Land Cover and Land Use Change in College Town: Amherst, New York– Identifying Indicators of Local and Student Population Dynamics and the Physical Changes in Consequence to Studentification

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Abstract

This project examined the land cover and land use (LCLU) changes between 2010 – 2024 in Amherst, New York. Additionally, since Amherst hosts multiple academic campuses– such as the University at Buffalo's (UB) North Campus, the study looked at any evidence of physical changes resulting from studentification. The study found that there was an increase in residential land use supporting the overall Town's population growth. The study also identified the majority of apartment land use change occurring within a two-mile radius of the university campus, which supports the University's increase student population along with the physical land use changes corresponding with the studentification process.

1.0 Introduction

Urban growth, enhanced by increasing populations, has been a primary factor in vegetation to urban surface land cover change (Ducey et al., 2018; Nyiranshimiyimanan & Mupenzi, 2020). In towns that host academic institutions, commonly referred to as “college towns”, overall town population varies based on the academic calendar, resulting in major seasonal increase and decrease population shifts (Sage et al., 2012).

College towns often face studentification, a process where the growing student population significantly affects town characteristics. The studentification process affects a range of social, cultural, economic, and physical transformations (Mohammed & Ukai, 2022; Smith, 2004). While an increase in student population does create some economic benefits, it often creates challenges for long-term residents (Jolivet et al., 2023; Mosey, 2017). An increase in student population often attracts private businesses, such as chain retailers and real estate developers, which increases urban cover and land use tailored towards students. This shift in businesses and land use can displace locally owned businesses and alter neighborhood characteristics (Savage, 2025; Zasina, 2021). The construction of student-oriented facilities also increases property values near the campus(s), making real estate unaffordable for non-student residents and increasing local residential feelings of exclusion from these areas (Baron & Diamant, 2016; Mosey, 2017; Rogaly & Taylor, 2015; Savage, 2025).

Physically, increase student populations often lead to more off-campus student housing– resulting in greater noise and traffic during the academic year, while academic breaks can leave parts of the town feeling like "ghost towns" (Kinton et al., 2018; Sage et al., 2012). Despite these challenges, an increase in student population can bring benefits such as higher consumerism and a workforce, allowing students to contribute positively to the local economy during academic periods (Zasina, 2021).

This project was conducted to examine land cover and land use changes between 2010 – 2024, in Amherst, New York, a college town. The study aims to assess whether these changes reflect the Town and the university's, residing inside the boundary, population dynamics and if there is any evidence of studentification based on the land use changes.

2.0 Study Area

The project focused on the Town of Amherst (Amherst), located in Erie County, New York. With parts of SUNY University at Buffalo (UB) and Erie Community College residing within the Town's boundary, Amherst is considered a college town (Town of Amherst, 2025). This project focuses on land cover and land use change across Amherst, and specifically near the UB's North Campus area. According to the US Census, the Town of Amherst experienced a 6.84% increase in its total population from 2010 – 2023. The population grew from 120,945 in 2010 to 129,209 in 2023, resulting in an increase of 8,264 residents (U.S. Census Bureau, 2023) (Fig. 1, Table 1).

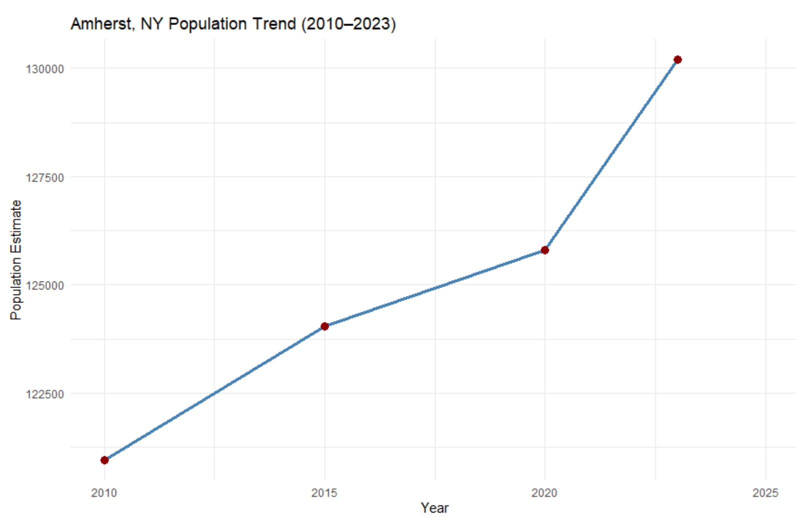

Figure 1. Amherst, NY Population Trend from 2010 – 2023 (U.S. Census Bureau, 2023)

Amherst Total Population from 2010 - 2023

year	population
2010	120945
2015	124044
2020	125799
2023	130209

Table 1. Amherst, NY total populations between 2010, 2015, 2020, and 2023 (U.S. Census Bureau, 2023)

From the University at Buffalo enrollment data, UB's student enrollment rose by 2.9% from 2010 to 2015, followed by an 8.5% increase from 2015 – 2020. However, between 2020 – 2024, total enrollment declined by 1.4% (University at Buffalo, 2023) (Fig. 2, Table 2).

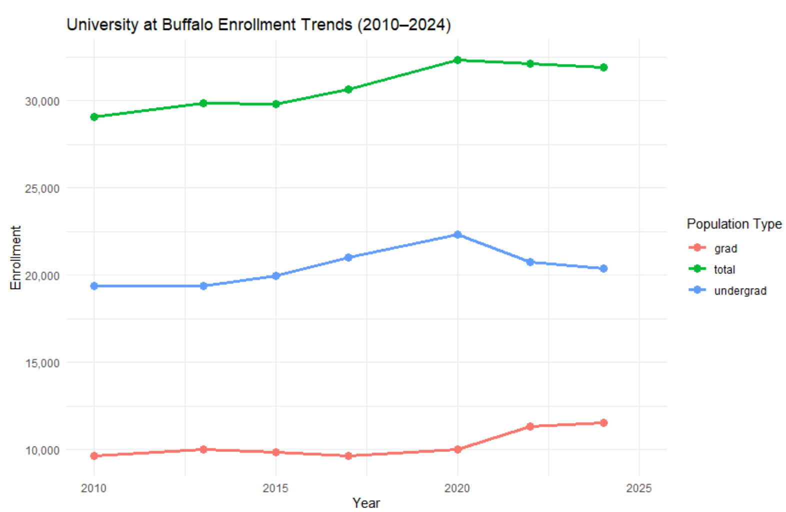

Figure 2. University at Buffalo Enrollment Trends 2010 - 2024 (University at Buffalo, 2023)

UB Enrollment Rates of Change (%)

Interval	Undergrad	Graduate	Total
2010–2015	2.898551	2.029196	2.609474
2015–2020	11.803920	1.887367	8.525129
2020–2024	-8.728593	14.968629	-1.372616

Table 2. University at Buffalo's 2010 - 2024 Enrollment Rates of Change (University at Buffalo, 2023)

3.0 Methods

3.1 Data

Landsat-5TM, Landsat-8 OLI, and Landsat-9 OLI-2 Surface Reflectance products (30 m^2; Path 17, Row 30) were used for this project. Sentinel-2 OLI products (10 m^2) were incorporated as the ground truth dataset for calculating Landsat land cover accuracy. Landsat products were sourced from *USGS EarthExplorer* and Sentinel products were sourced from the *Copernicus Browser*. All remote sensing products were acquired between August 1 to September 21 with the least visible cloud cover within the study site. Landsat products, used for classifications, were created in 2010, 2015, 2017, 2020, and 2024 while Sentinel products, used as ground truth samples, were created in 2017, 2020, and 2024. For the classification process, the blue (450-515 nm), green (525-605 nm), red (630-690 nm), and near-infrared (750-900 nm) bands were utilized (Landsat-5: B1, B2, B3, B4) (Landsat-8 and -9, and Sentinel-2: B2, B3, B4, B5).

3.2 Remote Sensing Imagery Preprocessing

Before the classification process begun, all remotely sensed images were reprojected to a common coordinate system: Universal Transverse Mercator (UTM) WGS 8436 using *ArcGIS Pro*. All remote sensing raster images were clipped to the Town of Amherst boundary. Areas where agricultural land use changed from bare soil to vegetation cover, due to harvesting, significantly affected multiple accuracy metrics. To address this issue, the images were further clipped to a bounding box of (easting 676515 – 687885, northing 4757295 – 4769175).

3.3 Image Classification

All images were classified using a supervised classification method in *ArcGIS Pro*. All Landsat and Sentinel images were initially classified into four land cover categories: Water, Building, Road, and Vegetation. Due to the large spatial resolution of Landsat products, the building and road classes were later merged into a single urban surface class to conduct a change analysis. Trainings samples were placed throughout the entire study area– with a minimum of 2,000 Landsat training pixels and 5,000 Sentinel training pixels. Due to the absence of accuracy assessments, higher quantities of training pixels were required for the 2010 and 2015 Landsat images with 9,776 and 5,686 total pixels, respectively. The 2017, 2020, and 2024 Landsat images were classified based on how well their results were during their accuracy assessments with the classified Sentinel images. After analyzing areas with inconsistent classifications, pixels classified as building or road were merged into one single urban surface class, to help the accuracy metrics using *RStudio*.

3.4 Accuracy Assessments

Accuracy assessments were performed with *ArcGIS Pro* on the classified 2017, 2020, and 2024 Landsat images, with the classified Sentinel 2017, 2020, and 2024 images used as the referenced ground truths. Four-class confusion matrices were created using randomly selected pixels within the study site. Each class had relatively similar randomly selected pixel counts within each year assessed. In 2017, 2020, and 2024, each class had between 400 – 450, 830 – 960, and 750 – 965 pixels, respectively. User Accuracy (UA), Producer Accuracy (PA), Overall Accuracy (OA), and Kappa Score were all derived from the resulting confusion matrices.

After assessing the accuracy measurements, the building and road classes were combined into a single urban surface class, to address challenges arising from the 30m^2 Landsat spatial resolution such as the poor edge detection in residential neighborhoods. The four-class confusion matrices were then updated to three-class confusion matrices and corresponding accuracies metrics were updated accordingly.

3.5 Land Cover Change Analysis

Land cover change analysis was performed in *RStudio*. Each classified Landsat image was reclassified with numerical values: 0 for Water, 1 for Urban Surface, and 3 for Vegetation. Change detection was carried out in three, roughly five-year, intervals: 2010 - 2015, 2015 - 2020, and 2020 - 2024. For each interval, changes in land cover were assessed by comparing the pixel values at corresponding locations between the two images to determine whether the two associated pixel classes changed or remained the same. The 2017 Landsat image was excluded from the analysis due to differences in its classification method and accuracy.

3.6 Land Use Change Analysis

Land use change analysis was conducted using 2010 and 2024 Landsat images and focused on the 2010 image pixels classified as vegetation and later reclassified in the 2024 image as urban surface. A local analysis was performed using a focal 5×5 pixel moving window to identify hotspots of vegetation-to-urban surface change. Hotspots were defined as areas where at least 15 out of the 25 neighboring pixels within the window indicated vegetation-to urban surface change. After each hotspot was identified, the land use was manually assigned using *Google Maps*.

Land use analysis was carried out for the entire study area. To investigate any correlation between land use change and University at Buffalo's student population dynamics, a two-mile buffer was placed around UB's North Campus. Land use hotspots, within this two-mile buffer, were later compared to the overall land use classification and the land use located outside the buffer.

4.0 Results and Discussion

4.1 Land Cover Classification and Accuracy

Accuracy assessments for the 2017, 2020, and 2024 Landsat land cover classifications had an average OA and Kappa score of 0.69 and 0.58, respectively. Further analysis of pixel misclassifications and other metrics, derived from the confusion matrices, indicated that the building, road, and vegetation classes contributed the most to the low OA and Kappa score. The Road class had the lowest average UA of 0.53– with true building and vegetation pixels incorrectly identifying as road pixels. This was primarily due to Landsat's $30m^2$ spatial resolution, which made it difficult to distinguish road, building, and vegetation pixels, specifically in residential neighborhoods, where these classes are located in close proximity. Additional training samples, located in residential areas, were added to the 2017 Landsat classification analysis to try to address the classification discrepancy. Despite the effort, the OA, Kappa, and road UA remained low. Due to the difference in classification accuracy and classification technique, the 2017 Landsat image was omitted from the land cover change analysis (Table 3, 4, and 5).

Since the building class had a higher average UA of 0.80, compared to the road class, the building and road classes were merged into a single class: urban surface class. After reducing the classification to three classes, the average OA and Kappa Score increased to 0.79 and 0.70, respectively (Table 6 and 7).

2017 - Confusion Matrix

Classfied	Referenced				Total	Accuracy
ClassValue	Water	Building	Road	Vegetation	Total	UA
Water	213.0	3.00	5.00	7.00	228	0.93
Building	29.0	303.00	31.00	4.00	367	0.83
Road	77.0	104.00	310.00	103.00	594	0.52
Vegetation	111.0	14.00	69.00	333.00	527	0.63
Total	430.0	424.00	415.00	447.00	1716	0.00
PA	0.5	0.71	0.75	0.74	0	0.68

Note:
Overall Accuracy = 0.68, Kappa = 0.57

2020 - Confusion Matrix

Classfied	Referenced				Total	Accuracy
ClassValue	Water	Building	Road	Vegetation	Total	UA
Water	800.00	45.00	6.0	2.00	853	0.94
Building	28.00	366.00	54.0	24.00	472	0.78
Road	17.00	482.00	860.0	328.00	1687	0.51
Vegetation	5.00	62.00	40.0	476.00	583	0.82
Total	850.00	955.00	960.0	830.00	3595	0.00
PA	0.94	0.38	0.9	0.57	0	0.70

Note:
Overall Accuracy = 0.7, Kappa = 0.59

2024 - Confusion Matrix

Classfied	Referenced				Total	Accuracy
ClassValue	Water	Building	Road	Vegetation	Total	UA
Water	559.00	52.00	17.00	18.00	646	0.87
Building	63.00	594.00	87.00	8.00	752	0.79
Road	122.00	260.00	728.00	185.00	1295	0.56
Vegetation	106.00	58.00	133.00	545.00	842	0.65
Total	850.00	964.00	965.00	756.00	3535	0.00
PA	0.66	0.62	0.75	0.72	0	0.69

Note:
Overall Accuracy = 0.69, Kappa = 0.58

Table 3, 4, and 5. Accuracy Assessments for Landsat-8 SR for 2017 and 2020, and Landsat-9 SR for 2024, respectively

2020 - Confusion Matrix (UrbanSurface merged)

Classified	Referenced			Total	Accuracy	
ClassValue	Water	UrbanSurface	Vegetation	Total	UA	PA
Water	800	51	2	853	0.94	0.94
Vegetation	5	102	476	583	0.82	0.92
UrbanSurface	45	1762	352	2159	NA	0.57

Note:
Overall Accuracy = 0.85, Kappa = 0.78

2024 - Confusion Matrix (UrbanSurface merged)

Classified	Referenced			Total	Accuracy	
ClassValue	Water	UrbanSurface	Vegetation	Total	UA	PA
Water	559	69	18	646	0.87	0.66
Vegetation	106	191	545	842	0.65	0.87
UrbanSurface	185	1669	193	2047	NA	0.72

Note:
Overall Accuracy = 0.78, Kappa = 0.69

Table 6 and 7. Accuracy Assessments for Landsat-8 SR 2020 and Landsat-9 SR, respectively

4.2 Land Cover Change Analysis

Land cover change across the study area was assessed for three, roughly five-year, intervals: 2010 – 2015, 2015 – 2020, and 2020 – 2024. The 2015 – 2020 interval showed an increase in water and vegetation pixels, and a decrease in urban surface pixels compared to other intervals. This difference is most likely due to human error, as each year was classified independently without any cross-referencing between Landsat images.

Overall, among the three intervals, the water class represented the smallest proportion of land cover, averaging just 3.2% of the total area. Changes in the water class were minimal, except between 2015–2020, when more than 54% of water pixels were reclassified as urban surface.

Vegetation accounted for 43.3% of the overall pixels, making it the second largest class. The primary change observed in the vegetation class was to urban surface, with the highest total pixel change (12,880 pixels) occurring in the 2015– 2020 interval (Table 8, 9, and 10).

Land Cover Changes (2010–2015)

From_Class	To_Class	Pixel_Count
Urban	Urban	56364
Urban	Vegetation	14494
Urban	Water	3477
Vegetation	Urban	3680
Vegetation	Vegetation	46515
Vegetation	Water	1086
Water	Urban	751
Water	Vegetation	843
Water	Water	1979

Land Cover Changes (2015–2020)

From_Class	To_Class	Pixel_Count
Urban	Urban	55730
Urban	Vegetation	4665
Urban	Water	399
Vegetation	Urban	12880
Vegetation	Vegetation	48809
Vegetation	Water	162
Water	Urban	3560
Water	Vegetation	1294
Water	Water	1688

Land Cover Changes (2020–2024)

From_Class	To_Class	Pixel_Count
Urban	Urban	61166
Urban	Vegetation	9243
Urban	Water	1782
Vegetation	Urban	6388
Vegetation	Vegetation	47519
Vegetation	Water	901
Water	Urban	305
Water	Vegetation	52
Water	Water	1898

Table 8, 9, and 10. Land cover changes between 2010 – 2015, 2015 – 2020, and 2020 – 2024, respectively.

The urban surface class appeared as the highest proportion land cover class, averaging 53.5% of the overall pixels, across the three intervals. The most common change from urban surface was to vegetation, which is likely due to the classification limitations brought by Landsat's 30m² spatial resolution– especially in suburban residential neighborhoods where different land cover types are relatively in close proximity. The high proportion of urban surface-to-vegetation pixel change is likely a result of misclassification, as the 30m² pixels, located in residential neighborhoods, often have both urban surface and vegetation within a single pixel, making accurate distinctions difficult.

In summary, the dominant land cover change observed was from vegetation to urban surface. Instances of urban surface changing to vegetation are likely due to misclassification, particularly due to the detection difficulties associated with 30m² pixels in suburban residential areas (Figure 3).

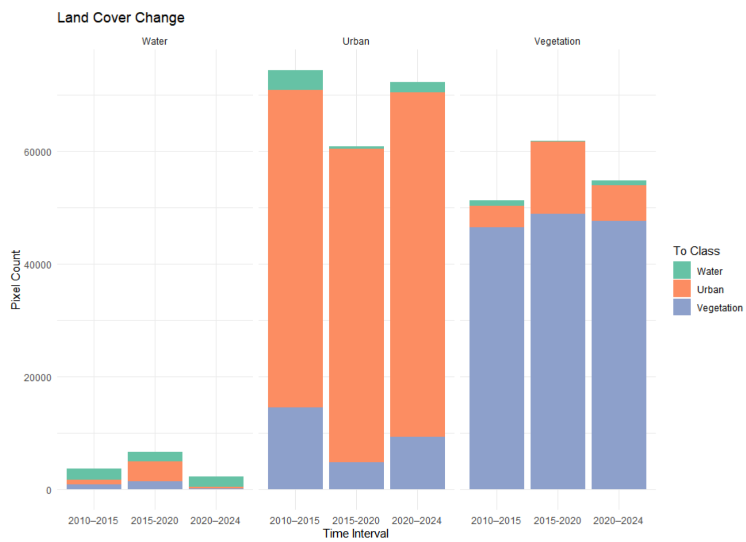

Figure 3. Land cover change between 2010 - 2015, 2015 - 2020, and 2020 – 2024

4.3 Land Use Change in Amherst, New York

Land use analysis, conducted between the 2010 and 2024 Landsat images, identified 29 hotspots, within the entire study region, where the vegetation class transformed into the urban surface class. Of these 29 hotspots, two hotspots were determined to be false classifications, which was likely due to the 15-pixel threshold used to define a hotspot. Among the 27 true vegetation-to-urban surface hotspots, the main land use types were classified as residential and apartments (11 and 8 hotspots, respectively) (Fig.4, Table 11).

The increase in residential and apartment developments aligns with population growth in Amherst between 2010 and 2023. The observed increase in housing land use positively correlates with Amherst's increasing population.

4.3.1 Land Use Change Near University at Buffalo's North Campus

A proximity analysis was conducted after applying a two-mile buffer around the University at Buffalo's North Campus. Of the 27 vegetation-to-urban surface hotspots identified within the study area, 14 hotspots were located within the two-mile buffer zone. Most of these hotspots, inside the buffer, were classified as apartments (7 out of 8 total apartment hotspots), suggesting that the apartment developments, within the buffer, are likely oriented towards university students. In contrast, the majority of residential hotspots (10 out of 11) were located outside the buffer, suggesting that these areas are oriented towards local residents (Fig. 4, Table 12).

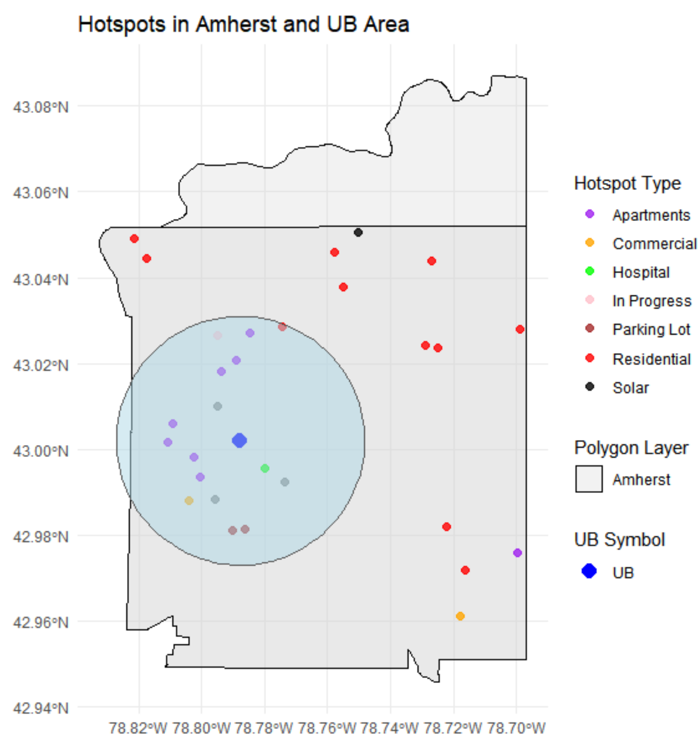

Figure 4. 2010 – 2024 Map of land use changes in the Amherst, NY and in a two-mile buffer from UB North Campus

2024 Hotspot Land Use

Name	Count
Apartments	8
Commercial	2
False	2
Hospital	1
In Progress	1
Misc.	1
Parking Lot	2
Residential	11
Solar	1

2024 Hotspot Land Use in 2 Mile Buffer of University at Buffalo

Name	Count
Apartments	7
Commercial	1
False	2
Hospital	1
In Progress	1
Misc.	1
Parking Lot	2
Residential	1

Table 11 and 12. 2010 – 2024 land use changes in the Amherst, NY and in a two-mile buffer from UB North Campus, respectively

The addition of the seven student-oriented apartments, near the campus, reflects the physical changes associated with studentification (Smith, 2004). As more developments are catered towards the seasonal student population, it is likely that these areas experience fluctuations in activity- becoming quieter and empty during academic breaks and busier with increased traffic and noise during the academic season. Additionally, University at Buffalo's enrollment data, from 2010 – 2024, showed an increase in student enrollments between 2010 – 2020, which may have contributed to the rise in apartment buildings. However, the enrollment decline from 2020 – 2024, could further enhance the sense of emptiness in these student-focused areas during academic breaks (Kinton et al., 2018; Sage et al., 2012).

5.0 Conclusion

This project aimed to analyze 2010 – 2024 land cover and land use change in Amherst, NY, at roughly five-year intervals, with a focus on identifying areas that transitioned from vegetation to urban surfaces. An addition goal was to examine if new urban land use hotspots supported the population changes for both the Town of Amherst and University at Buffalo and find any evidence of supporting studentification in the college town.

Between 2010 – 2024, the dominant land cover change observed was from vegetation to urban surface. The analysis also detected transitions from urban surface to vegetation but was later concluded to have issues since it was most likely due to classification limitations in Landsat's 30 m^2 spatial resolution. The close proximity of vegetation and urban features in residential neighborhoods complicated accurate urban surface and vegetation classifications. For future studies, higher resolution imagery, such as Sentinel-2 10 m^2 resolution would be recommended to easily distinguish the road, building, and vegetation class in residential areas.

A total of 27 vegetation-to-urban surface hotspots were identified over the study period. The major hotspots were identified as residential neighborhoods and apartment buildings. Residential hotspots were primarily located outside the two-mile radius from the University at Buffalo's North Campus– suggesting they are oriented toward local residents and reflect the overall growing town population indicated by US Census data.

In contrast, majority of apartment hotspots were concentrated within the two-mile buffer zone around the academic campus– likely serving the student population. The increase in off-campus student housing supports signs of studentification, specifically the physical land change aspect. Based on other studentification studies, these student-oriented neighborhoods may experience seasonal fluctuations; neighborhoods appear quieter during academic breaks and significantly busier, with increased traffic and noise, during the academic year.

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