Shroomin' in the Forest

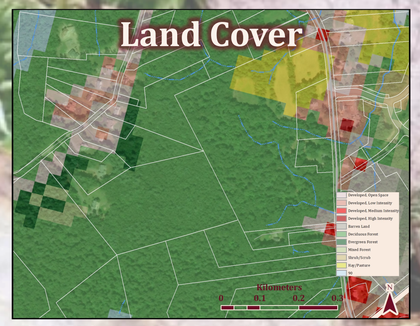
A Quest for Suitable Agroforestry Land in Holden, Massachusetts

Introduction

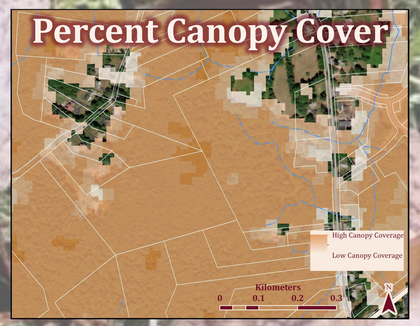
Agroforestry, or the harvest and sale of agricultural products from forests rather just traditional monocropping methods, has the potential to deliver diverse, profitable, and environmentally sustainable land use systems. These benefits, however, are only realized when the land being used for agroforestry practices is suitable for the species or crop of interest. This project looks at land suitable to grow a polyculture of shiitake mushrooms, ginseng, and ferns. These agroforestry crops were chose together because they all flourish under similar growing conditions, including:

- Land that is already covered in deciduous forest and provides at least 70% canopy cover shade. Heavy shade improves crop quality, while existing forest minimizes start-up costs and improves landowner profitability.
- Slopes between 5 and 20% since they facilitate necessary air and water drainage.
- Aspect facing N, NE, E, NW, or SE to ensure that land is moist, protected, and well-draining.
- Prime forest land to provide soil that is appropriate for deciduous trees to thrive.

The town of Holden, Massachusetts was selected for this study due to its relatively high forest density, low population, and presence of existing agricultural activity. Overall, this project explores the feasibility of using several easy-to-obtain datasets as a tool in evaluating and comparing sites that may be suitable for agroforestry. Upon evaluation of this project, I will make recommendations as to whether this sort of a model would be useful to apply for a state-wide implementation.



The MMU for land cover ranges from 1 to 7.12 acres (2.67 acres for deciduous forests). Because I am looking for plots of deciduous forest that may be smaller than 2.67 acres, this dataset will likely omit suitable plots of forest. Also, land cover has likely changed from 2011 to 2019 due to development, resulting in an overestimation of deciduous forest.



Canopy cover is measured from 0 to 100 percent coverage. Medium spatial resolution is 30 meters, thus any dense canopy cover under 30 meters in size will likely be missed. Though 30 meters is quite small, especially when considering a large enough piece of land to farm, this spatial resolution likely omits shaded areas for these crops to thrive.

The MMU for prime forest land data is 0.5 acres, meaning that this dataset will likely miss any prime forest land or cleared areas less than 0.5 acres in size, resulting in both an under and overestimation of prime forest land in different areas. Relative to other datasets, however, this MMU is quite small.

Slope (elevation) data has a raster size of about 9 meters. This cell size smooths over anything a third of its size or smaller, which would be 30 meters or smaller in extent. Slopes that change in under 30 meters will be obscured from view, resulting in both omission and commission of slopes suitable for agroforestry.

Methodology

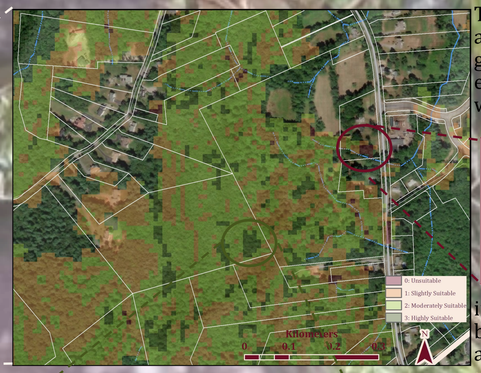
For the final polyculture suitability maps, I used deciduous forest and tree canopy cover data to determine shading, elevation data to examine slope and aspect, and prime forest land data to locate optimal forest land. For each of these datasets, I created simple models by assigning each of the categories a score based on how hospitable they are to the cultivation of this species. Scores increasing in value were most suitable with 0 categorized as unsuitable and 3 categorized as highly suitable.

It is important to plant these species on land that is in fact designated for forestry. Using NRCS designations, "Prime Forest Land" categories are ranked as 3 for highly suitable, all other types of forest categories are ranked as 2 for moderately suitable, and all wetlands or non-forested categories were ranked as 0 for unsuitable. Shiitakes, ginseng, and ferns all grow best on land with slopes from 5-20% because they facilitate the necessary air and water drainage. Slopes with a steepness of 10-20% were ranked as 3, slopes with a steepness of 5-10% were ranked as 2, and all other slopes were ranked as 0. These crops also grow best on land facing N, NE, and E, as these aspects offer more shade and available moisture than other aspects. Slopes facing N, NE, and E were ranked as 3, slopes facing SE, S, and NW were ranked as 1, and all other aspects were ranked as 0. These crops thrive when shaded by at least 70% deciduous tree canopy cover. To find land with sufficient shading, I averaged USGS land cover and percent tree canopy coverage into one score. Deciduous tree land cover was ranked as 3 and all other land covers, such as coniferous forests or mixed forests were not even considered. Percent canopy cover 70% and over were ranked as 3 and any under 70% were not even considered.

I then averaged these four individual scores, with equal weights, to obtain composite scores for all areas of land in Holden, MA to determine their relative suitability to grow shiitake mushrooms, ginseng, and ferns. For the purposes of this project, I am looking at parcels greater than 1 acre in size, as this will likely rule out most single-family homes and only consider large parcels with sufficient land for agroforestry.

Conclusions

Based on this model, 287 hectares in Holden, MA, or 3% of the state, is considered highly suitable to grow shitakes, ginseng, and ferns within an agroforestry setting. The datasets, reclassifications, and rankings I used throughout this model overall appear to be successful at modeling this suitability, however they are not without their shortcomings.



The dark green 1,830 square meter area (roughly 0.5 acres) within the green in southeastern Holden is covered entirely by deciduous forest with 87% canopy shade. It is located in Prime Forest Land 2 as designated by the USDA NRCS, sloped at 16.3%, and is facing NE. This area is highly suitable to grow the agroforestry crops of interest.

Condition	Observation	Evaluation
Land cover	Deciduous forest	Highly Suitable
Percent Canopy Cover	74%	Highly Suitable
Land appropriate for forestry	No (Non-Forest Land)	Incorrect Evaluation
Slope	35.0%	Unsuitable
Aspect	W	Unsuitable
Composite Evaluation	--	Unsuitable

Condition	Observation	Evaluation
Land cover	Deciduous forest	Highly Suitable
Percent Canopy Cover	87%	Highly Suitable
Land appropriate for forestry	Yes (Prime Forest Land 2)	Highly Suitable
Slope	16.3%	Highly Suitable
Aspect	NE	Highly Suitable
Composite Evaluation	--	Highly Suitable

While the dark red area 743 square meter area (roughly 0.18 acres) within the red circle in southeastern Holden is also covered entirely by deciduous forest with 74% canopy shade (highly suitable), it is sitting on a slope that is graded at 35.0% and is facing W–two conditions that are unsuitable for this polyculture. The model also noted that the NRCS dataset regarded this area as non-forested land, which also contributed to this area's unsuitable rating. If we look closely at the aerial map underneath, we can see that this area is in fact covered in trees. Because the minimum mapping unit (MMU) for Prime Forest Land was 0.5 acres, this dataset omitted this area of forested land since it was less than the MMU. Thus, our model shows us that this land is completely unsuitable for these species when in reality it might actually be slightly or even moderately suitable. This omission is particularly significant since it is connected to a larger plot of land that is more suitable for cultivation. Due to the size of the MMU, it is also possible that the prime forest land data also missed cleared areas that were smaller than the MMU and included locations as prime forest land when they were actually not.

Despite imperfect data, this model can serve as a foundational tool to help farmers, landowners, and planners understand how to find suitable areas for agroforestry throughout the state of Massachusetts. Future work may include studying different conditions suited to different agroforestry cropping systems. Additionally, because forests provide essential conservation and economic benefits to farms, future work could also assess the suitability of agroforestry specifically on parcels specifically adjacent to farms. Finally, this work can be taken even further to help find sites that may be suitable to plant new deciduous forests to later serve as agroforestry locations.

References

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NUTR 231: Fundamentals of GIS, Spring 2019; Projection: Massachusetts State Plane Projection

Data Sources: 1. NRCS/MassGIS Prime Forest Land (2013); 2. USGS Elevation 1/3 arc second (2018); 3. USGS NLCD Land Cover 3X3 degree (2011); 4. USGS NLCD USFS Percent Tree Canopy 3X3 degree (2011); 5. MassGIS Standardized Assessors Parcels Holden, MA (2019); 6. Aerial Basemap, Esri, DigitalGlobe, GeoEye, Earthstar Geogrpahics, CNES/Airbus DS, USDA, AeroGRID, IGN, and GIS User Community

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