their ability. Natural gas is dominating the energy resource, but what happens when its source is depleted? Renewable energy is a solution that can sustain a watershed and allow for economic growth and self-reliance for energy without jeopardizing the environment.

Types of Renewable Energy Resources

Solar

The use of solar panels attracts the suns radiation waves and absorbs them. This is then transfered to electricity to be used for all purposes. The greatest strength of solar energy is the small size which allows implementation almost anywhere. It can also take a house off the grid, meaning no more reliance on power lines for electricity.

Wind

Wind turbines are placed in open areas and move when the wind blows. This movement generates energy and it can be used for electricity. There are different sizes of wind turbines that allow for wind energy development on varying scales. The larger sized turbines have been known to impact bird migration paths. Also, the size creates unwanted visual impacts.

Biomass

Biomass takes crops or any other plant byproduct, from switch grass to wood chippings, and burns them to create energy. The plants, and other sources of biomass, take energy from the sun to grow and produce the nutrients required to produce useful energy for humans. Since plant products are mostly used, little to no environmental impacts occur.

Traditional Energy

Natural Gas

Natural gas is the current fuel used for energy. It extracts the gas from miles below the earth's surface to then be used for various energy reasons. The supply of this fossil fuel will diminish over time when more is being used. Harmful environmental impacts, air and water pollution, have been known to be occur during extraction.

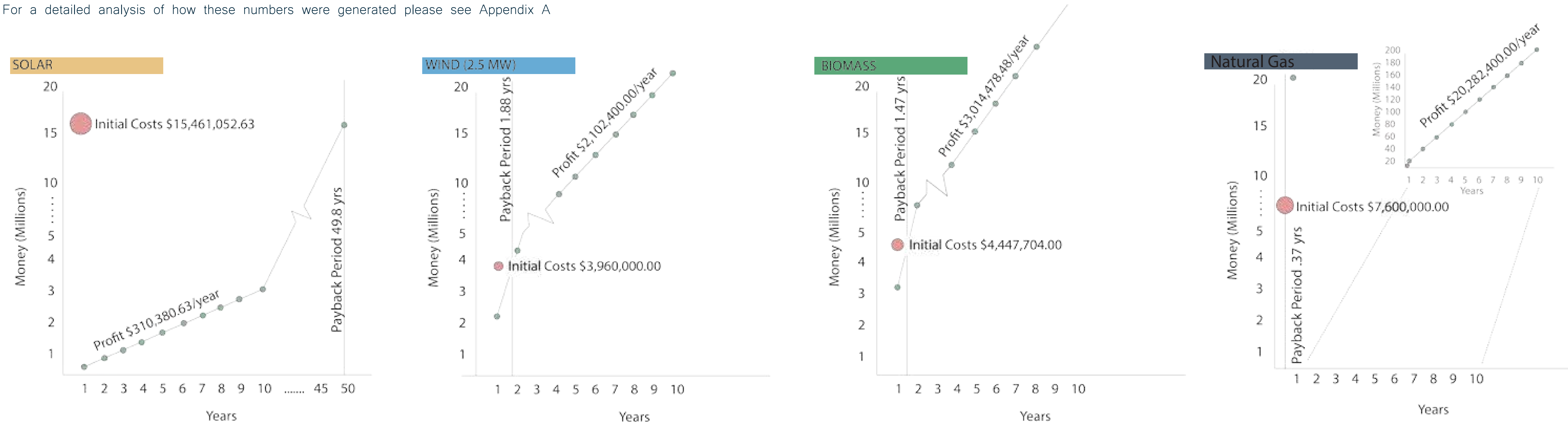
Energy Compared: Cost and Area

Different energy types require different initial costs as well as land needed to produce the same amount of energy. What if we tried to meet the energy needs of these watersheds by only using one energy type? What would the costs be and the pay back period? How much space would be needed to produce 15,600,000 kWh/yr?

Cost *

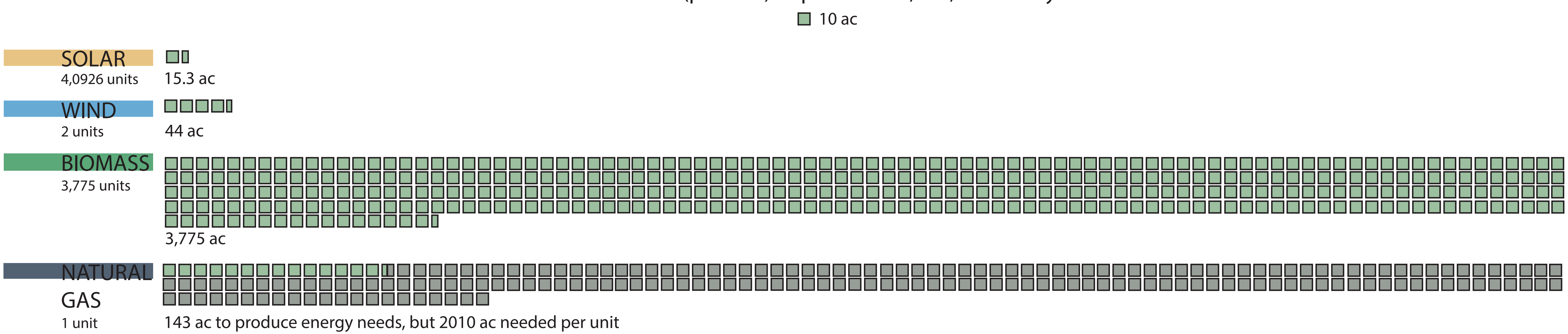
* For a detailed analysis of how these numbers were generated please see Appendix A

Based on the production of 15,600,000 kWh/yr



Area

Acres needed (per unit) to produce 15,600,000 kWh/yr



Areas Most Suitable for Renewable Energy Development

Solar

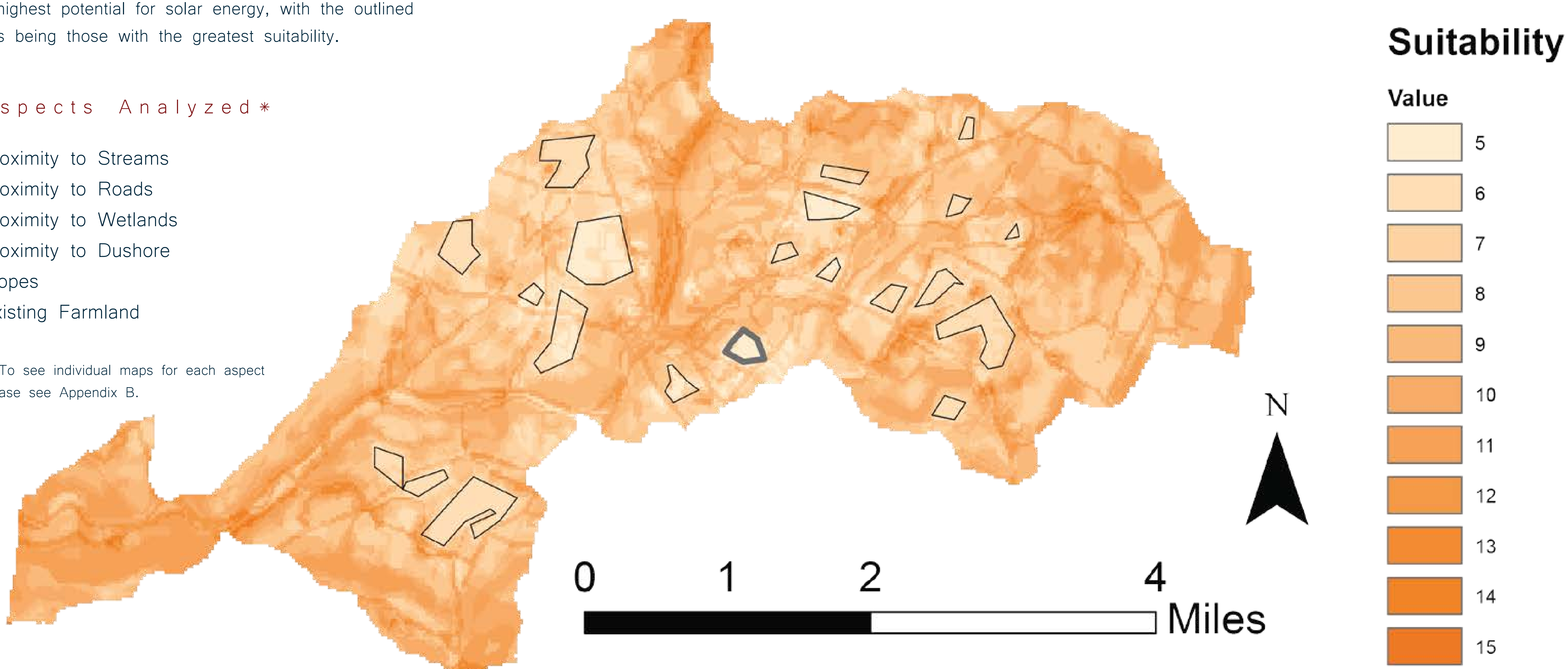
To create this suitability map different aspects of the Marsh Run and Little Loyalscok Watersheds were looked at to determine the areas that were best suited for solar energy. The aspects looked at can be found below. Overlaying that information resulted in the adjacent map, where lighter colors show areas with the highest potential for solar energy, with the outlined areas being those with the greatest suitability.

It was determined previously that only 15.3 acres are needed to fulfill the energy requirements for these watersheds. The total area most suitable is 665 acres. This means all the **energy needed** for the watersheds **can** be developed just from solar energy.

Aspects Analyzed*

Proximity to Streams
Proximity to Roads
Proximity to Wetlands
Proximity to Dushore
Slopes
Existing Farmland

* To see individual maps for each aspect please see Appendix B.



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Areas Most Suitable for Renewable Energy Development

Wind

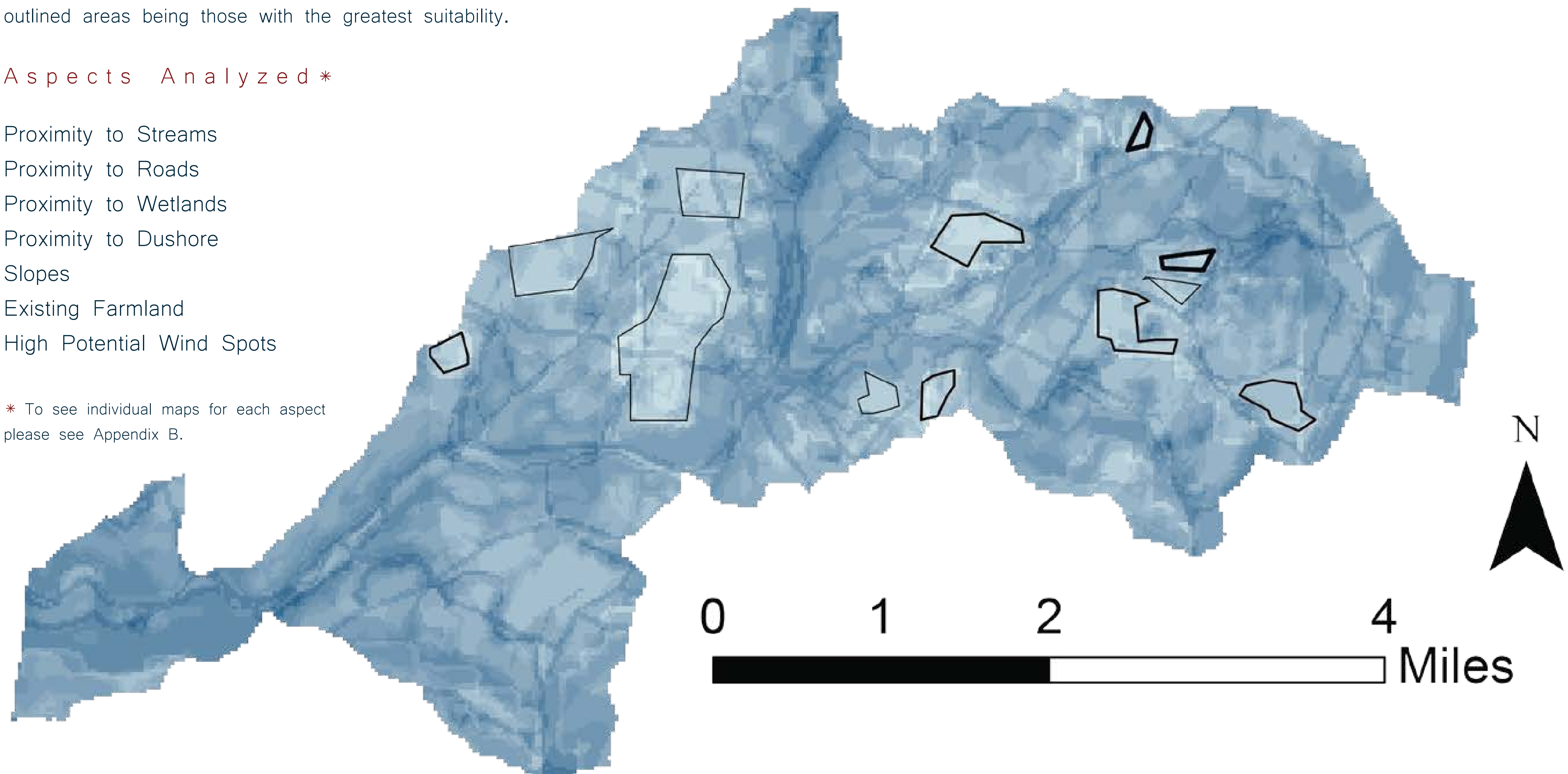
To create this suitability map different aspects of the Marsh Run and Little Loyalsck Watersheds were looked at to determine the areas that were best suited for wind energy. The aspects looked at can be found below. Overlaying that information resulted in the adjacent map, where lighter colors show areas with the highest potential for wind energy, with the outlined areas being those with the greatest suitability.

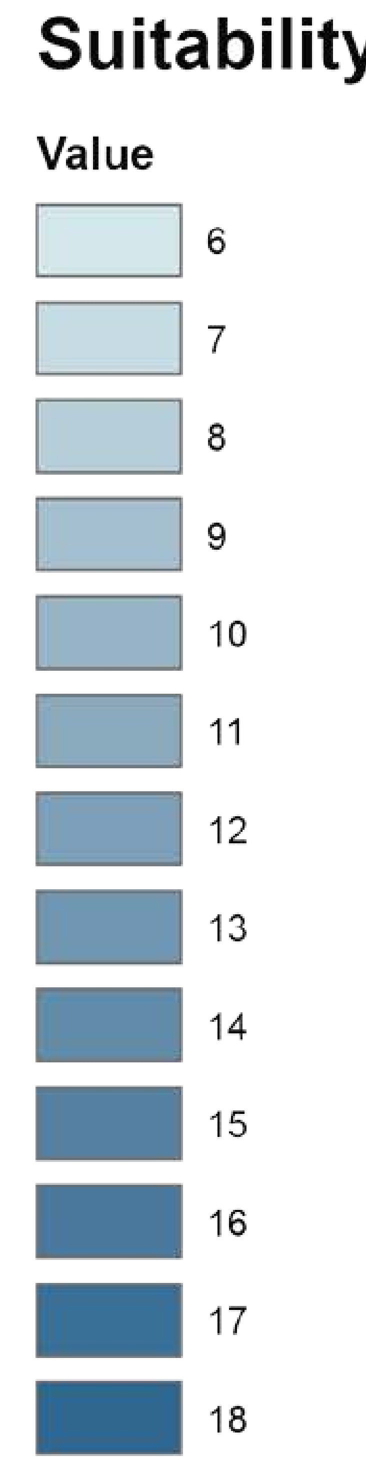
It was determined previously that only 44 acres are needed to fulfill the energy requirements for these watersheds. The total area most suitable is 680 acres. This means all the **energy needed** for the watersheds **can** be developed just from wind energy.

Aspects Analyzed*

Proximity to Streams
Proximity to Roads
Proximity to Wetlands
Proximity to Dushore
Slopes
Existing Farmland
High Potential Wind Spots

* To see individual maps for each aspect please see Appendix B.





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Areas Most Suitable for Renewable Energy Development

Biomass

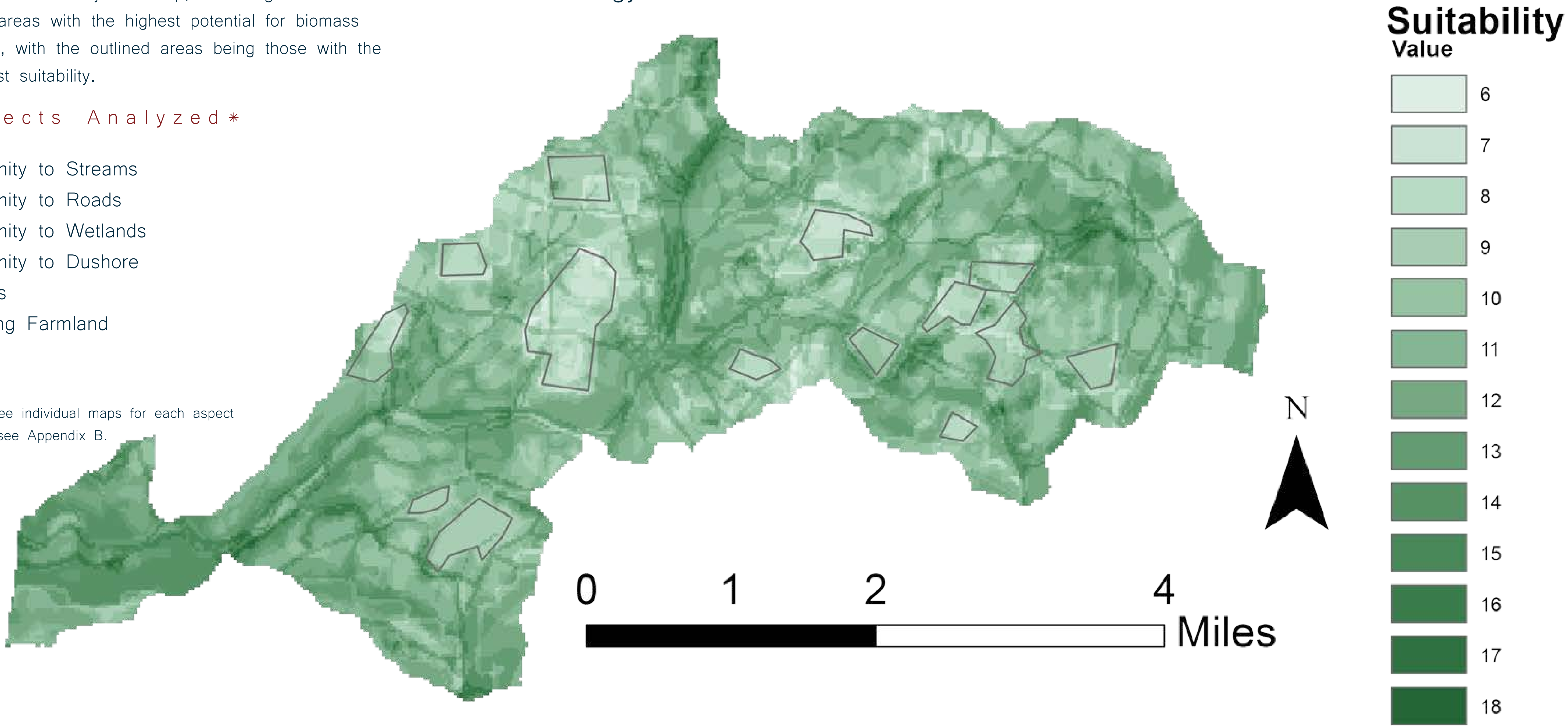
To create this suitability map different aspects of the Marsh Run and Little Loyalscok Watersheds were looked at to determine the areas that were best suited for biomass energy. The aspects looked at can be found below. Overlaying that information resulted in the adjacent map, where lighter colors show areas with the highest potential for biomass energy, with the outlined areas being those with the greatest suitability.

It was determined previously that 3,775 acres are needed to fulfill the energy requirements for these watersheds. The total area most suitable is 885 acres. This means all the **energy needed** for the watersheds **cannot** be developed just from biomass energy.

Aspects Analyzed*

Proximity to Streams
Proximity to Roads
Proximity to Wetlands
Proximity to Dushore
Slopes
Existing Farmland
Soils

* To see individual maps for each aspect please see Appendix B.



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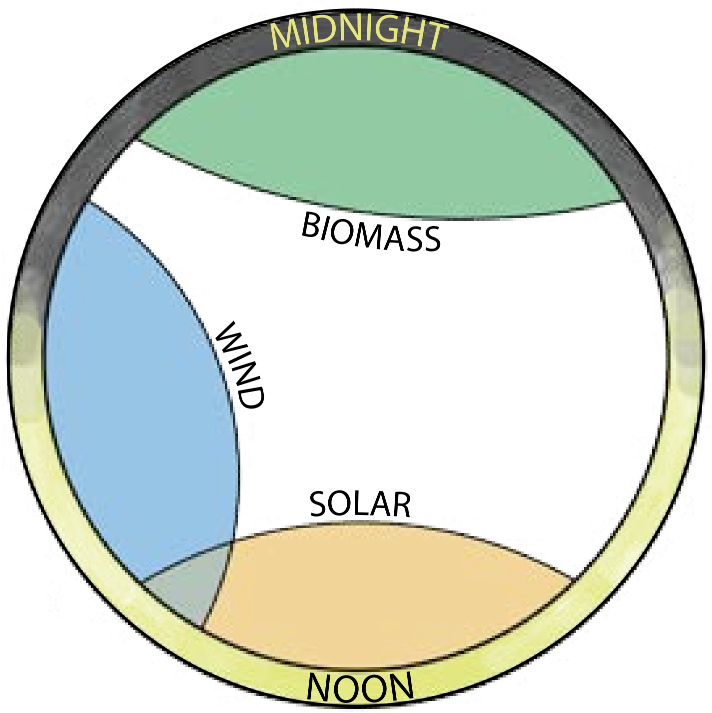
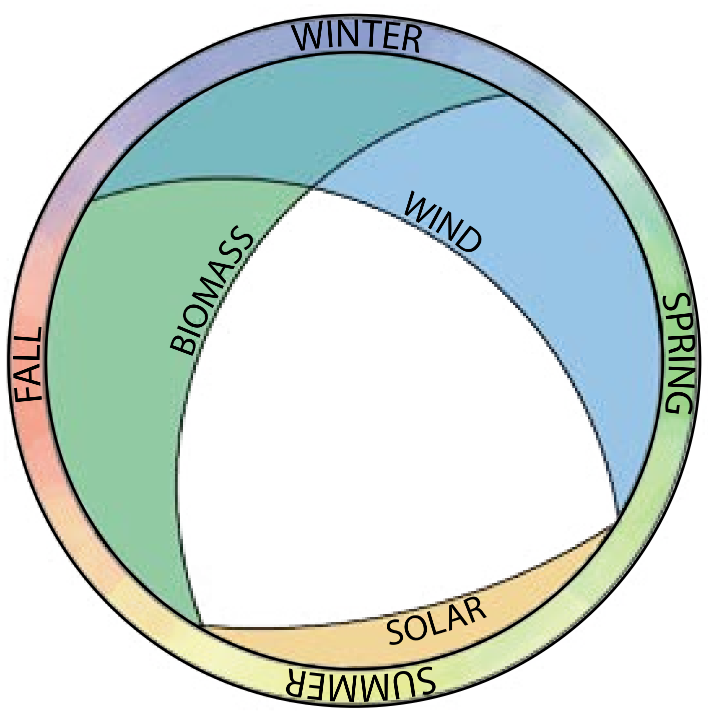
Renewable Energy Master plan



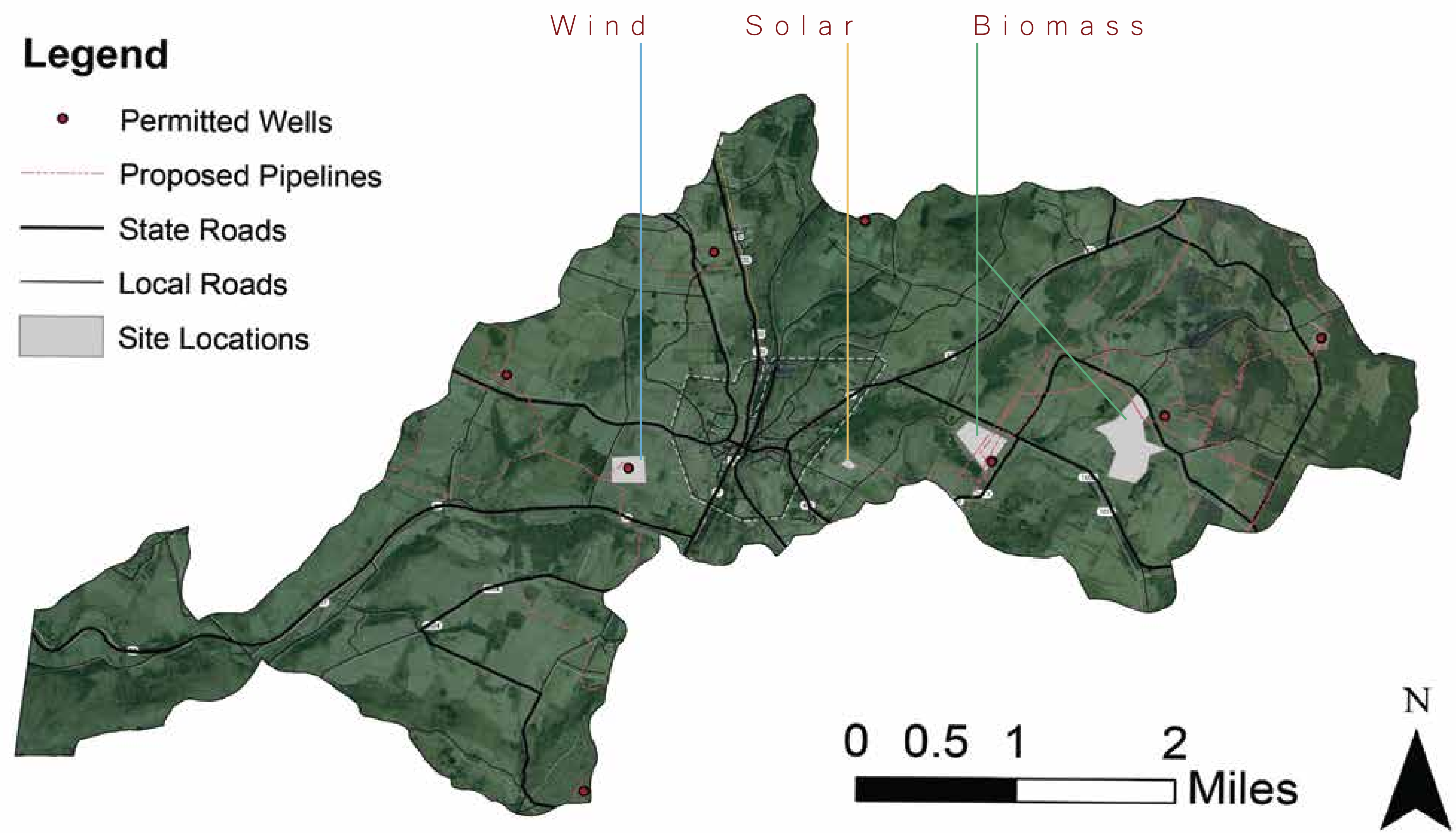


Renewable energy types **peak at different times of day and year**, so having all three implemented will allow for a **flexible and reliable energy source**.

22 Acres of Wind, 2 acres of Solar, 110 acres of Biomass to create an energy sustained watershed. 134 Acres out of a total of 10,570 Acres within the Marsh Run and Little Loyalsock Watershed

The suitability maps show areas that had the highest potential for each renewable energy source; solar, wind, and biomass, within the watersheds. It also determined that solar and wind could be the sole producer of energy to meet the community needs, and biomass could not in the land that was available. However, as the diagrams to the left show, each energy source has different peak times. So by designing a master plan with all three renewable energy types, a reliable energy source is created.

The suitability maps were used to determine where renewable energy types would be located in the final master plan found below. The sites selected were favored because of their proximity to existing or proposed natural gas infrastructure, since it will be demonstrated how to transition from natural gas to renewable energy.



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Visual Transition: Traditional to Renewable Energy

Solar

Solar panels are very flexible with where they can be implemented. That's why the transition from gas industry to solar energy would be very simple. The well pad would already impact the farming land that it is located on. When gas is extracted and the well pad no longer is being used, solar panels can be placed, south-facing, right on site. Access to the drilling site can still be reached because of the small size of the solar panels.

Types of Solar Panels

Monocrystalline

Polycrystalline

All Black

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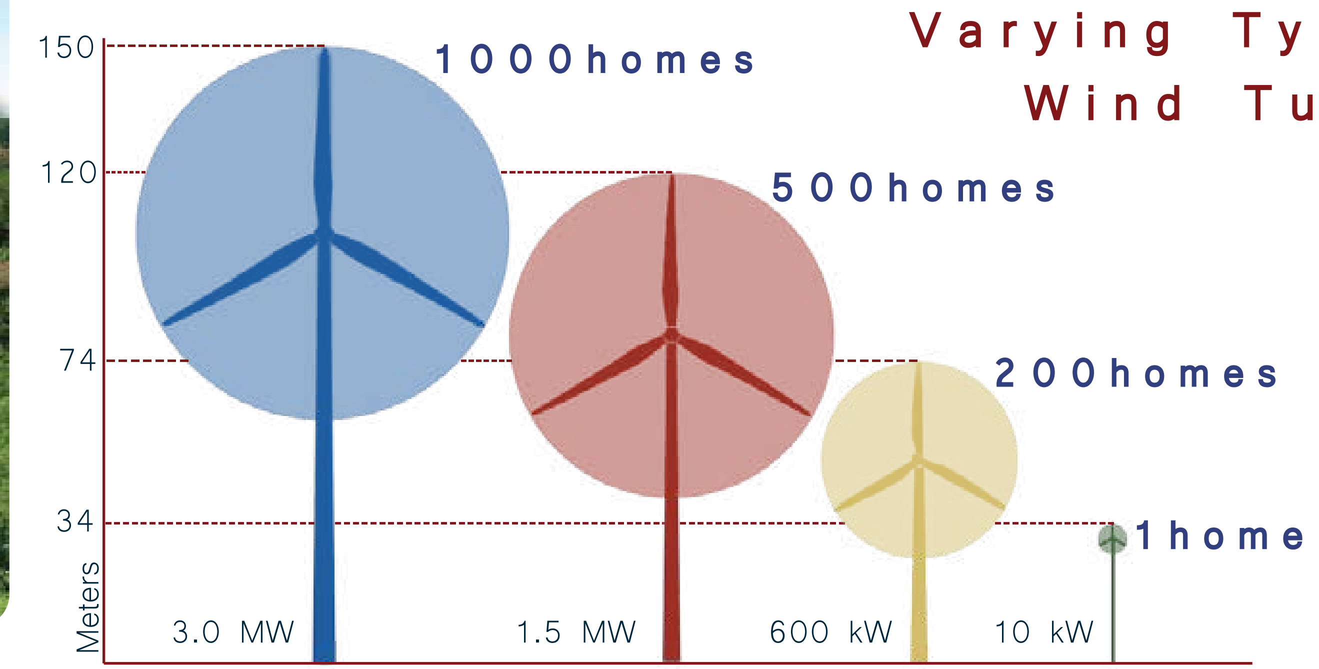
Visual Transition: Traditional to Renewable Energy

Wind

Wind turbines are not as flexible as solar panels because of their size. However, when a site is picked with a high wind potential turbines can be easily retrofitted on to it. This particular site is the location of a proposed well. So, after the well is drilled and all the natural gas is extracted, it can be a site for a 2 MW wind turbine. The same access road can be used for maintenance on the wind turbine while allowing access to the old well.

Varying Types of Wind Turbines



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Visual Transition: Traditional to Renewable Energy

Biomass

Biomass is the most flexible renewable energy source out of the three because it is essentially just planting plant material, so it can grow and then be used. This means that certain gas industry sites can start to grow biomass around it now. However, once a gas well is no longer needed, it is also quite simple to use that land for biomass development. Access roads can still be kept on site, and hardly impact the amount of biomass that can be produced.

Types of Biomass

Switch Grass

Corn

Wood Chips

Rape Seed

Visual Transition: Renewable Energy Now

Biomass

Because of the flexibility biomass has to offer, it is very easy to start using biomass now. The images to the left show how one can simply grow biomass, such as switch grass, on pipeline corridors. As well, since biomass is plant material, it can be used to buffer streams and other water resources to filter out unwanted chemicals and pollution. To learn more about water protection please see the third section of the sustainable watershed project, Emma Pritchett's work on sustainable water.

Wind and Solar

Although wind and solar energy resources work best in large open areas to provide large quantities of energy, both can still be implemented now, on smaller scales. Take downtown Dushore as an example. The images to the right display the opportunities residents can take now to start the transition to renewable energy. Things such as solar panels on their roofs to small wind turbines could generate enough energy to supply the energy needs of one household.

Greater Potential For Renewable Energy

Through the sustainable energy project it was discovered that only 134 Acres of land is needed to provide the Marsh Run and Little Loyalsock Watersheds with enough energy to sustain the community's needs. This leaves a lot of land left for potential development. What if it was converted all to renewable energy? It could make Marsh Run and Little Loyalsock watersheds energy producers and allow for exportation of excess energy for profit.

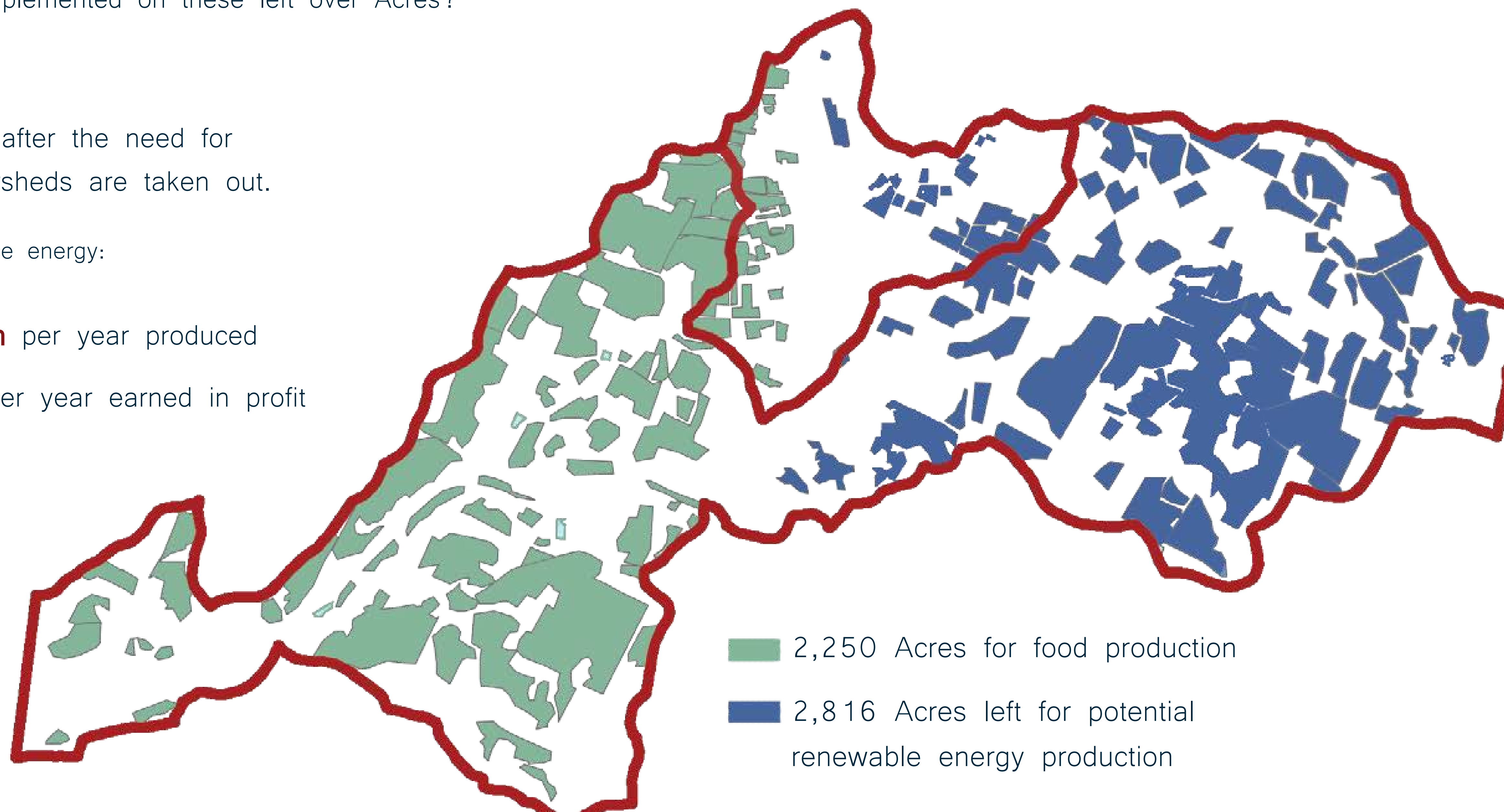
The second portion of the sustainable watershed project looks at sustainable food practices worked on by Kyrie Yaccarino. She found that 2,250 Acres are needed to grow the food requirement for these watersheds. Take that and the 134 Acres of land needed to produce the energy needs away from the 5,200 Acres of farmland that is currently available, and that leaves 2,816 Acres that can still be used. What potential benefits could be seen by these watersheds if renewable energy was to be implemented on these left over Acres?

2,816 Acres left of farmland after the need for energy and food for the watersheds are taken out.

If converted to renewable energy:

potential **1,570,000,000 kWh** per year produced

potential **$125,600,000.00** per year earned in profit



Appendix A: Detailed Cost Analysis

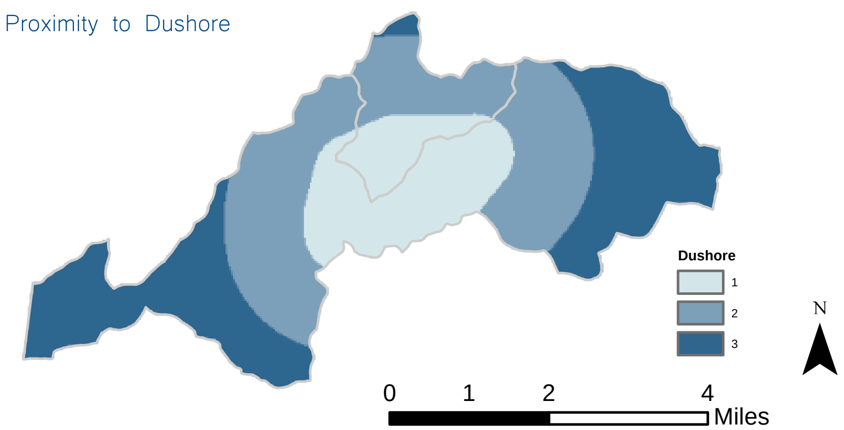
marsh/little watershed

	Acres Available	Acres Needed/Unit	Number of Units	Capacity Used	kWh/Year/Unit	Annual kWh	Production Cost/kWh	Market Value ($)/kWh	Initial Investment/Unit	Total Investment	Gross Annual Earnings	Gross Annual Royalties (12.5%)	Net Earnings (10 Years)	Net Earnings (20 years)
Natural Gas														
Horizontal Deep Well	3522.99	2010	1.752731343	100%	225360000	394995535.5	$ 0.04	$ 0.13	$ 7,600,000.00	13,320,758.21	35,549,598.20	4,443,699.77	342,175,223.76	697,671,205.73
Biomass														
Rapeseed	339.3	1	339.3	100%	4111.4	1394998.02	$ 0.05	$ 0.13	473.16	160,543.19	108,809.85	13,601.23	927,555.27	2,015,653.72
Sunflower	339.3	1	339.3	100%	3302.6	1120572.18	$ 0.05	$ 0.13	396.91	134,671.56	87,404.63	10,925.58	739,374.74	1,613,421.04
Pumpkin Seed	339.3	1	339.3	100%	1853.5	628892.55	$ 0.05	$ 0.13	1,785.00	605,650.50	49,053.62	6,131.70	(115,114.31)	375,421.88
Flaxseed	339.3	1	339.3	100%	1651.3	560286.09	$ 0.05	$ 0.13	336.59	114,204.99	43,702.32	5,462.79	322,818.16	759,841.31
Soybeans	339.3	1	339.3	100%	1550.2	525982.86	$ 0.05	$ 0.13	349.63	118,629.46	41,026.66	5,128.33	291,637.17	701,903.80
Oats	339.3	1	339.3	100%	741.4	251557.02	$ 0.05	$ 0.13	336.88	114,303.38	19,621.45	2,452.68	81,911.09	278,125.57
Corn	339.3	1	339.3	100%	606.6	205819.38	$ 0.05	$ 0.13	536.41	182,003.91	16,053.91	2,006.74	(21,464.80)	139,074.32
Wind														
2.5 MW	197	22	8.954545455	60%	13140000	117662727.3	$ 0.05	$ 0.13	$ 1,980,000.00	17,730,000.00	9,413,018.18	1,176,627.27	76,400,181.82	170,530,363.64
50 KW	197	11	17.90909091	60%	262800	4706509.091	$ 0.05	$ 0.13	99,000.00	1,773,000.00	376,520.73	47,065.09	1,992,207.27	5,757,414.55
10 KW	197	0.5	394	60%	52560	20708640	$ 0.05	$ 0.13	19,800.00	7,801,200.00	1,656,691.20	207,086.40	8,765,712.00	25,332,624.00
Solar														
1 KW PV Cell	339.3	0.0038	89289.47368	44%	3854.4	344157347.4	$ 0.11	$ 0.13	3,840.00	342,871,578.95	6,883,146.95	860,393.37	(274,040,109.47)	(205,208,640.00)

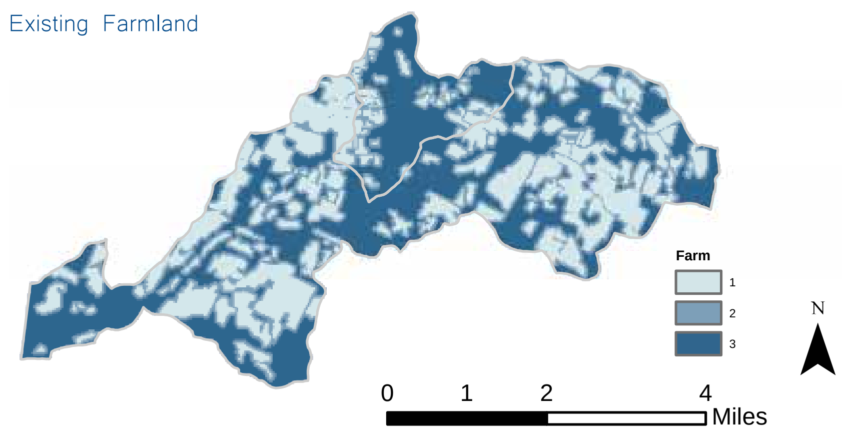
	Royalty Based Net Earnings (10 Years)	Royalty Based Net Earnings (20 Years)	Initial Investment Subsidy	Subsidized Total Investment	kWh Subsidy	Subsidized Gross Annual Earnings	Subsidized Gross Annual Royalties (12.5%)	Subsidized Net Earnings (10 Years)	Subsidized Net Earnings (20 years)	Subsidized Royalty Based Net Earnings (10 Year	Subsidized Royalty Based Net Earnings (20 Year
Natural Gas											
Horizontal Deep Well	297,738,226.01	608,797,210.24		13,320,758.21	$ -	35,549,598.20	4,443,699.77	377,724,821.96	1,053,167,187.70	333,287,824.21	964,293,192.21
Biomass											
Rapeseed	791,542.96	1,743,629.11		160,543.19	$ 0.011	124,154.82	15,519.35	1,051,710.09	3,257,201.96	896,516.56	2,946,814.90
Sunflower	630,118.95	1,394,909.46		134,671.56	$ 0.011	99,730.92	12,466.37	839,105.66	2,610,730.28	714,442.01	2,361,402.97
Pumpkin Seed	(176,431.33)	252,787.83		605,650.50	$ 0.011	55,971.44	6,996.43	(59,142.87)	935,136.25	(129,107.17)	795,207.66
Flaxseed	268,190.27	650,585.53		114,204.99	$ 0.011	49,865.46	6,233.18	372,683.63	1,258,495.93	310,351.80	1,133,832.28
Soybeans	240,353.84	599,337.14		118,629.46	$ 0.011	46,812.47	5,851.56	338,449.65	1,170,028.55	279,934.05	1,052,997.36
Oats	57,384.28	229,071.95		114,303.38	$ 0.011	22,388.57	2,798.57	104,299.67	502,011.32	76,313.95	446,039.88
Corn	(41,532.19)	98,939.54		182,003.91	$ 0.011	18,317.92	2,289.74	(3,146.87)	322,253.57	(26,044.28)	276,458.76
Wind											
2.5 MW	64,633,909.09	146,997,818.18	25%	13,297,500.00	$ 0.022	12,001,598.18	1,500,199.77	92,834,280.00	294,978,845.45	77,832,282.27	264,974,850.00
50 KW	1,521,556.36	4,816,112.73	30%	1,241,100.00	$ 0.022	480,063.93	60,007.99	3,004,171.20	11,089,953.82	2,404,091.29	9,889,794.00
10 KW	6,694,848.00	21,190,896.00	30%	5,460,840.00	$ 0.022	2,112,281.28	264,035.16	13,218,353.28	48,795,796.80	10,578,001.68	43,515,093.60
Solar											
1 KW PV Cell	(282,644,043.16)	(222,416,507.37)	30%	240,010,105.26	$ 0.022	14,454,608.59	1,806,826.07	(156,724,027.20)	42,198,919.58	(174,792,287.94)	6,062,398.11

Appendix B: Suitability Map Elements

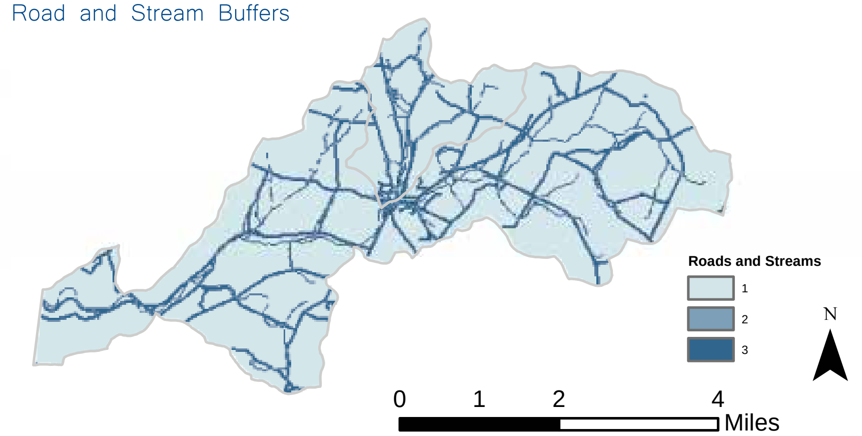
Proximity to Dushore



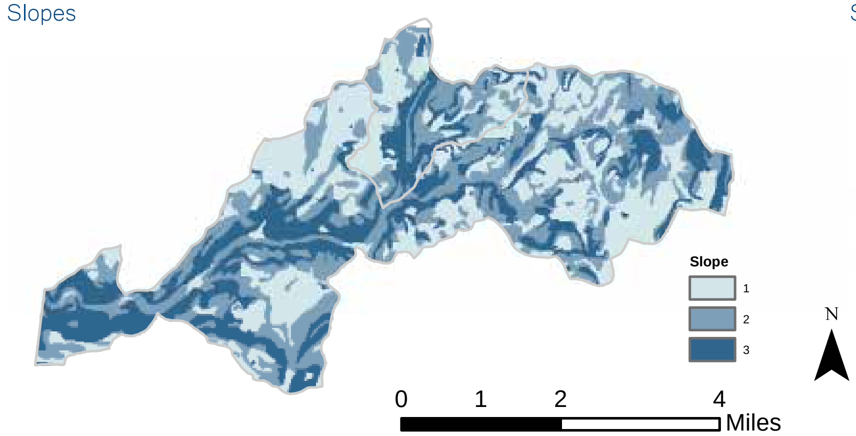
Existing Farmland



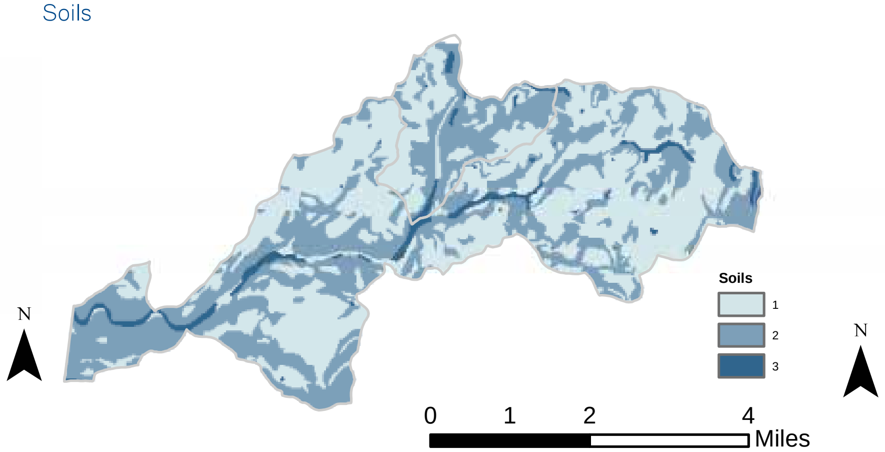
Road and Stream Buffers



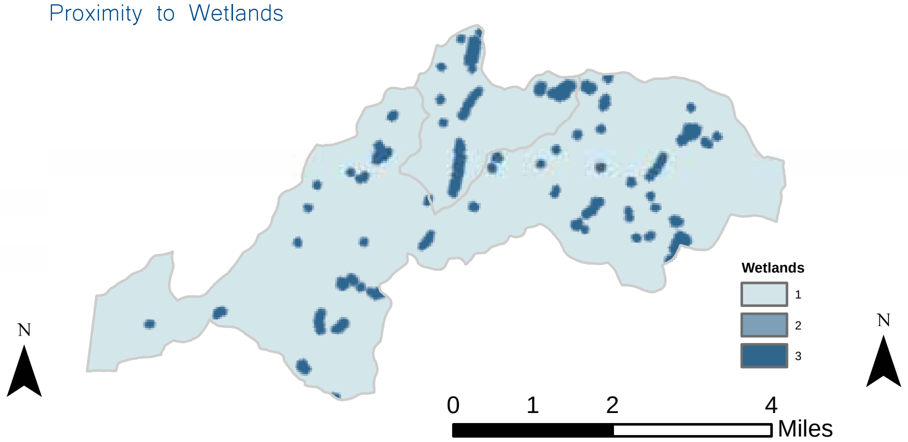
Slopes



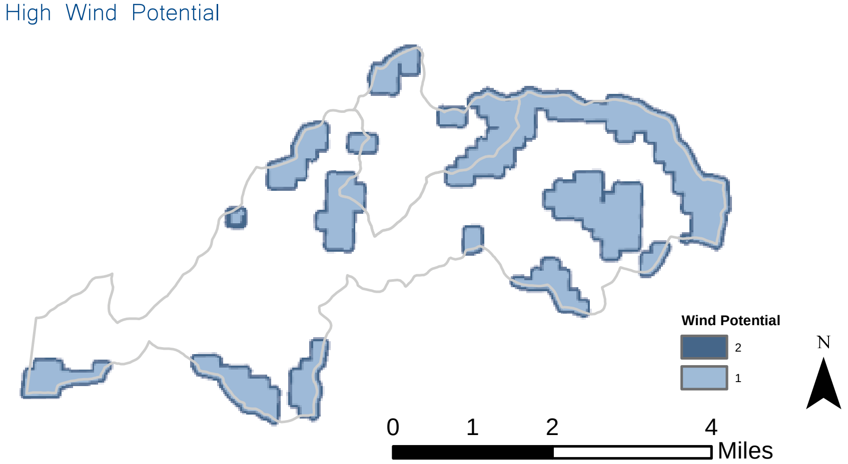
Soils



Proximity to Wetlands



High Wind Potential



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