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# IMPERVIOUS SURFACE TRENDS IN THE HUNTING CREEK WATERSHED

## *ARE WE SHEDDING TOO MUCH AND ABSORBING TOO LITTLE?*

By:
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# Impervious Surface Trends in the Hunting Creek Watershed: Are We Shedding Too Much and Absorbing Too Little?

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*"They paved paradise, put up a parking lot."*
Joni Mitchell (1970)

## A Little Background Information

For starters, what are impervious surfaces and why do we care about them? Impervious surfaces are hard, non-absorbing things we humans build—like roads, parking lots, sidewalks, roofs, grass and synthetic athletic fields, and even compacted/manicured residential lawns. We care about impervious surfaces because we also care about Calvert County's streams and the aquatic life (biota) that dwells therein. We want our streams to be as clean and ecologically healthy as possible. We also care about the Patuxent River and Chesapeake Bay, into which county streams drain.

So, before we explore the connection between impervious surfaces and stream health, we provide a little more background about Calvert County.

The landscapes in Calvert County and the rest of Maryland that foster the healthiest streams—those tributaries that contain clean water, good habitat, and abundant aquatic biota—are forests, especially mature contiguous forests, and wetlands. Why? Because forests and wetlands influence how stormwater reaches streams and provide the essential habitats that stream inhabitants need to survive and thrive. Streams in Calvert County that drain mature forests and wetlands are where the aquatic biota living in these places evolved over millennia and to which they are uniquely adapted. That's about as close to paradise as it gets for them.

## Way Back Then

In the early 1600s, when Europeans first arrived in what is now Calvert County, the landscape was rolling, covered in expansive mature forests, and bisected by many east-west flowing streams that made the region look more like the Piedmont that the Coastal Plain (Ref. 1). The colonists also encountered widely scattered settlements of American Indians, members of the Piscataway tribes, who had been living here for at least 12,000 years. The largest of the American Indian villages in Calvert County was located at the mouth of Battle Creek, where they tilled large cornfields, in addition to hunting, fishing, and gathering.

The dense vegetation covering Calvert County about 400 years ago was likely characteristic of a Mesic mixed hardwood forest (Ref. 2). This forest community is common on gentle and moderately-steep slopes, in wide ravines above and around streams, and on rolling uplands with deep soils. Dominant trees included American Chestnut, American Beech, Tulip Poplar, White Oak, Northern Red Oak, and American Holly.

A dominant animal species back then was Nature's water engineer, the North American Beaver. In her well-known 2009 paper on historical land use in the Chesapeake watershed (Ref. 3), Dr. Grace Brush wrote that abundant beaver populations in pre-colonial times may have numbered between 10 and 80 animals per square mile. Beavers likely built dams and created a series of ponds which formed wetlands along almost every stream in Calvert County. By the mid- to late-1800s, beavers were intensively harvested to make fashionable hats and almost exterminated in North America. The landscape and streams that drained it were also changing.

The European colonists were neither hunter/gatherers nor subsistence fishers. So, wherever they settled, they cut down trees to obtain building materials and firewood as well as to create open areas for growing crops and grazing non-native livestock species. American Indians also harvested trees and cleared patches for crops, but less intensively. Early colonial agriculture started slowly, though more expansive than American Indian practices. The pollen record shows that forests still covered most of Calvert County into the early 1800s, when the population was about 8,000 (Ref. 4). Improvements in farm equipment and cultivation practices plus

more and better fertilizers greatly increased the intensity of farming during the 19th and early 20th century. As more forests were cleared, soil erosion became more severe (Ref. 3).

## The Gift That Keeps on Giving

Forests and wetlands regulate the flow of precipitation on the landscape and filter the water as it passes through, a free gift from Mother Nature called an Ecosystem Service (Read more about Ecosystem Services in Hunting Creek here). The leafy tree canopy intercepts and slows the rainfall. The forest floor acts like an enormous sponge, soaking up rainfall; the water then infiltrates the soil and is gradually released to the shallow groundwater and stream channels. Only 10-20% of the rain that falls on a mature forest, wetland, or other natural area runs off the surface to downslope water courses. The rest is evaporated and absorbed, just like Nature intended.

The forest floor is absorbent because of its 1-2 inch thick layer of detritus or litter—organic material composed of dead and decaying leaves, branches, and fallen trees—collectively called “duff”. This layer provides a home for living decomposers and predators, including invertebrates, fungi, algae, and bacteria. Incidentally, these organisms are critical components of nutrient cycling and pollutant removal.

Fun fact: The average number of leaves on a mature deciduous tree is 100,000-200,000 (Bay Journal, November 2024). Deciduous means falling off at a certain season. So, the typical mature forest drops a lot of leaves every year that renew and perpetuate the absorbent duff layer.

## Working Against Mother Nature is Not Smart

Streams are healthiest when they drain mature forests and wetlands. So, what human-induced changes to the natural landscape are major stream stressors and even stream killers? The answer should come as no surprise to anyone. In Calvert County and many other places, the answer is development, which includes those human activities of clearing forests, filling in or draining wetlands, compacting the soil, and replacing Mother

Nature's sponges with impervious surfaces. Development is the connection between impervious surfaces and stream health we alluded to earlier and are now ready to discuss.

When humans develop and change the land cover, we work against Mother Nature. We convert the absorbing and filtering sponges of forests and wetlands to the equivalent of sheets of wax paper. The impervious surfaces we create never met a raindrop they didn't want to shed. And when raindrops are shed, gravity insists that they flow rapidly downhill, carrying soil and pollutants to the nearest stream.

Did you know that one inch of rain falling on one acre of mature forest will typically shed only about 750 gallons of runoff? In stark contrast, this same one inch of rain falling on a one-acre asphalt or concrete parking lot will shed 36 times that amount of runoff, about 27,000 gallons—a not-so-fun fact (Upper and Middle James Riparian Consortium).

During major rain events, and even modest storm events in a short period of time, the rapid runoff of this stormwater into streams can cause flashy flood-level flows that erode the banks, scour the channel, and wreak havoc on the aquatic biota. Check out this sediment-laden flood flow in Willow Run, a tributary to Mill Creek in the Hunting Creek watershed, just after Tropical Storm Isaias dumped 7-8 inches of rain on Calvert County on August 4-5, 2020 (Figure 1).

*Figure 1. Willow Run in Hunters Ridge after Tropical Storm Isaias (photo by Ron Klauda).*

Just as certain as the sun will rise again tomorrow morning over the Chesapeake Bay, with human population growth comes more development accompanied by more impervious surfaces, more soil erosion, more miles of ecologically unhealthy streams, and ultimately more sediments and nutrients transported to the Chesapeake Bay. Not surprisingly, the more intense the development, the more imperviousness we create (Figure 2, Ref. 5,6,7), which is expressed in this report as percent impervious surface or % IS.

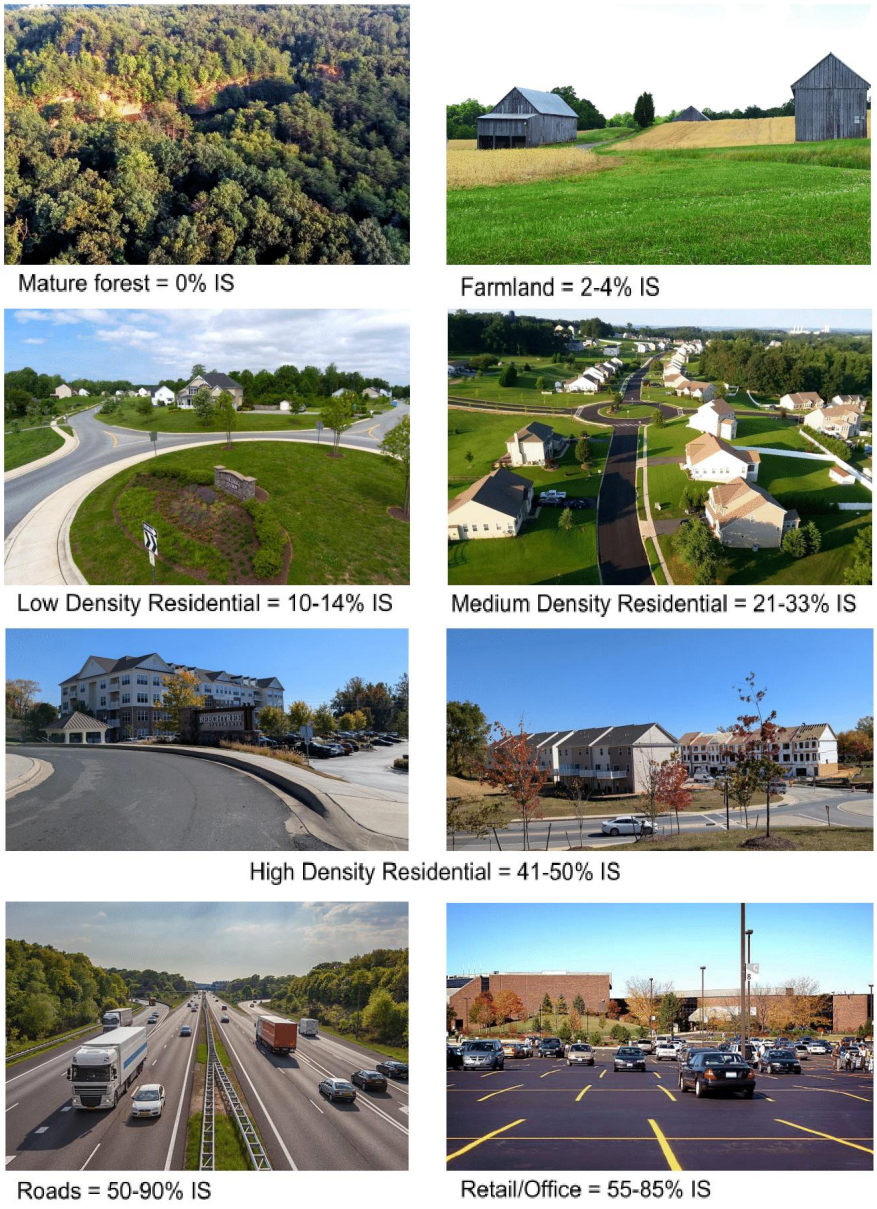


*Figure 2. Photos showing different levels of development and associated % IS values. (photos by Ron Klauda).*

## How Much % IS is Too Much?

% IS is a metric that integrates several kinds (levels) of development on the landscape drained by a given stream (i.e., its catchment). From the perspective of stream health, no increase in % IS is benign. An increase in % IS above 5 will be stressful to most aquatic biota. However, the abundance of especially sensitive aquatic animals can decrease at % IS levels lower than 5. For example, Brook Trout are generally found in watersheds where impervious surfaces are no greater than 4%. Additionally, some stream salamanders are only found in watersheds with no more than 0.3% impervious surfaces. For more information, refer to this DNR webpage and fact sheet.

Studies in Maryland Coastal Plain streams have shown that stream health, as determined by communities of benthic macroinvertebrates (e.g. aquatic larvae, scuds, worms, snails, mussels) and fish present, is typically Good when % IS is between 0 and 5, Stressed when % IS is >5-10, Poor when % IS is >10-15, and Degraded when % IS is >15 (Refs. 5, 6, 7, 8, 9). If a stream's catchment is developed to the point where % IS exceeds 20 or 25, it's almost certain that it no longer supports a functioning biological community, meaning that its ecological health will be Severely Degraded. In other words, if we know the % IS of a stream's catchment, we should be able to predict the stream's ecological health.

Aquatic ecologists continue to study and describe the gory details about the relationship between stream degradation and increasing % IS levels in catchments and larger watersheds. In 2005, they coined a name to collectively describe the array of symptoms and causes of stream degradation: Urban Stream Syndrome. If you want to take a deep dive into this topic, we recommend two review publications (Refs. 10, 11). These documents will lead you to many other publications on the Urban Stream Syndrome.

## Moving Right Along

Let's bring the discussion home to Calvert County and the Hunting Creek watershed, the geographical focus of this report (Figure 3). Located in central Calvert County, Hunting Creek drains the largest watershed in the county (19,127 acres) and flows into the Patuxent River at Potts Point (Figure 4). About half of the Prince Frederick Town Center lies in the headwaters of Hunting Creek and primarily drains into the Fox Run and Mill Creek catchments. A smaller northern portion of the Town Center drains into the Fox Point Creek catchment.

*Figure 3. Hunting Creek area circled on a map of Calvert County*

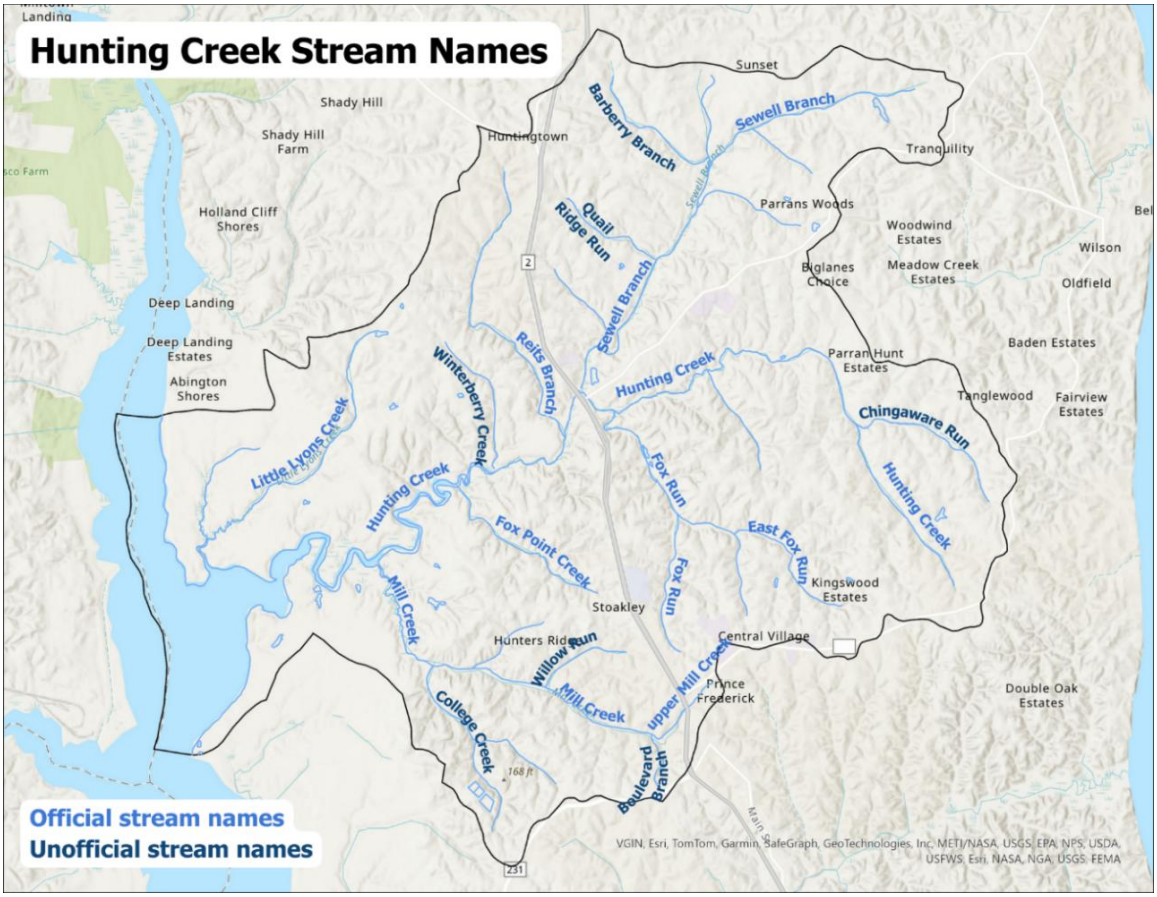


*Figure 4. Map of Hunting Creek watershed with stream names*

## Some Important Methodology

It is important to understand how the % IS numbers discussed in this report were derived, since there are a variety of methods.

Our % IS estimates are based on a significant positive relationship between impervious surfaces and the number of structures (residential, commercial, and institutional) present within a given area—catchments in this report. As more structures are built, the % IS will increase (Ref 12).

Annual property assessments that record if a structure is present on a property parcel are compiled by the Maryland Department of Planning (MDP) and made available for the public on a biennial basis. Because these data include the year a structure was built, the amount of development in a given catchment or larger watershed can be estimated for any year. Percent impervious surface estimates were calculated from high resolution land cover maps created by the Chesapeake Conservancy for the years 2013-2014.

Using 2013 structures data from MDP, we developed a mathematical model that enabled us to convert structure count per area to % IS. Incidentally, our model indirectly accounted for other impervious surfaces such as roads and parking lots. Our model estimates were refined by comparing them to the original % IS estimates from the Chesapeake Conservancy and then calculating unique catchment and watershed correction factors. Using the model and correction factors, the % IS for a given catchment was estimated for each year and visualized as an annual time series of development activities—a product unique to this method. All % IS estimates were calculated and mapped by Marek Topolski at the Maryland Department of Natural Resources.

## The Inevitable Linkage

U.S. Census data tells us that the population of Calvert County grew from only 10,484 in 1940 to 92,783 in 2020, a 785% increase. Population estimates since the 2020 census are 94,233 (in 2021), 94,573 (in 2022), and 94,728 (in 2023). Projections from the Maryland Department of Planning (December 2020) for Calvert County's population in 2030 and 2040 are 96,950 and 97,930, respectively. The County's population will

likely hit six figures by 2050—a nice annual salary goal; but not so nice for those of us driving up and down Rt. 2/4.

In addition to having a relatively low population in 1940, about 75% of the total land area of Calvert County (102,000 acres) was being tilled by families living on 1,177 farms (Bowen 2024). But, by 1974, farmland acreage had decreased to 56,000 on 58 farms. Development was still relatively low in 1974, but over the next 50 years that would soon change and not in a good way for County streams.

Knowing that the population of Calvert County soared between 1940 and 2023, we were not surprised to learn that the % IS in the Hunting Creek watershed also increased dramatically (Figure 5). Increasing human population inevitably leads to more development on the landscape and the creation of more impervious surfaces. The % IS was <1 (reflecting the large amount of mature forest and suggesting Good stream health) in the Hunting Creek watershed in 1940. By 2023, 83 years later, % IS reached ~9, moved into the Stressed category for stream health, and is creeping closer to the Poor threshold of >10% IS.

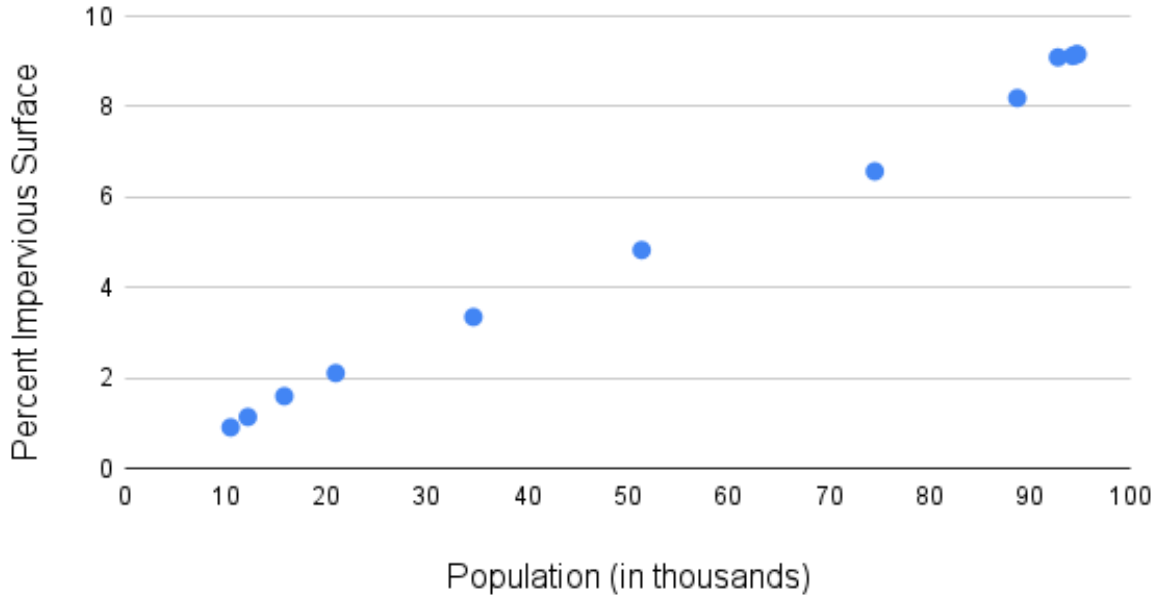


*Figure 5. Relationship between population growth and percent impervious surface in the Hunting Creek watershed, 1940-2023 (percent impervious surface data from Marek Topolski, MD DNR; population data from U.S. Census Bureau).*

On a more positive note, population growth in the county is slowing and so is the increase in % IS. Between 2020 and 2023, Calvert County's

population increased by ~500 people, and annual % IS levels in the Hunting Creek watershed increased from 8.8% to 8.9%, only a 0.033 % increase per year. At that rate, % IS in the watershed won't reach the stream health threshold of >10 (Poor) until the year 2056, a little over 30 years from now.

Before taking too much comfort in this prediction, we must acknowledge that global warming is causing climate change, and that fact could darken this somewhat rosy picture of % IS and stream health down the road. Two relevant questions are in order: (a) Are rainfall patterns in Calvert County changing? and (b) If yes, could these changes significantly increase the amount of stormwater runoff from impervious surfaces already present in the Hunting Creek watershed?

Fortunately, we have the results of a recent study by two Chesapeake Biological Laboratory scientists that answer "Yes" to question (a). In September 2024, Drs. Vyacheslav and Kilbourne submitted a final report titled "Making Our Community More Resilient: Accounting for Changing Rainfall in Calvert County" to the County's Department of Public Works (Ref. 13). The authors used the most recent precipitation data and ultra-high resolution climate model output to draw several important conclusions:

1. Precipitation patterns in Calvert County are changing.
2. Extreme precipitation events are more frequent now and are expected to become even more frequent in the future.
3. Historical rainfall data are no longer adequate for local planning purposes and for designing effective stormwater management practices.
4. The responsible use of public funds by DPW requires adaptation to changing precipitation patterns to minimize risks of infrastructure failures and their associated costs.

Based on this study's findings, the answer to question (b) above appears to be a "Yes" as well.

## Let's Take a Closer Look

The % IS trend in the entire Hunting Creek watershed increased from only 0.74% in 1935 to 8.9% in 2023. However, this change is not the only story to tell. The watershed is large and not homogeneous throughout, so we need to take a closer look at the % IS trends in each of the 13 major catchments that comprise the whole. Based on high resolution land use/land cover data collected in 2017-2018 by the Chesapeake Conservancy (personal communication with John Wolf, U.S. Geological Survey) tells us that the catchments with the largest and smallest percentages of forests and wetlands are Fox Run/East Fox Run (72.3%) and Reits Branch (43.0%). We also know that almost a third (31.3%) of the Little Lyons Creek catchment is agriculture land (farm fields and pasture), compared to a low of only 2.3% agricultural land use in the Fox Run/East Fox Run catchment. To better understand which catchments of the entire Hunting Creek watershed are in the best and worst condition from the perspective of development-related threats to stream health, we can examine what happened with the % IS trends in each of the 13 catchments.

Maps of the catchments plus graphs showing increases in % IS estimates between 1935 and 2023 are included in the Appendix.

The % IS estimates in 2023 ranged from a low of 5.9 in Little Lyons Creek to a high of 22.1 in Willow Run, a tributary to Mill Creek (Figure 6). As mentioned above, Willow Run drains a large portion of the western half of the Prince Frederick Town Center, a landscape that has been experiencing high-density residential and commercial development for about 35 years. More about that later.

None of the 13 catchments had % IS estimates in 2023 that fall into the Good (<5%) category—i.e., streams resembling near pristine, pre-colonial conditions. This is not unexpected, given that Maryland was settled by English colonists about 400 years ago and major landscape changes have occurred since then. Six catchments had % IS estimates in the Stressed category in 2023, but still <10% IS. Streams in these six catchments are likely experiencing a modest degree of stream habitat degradation but still

retain some of the biological integrity associated with minimally-impacted streams in Maryland's Coastal Plain.

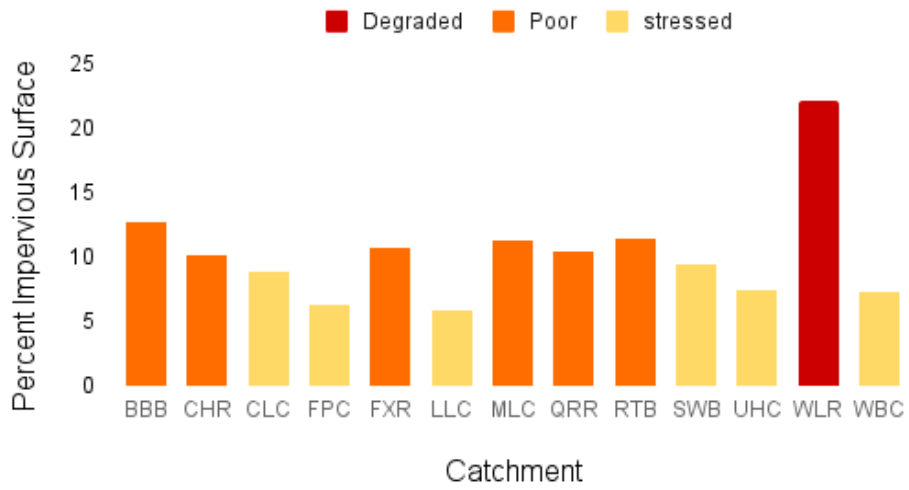


*Figure 6. Histogram of percent impervious surface in each of the 13 catchments in the Hunting Creek watershed. Catchment abbreviations are as follows: BBB=Barberry Branch, CHR=Chingaware Run, CLC=College Creek, FPF=Fox Point Creek, FXR=Fox Run, LLC=Little Lyons Creek, MLC=Mill Creek, QRR=Quail Ridge Run, RTB= Reits Branch, SWB=Sewell Branch, UHC=Upper Hunting Creek, WLR=Willow Run, WBC=Winterberry Creek.*

Biological Integrity is the ability of a stream system to maintain a balanced community of aquatic organisms that is comparable to a natural habitat unaffected by human activities. The more a stream is altered and degraded, the less biological integrity it has. Information obtained from collections of benthic macroinvertebrates and fish are used to measure the biological integrity of a stream (Ref. 14).

Six catchments in the Hunting Creek watershed had % IS estimates in 2023 that fell into the Poor (10-15%) category, more cause for concern. In these catchments, the streams are likely experiencing a substantial degree of habitat degradation and should exhibit only a few aspects of biological integrity associated with minimally-impacted streams.

We are pleased that only one of the 13 catchments in the Hunting Creek watershed had a % IS estimate in 2023 that fell into the Degraded (>15%) category. But, to know that Willow Run, at 22.1% IS, is likely experiencing a strong degree of habitat degradation and should therefore exhibit no aspects of biological integrity associated with minimally-impacted streams is cause for concern to the Friends of Hunting Creek.

As previously mentioned, Willow Run drains a portion of the western half of the Prince Frederick Town Center where the clearing of contiguous forest on relatively steep slopes (>15%) with highly erodible soils, extensive grading, and high-density residential development has been ongoing since the mid to late 1990s. Development in this area was accelerated by the construction of Prince Frederick Blvd. through the entire length of the western edge of the Town Center and across the headwaters of Willow Run and the mainstem of Mill Creek.

Chapline Place Shopping Center was built on the west side of Prince Frederick Blvd. in 1999 and added at least 27 acres of impervious surfaces. In 2002 and 2005, Chapline House I (60 apartments) and Chapline House II (30 apartments) were built, also on the west side of Prince Frederick Blvd. Then came Beechtree Apartments (249 units) in 2019, Calvert Hills (96 apartments) in 2021, and Patuxent Commons (67 townhouses) that will open in 2025. The Friends of Hunting Creek have documented stormwater management failures and soil erosion problems at Calvert Hills.

Not only did the Willow Run catchment have the highest % IS estimate in 2023 (22.1), it also had the largest percentage increase in % IS between 1935 and 2023 (3,583%, Figure 7). Estimates of % IS in the Willow Run catchment increased sharply in 1987, leveled off somewhat at 6-7% between 1990 and 1997, jumped up to 22.3% in 2003, and then stayed at about this percentage to 2023 (see Appendix).

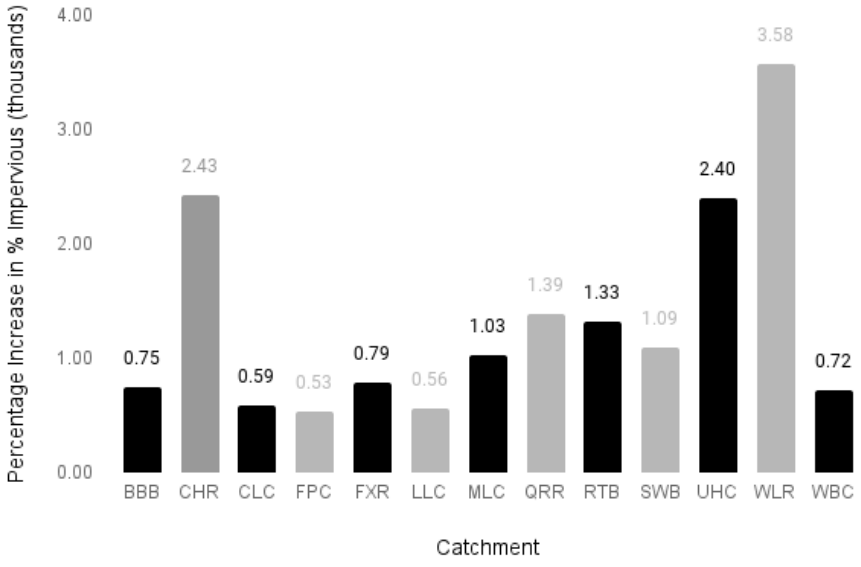


*Figure 7. Increase in percent impervious surface in Hunting Creek catchments from 1935 to 2023*

The Friends of Hunting Creek collected benthic macroinvertebrate samples in Willow Run in spring 2022 and 2023, using Maryland Biological Stream Survey methods (Ref. 15). Not surprising, given the level of upstream development described above, the Benthic Indices of Biotic Integrity (BIBI) scores were only 2.7 (on a scale of 1 worst to 5 best) in both years. These BIBI scores are in the Poor condition category for stream health and show a significant deviation from reference stream conditions (Ref. 16), consistent with Willow Run's Degraded % IS estimate (Figure 6).

Two other catchments, Chingaware Run and Upper Hunting Creek, also had relatively large percentage increases in % IS estimates between 1935 and 2023 (Figure 7). Fortunately, so far, the % IS estimates in these two catchments have remained well below 15% (Figure 6). Also, development in these two catchments has been low to medium density residential on large lots.

## Looking Ahead

The Mission of the Friends of Hunting Creek is to promote the ecological health and resiliency of the watershed's 50 miles of streams and over 19,000-acre landscape, so that residents, government agencies, and elected officials will together take an active role in protecting and sustaining the natural and cultural resources. One of our major goals is to expand the scientific understanding of our land and water resources. Given these commitments, now knowing the status and trends of impervious surface creation in our watershed, and understanding how this development-related land use change can degrade our streams, what would the Friends of Hunting Creek like to see happen in our watershed and what can we do to help?

These actions come to mind that, admittedly, include a wide range of challenges.

1. Stop cutting down forests.
2. View streams and wetlands as important natural assets rather than drains and wasted land.
3. Stop creating more impervious surfaces.

4. Make the developed places on the landscape absorb more rainfall and shed less runoff by retrofitting failing stormwater management structures, rigorously enforcing current stormwater regulations, and increasing the fines paid by violators,
5. Require more effective stormwater management practices that embrace current and <u>future</u> precipitation patterns for all new development.
6. Monitor water quality, aquatic biota, and assess the ecological health of streams throughout the Hunting Creek watershed.
7. Share our water monitoring data and assessments with Calvert County agency staff and elected officials.
8. Communicate what we're learning about development-related impacts on stream health to watershed residents and encourage them to become more vigilant watch dogs.
9. Embrace the fact that knowledge is power.
10. Speak up and speak out to advocate for better protection of our healthiest streams and restoration of degraded waters.

By ourselves, since 2020, the Friends of Hunting Creek have been and will continue to pursue action items 6 through 10 that will, hopefully, help us also achieve item 2. To achieve action items 1, 3, 4, and 5, we will need help from engaged and informed citizens, government agencies (state and county), and our elected officials.

## Summary of Key Points

1. When Europeans first arrived in what is now Calvert County in the early 1600s, the landscape was almost entirely covered in expansive dense forests.
2. Forests and wetlands regulate the flow of precipitation on the landscape and also filter/clean the water as it passes through--free gifts from Mother Nature called Ecosystem Services.
3. The forest floor acts like an enormous sponge, soaking up rainfall before slowly releasing it to natural water channels.

4. Development of the natural landscape by human activities converts the absorbing and filtering sponges of forests and wetlands to hard and impervious surfaces that work against Mother Nature and lead to stream degradation.
5. With population growth comes more development that creates more impervious surfaces, increases polluted stormwater runoff and soil erosion, and leads to more miles of ecologically-unhealthy streams—plus, ultimately, more sediments, contaminants, and nutrients transported to the Chesapeake Bay.
6. No increase in the percentage of impervious surfaces (% IS) in a watershed above 2 or 3 is benign for stream health.
7. When the % IS goes above 5, most aquatic biota will be stressed; and the larger the % IS, the higher the stress level.
8. The collective array of causes and symptoms that account for the direct relationship between increasing % IS and stream degradation is referred to as the Urban Stream Syndrome.
9. The population of Calvert County increased by over 800% between 1940 and 2023.
10. % IS estimates in the Hunting Creek watershed going back to 1935 also increased dramatically, reaching 8.9 in 2023, and the overall watershed moved into the Stressed category for predicted ecological stream health.
11. In 2010, a total of 9371 people (413.5 per square mile) in 3121 households were living within the watershed.
12. None of the 13 catchments (subwatersheds) had % IS estimates of 5 or lower (with predicted stream health = Good) in 2023.
13. % IS estimates ranged from a low of 5.9 (Stressed) in the Little Lyons Creek catchment to a high of 22.1 (Degraded) in Willow Run.
14. Willow Run, a tributary to Mill Creek, drains a large portion of the western half of the Prince Frederick Town Center—a landscape that has been experiencing high-density residential and commercial development for about 35 years.
15. Benthic macroinvertebrate sampling in Willow Run by the Friends of Hunting Creek in 2022 and 2023 revealed Poor biological integrity

scores, one measure of stream health that is consistent with this catchment's Degraded condition in 2023.

16. Global warming is causing changes in our climate and precipitation patterns.
17. Extreme rain events are already becoming more frequent in Calvert County, and recent modeling analyses predict that extreme events will become even more frequent in the future.
18. Without significant improvements in stormwater management in the county, the more frequent extreme rain events will produce greater volumes of polluted runoff from impervious surfaces, resulting in more miles of degraded streams in the Hunting Creek watershed.
19. Knowing the status and trends of % IS in each of the 13 catchments from 1935 to 2023 tells us which ones are likely to have the healthiest and the most degraded streams.
20. Insights gained from examining these % IS trends will help the Friends of Hunting Creek target our stream monitoring programs and rally County agencies to help us pursue watershed protection and stream restoration goals.

## Parting Thought

"*I'd rather be a forest than a street*….."
Simon and Garfunkel (1970)

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# Appendix

## Map 1

### Hunting Creek watershed percent impervious surface trends

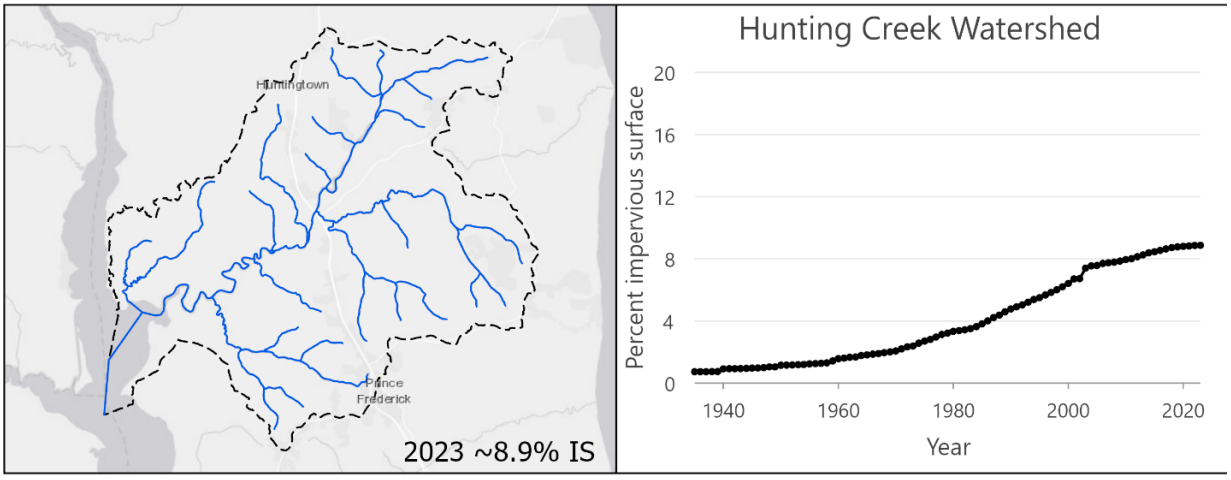
Percent impervious surface estimates are based on the number of structures from the MD Property View dataset within a subwatershed and calibrated using Chesapeake Conservancy's 2017/2018 land cover dataset.

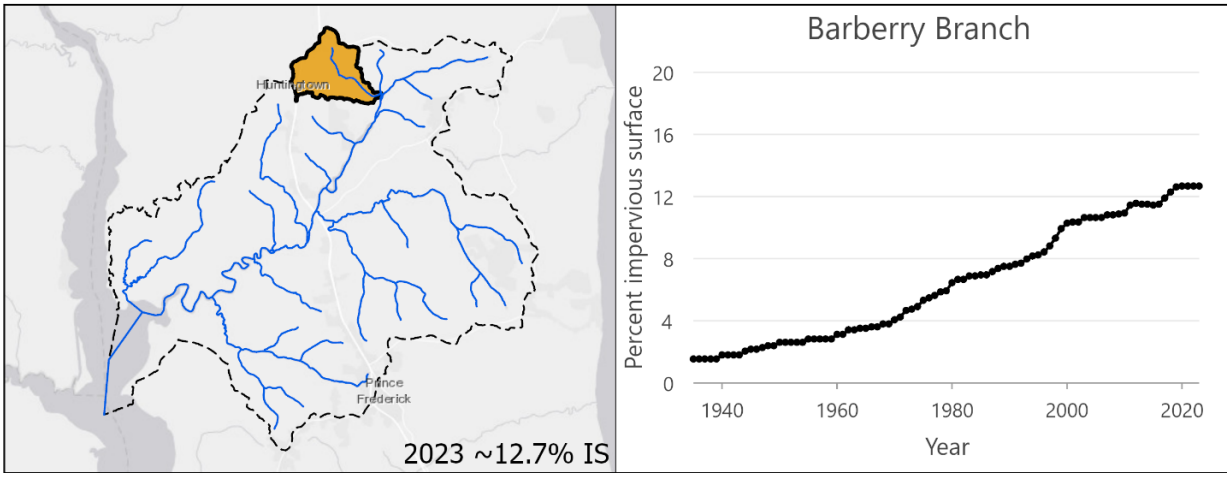
Prepared by Marek Topolski - marek.topolski@maryland.gov

**Legend**

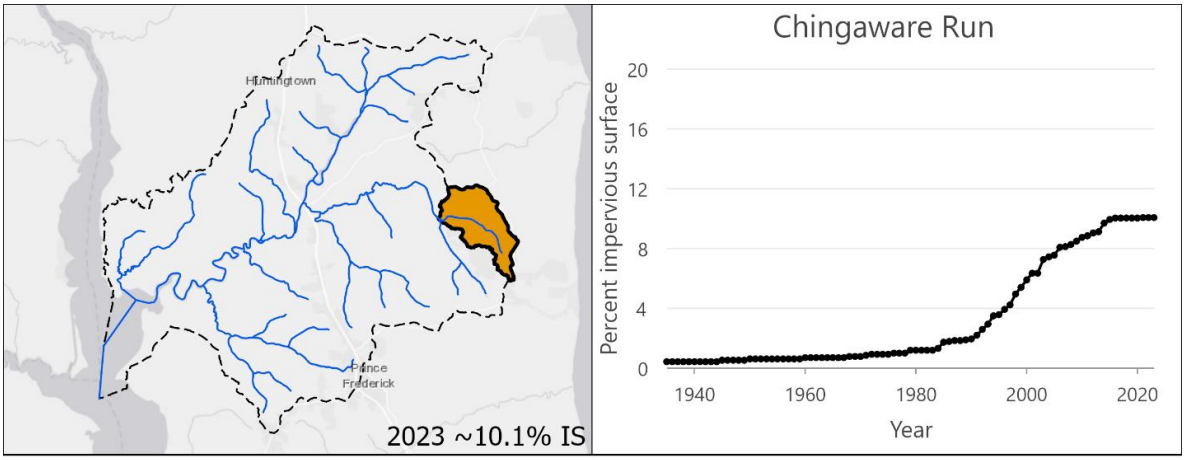
Tributary
Hunting Creek Watershed
Watershed of Interest

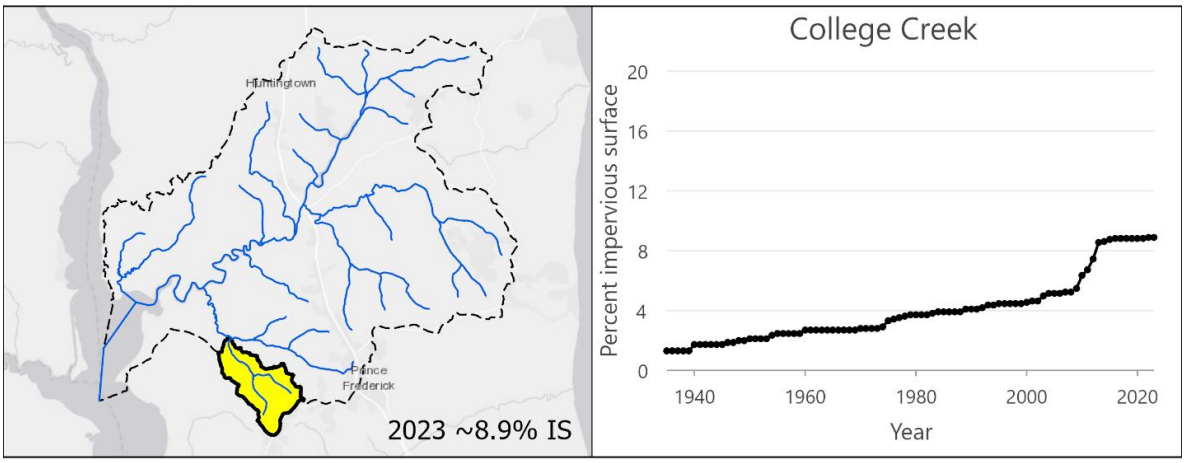
Status
Good
Stressed
Poor
Degraded

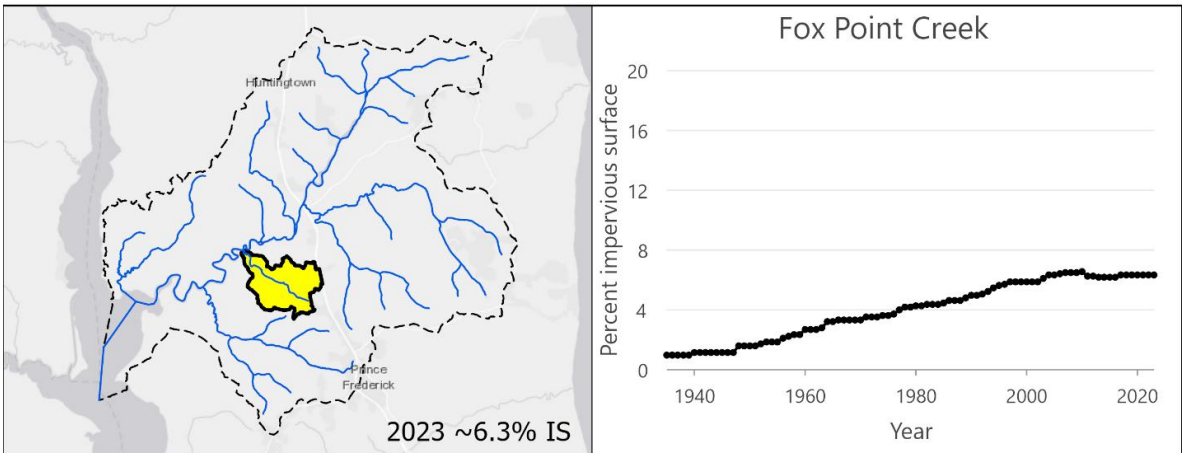


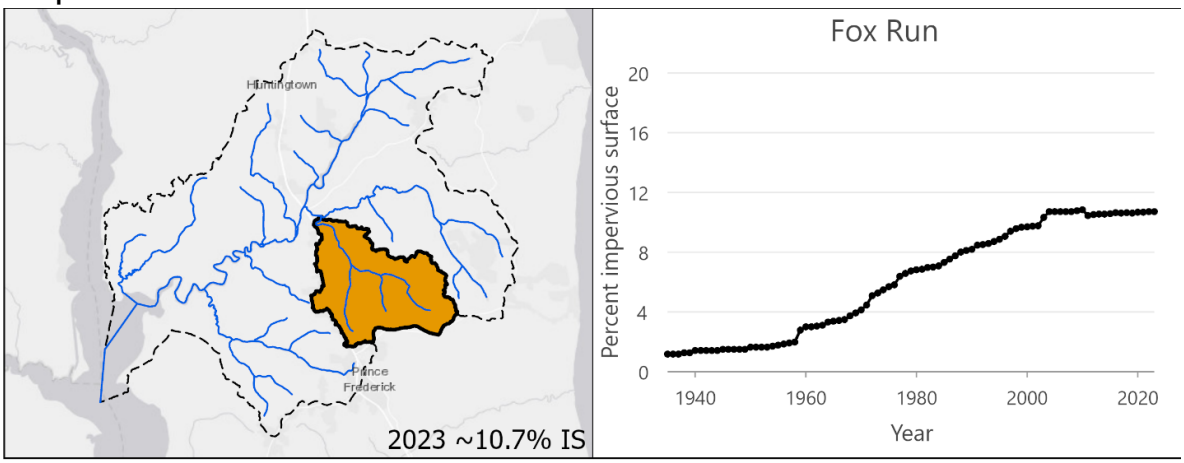
## Map 2

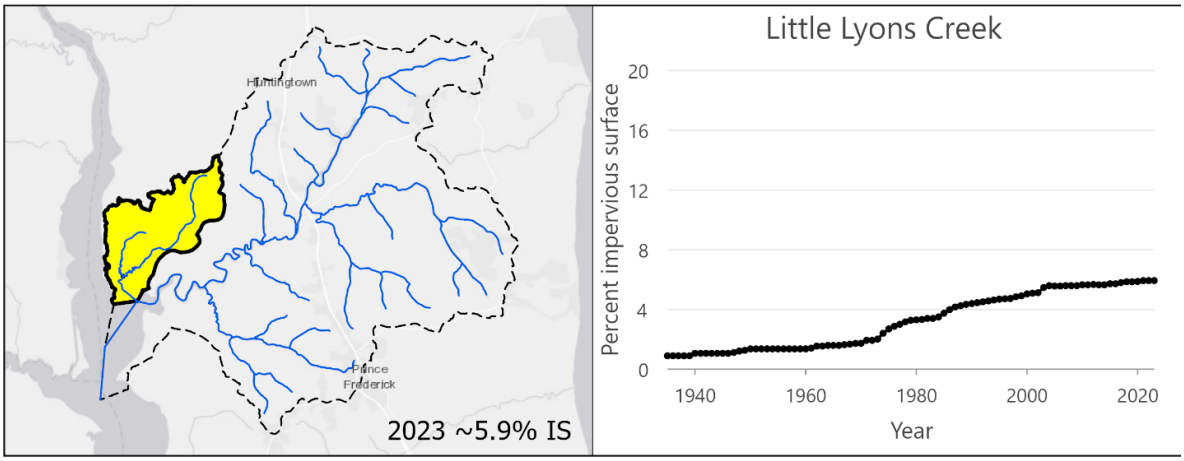

Huntingtown
Prince Frederick
2023 ~10.1% IS
Chingaware Run
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year

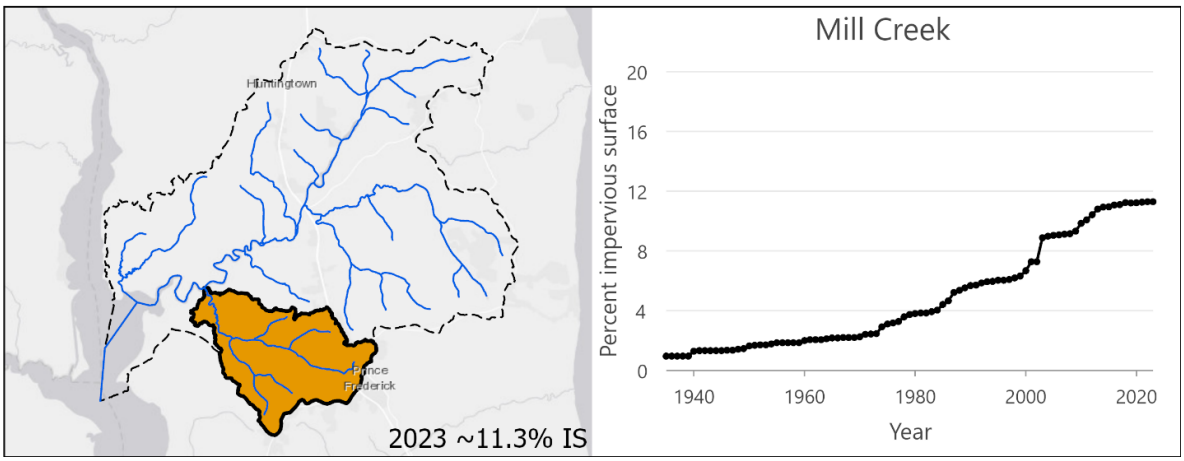

Huntingtown
Prince Frederick
2023 ~8.9% IS
College Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year


Huntingtown
Prince Frederick
2023 ~6.3% IS
Fox Point Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year

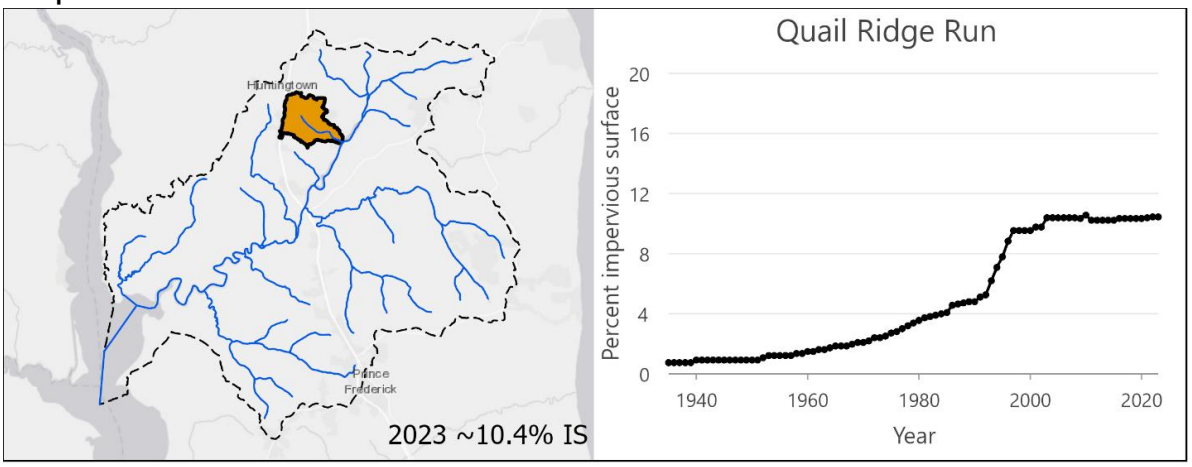
## Map 3

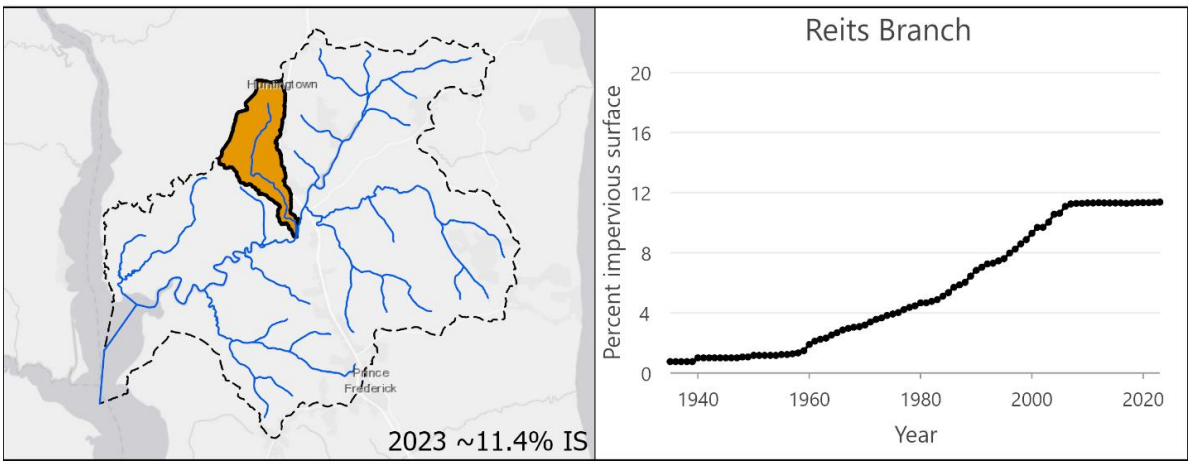

Hunnington
France
Frederick
2023 ~10.7% IS
Fox Run
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year

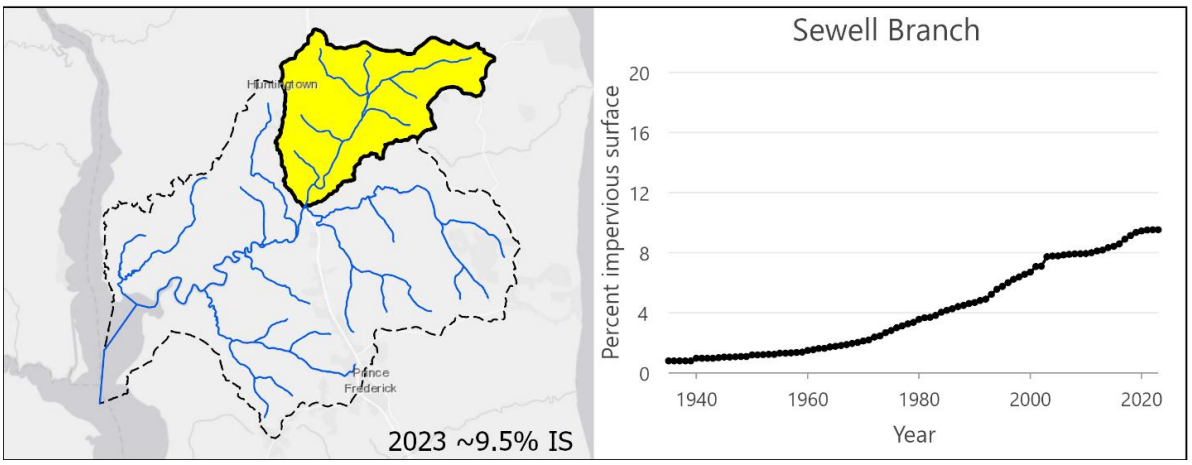

Hunnington
France
Frederick
2023 ~5.9% IS
Little Lyons Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year


Hunnington
France
Frederick
2023 ~11.3% IS
Mill Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year

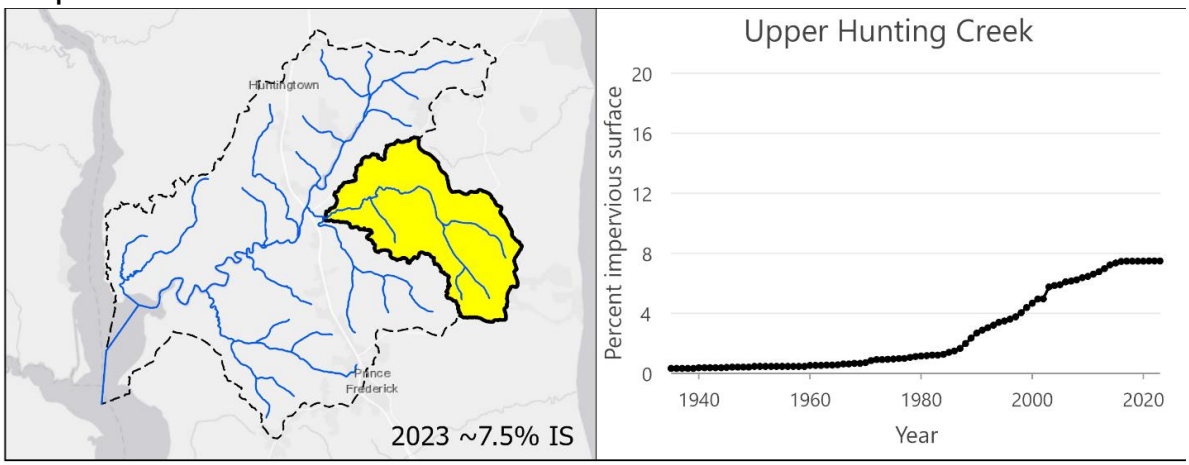
# Map 4

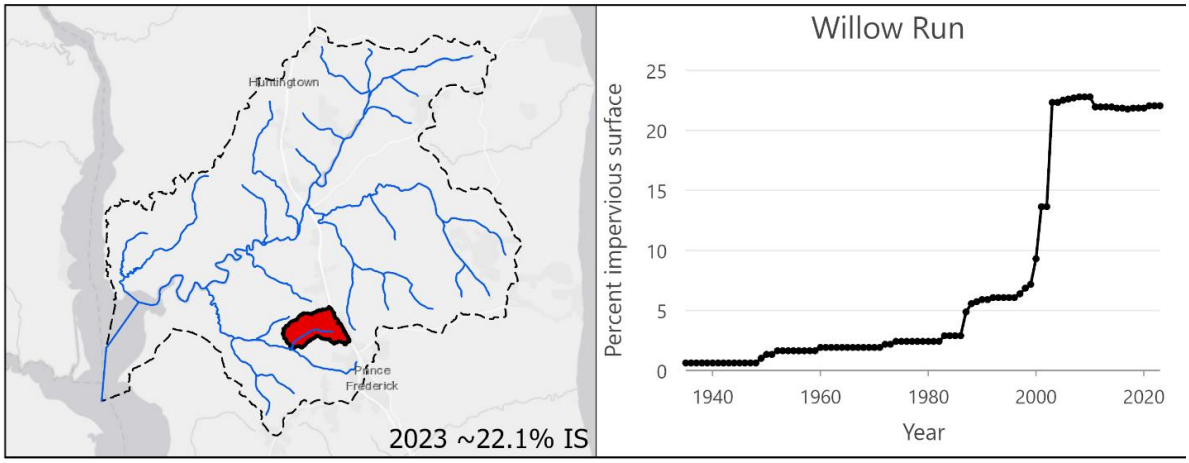

Quail Ridge Run
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year
Prince Frederick
2023 ~10.4% IS

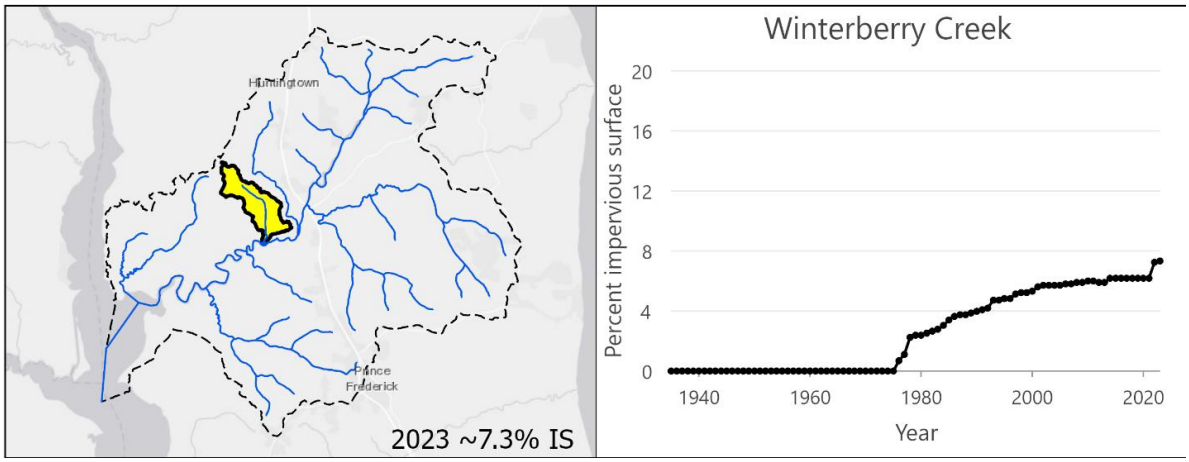

Reits Branch
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year
Prince Frederick
2023 ~11.4% IS


Sewell Branch
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year
Prince Frederick
2023 ~9.5% IS

# Map 5


Huntingtown
Prince Frederick
2023 ~7.5% IS
Upper Hunting Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year


Huntingtown
Prince Frederick
2023 ~22.1% IS
Willow Run
Percent impervious surface
0
5
10
15
20
25
1940
1960
1980
2000
2020
Year


Huntingtown
Prince Frederick
2023 ~7.3% IS
Winterberry Creek
Percent impervious surface
0
4
8
12
16
20
1940
1960
1980
2000
2020
Year