Development of an Artificial Intelligence Model to Aid in Determination of Invasion in Pulmonary Adenocarcinoma

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2. Aiforia, Cambridge, MA

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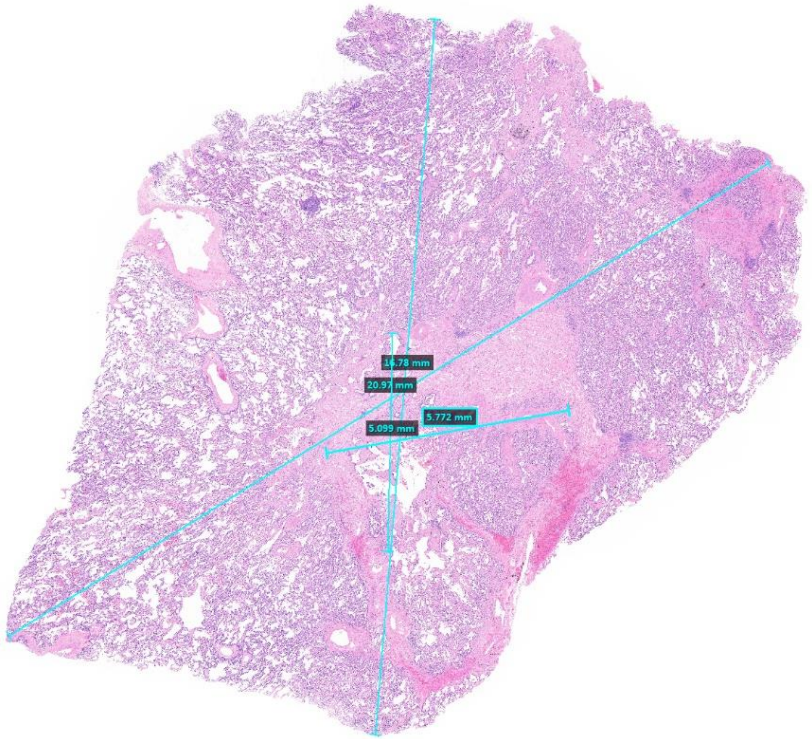
Background

- WHO classification of pulmonary adenocarcinoma is complex!
- Pathological reporting may be a challenge, particularly determining invasion size in lepidic-predominant tumors
  - Significant inter-observer variability
  - Determinant of tumor stage



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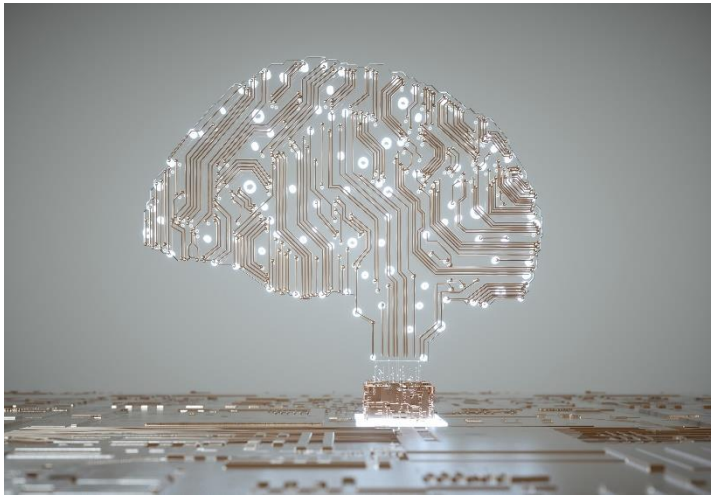
Hypothesis

- Artificial intelligence (AI) promises to aid pathologists in time consuming tasks that suffer from poor reproducibility
- It might be helpful in the context of determining invasion in pulmonary adenocarcinoma



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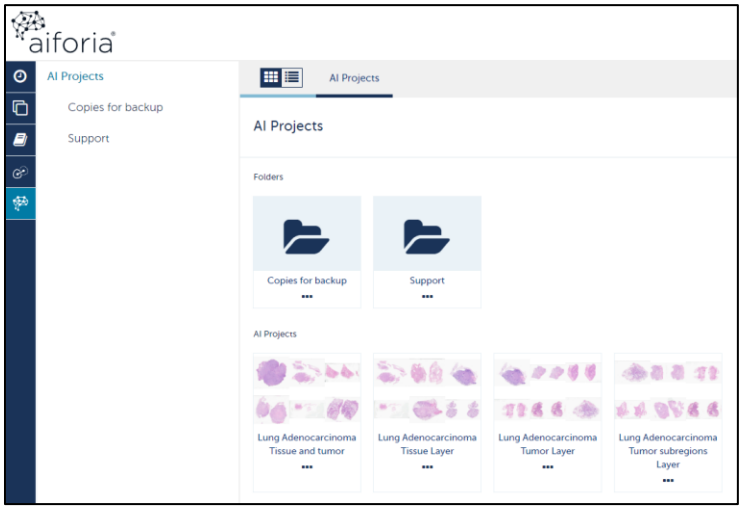
Design

- One representative H&E slide was selected from 100 resected pulmonary adenocarcinomas
  - Arbitrarily divided into training (n=35) and validation (n=65) sets
  - Slides were scanned and uploaded to Aiforia for AI model creation



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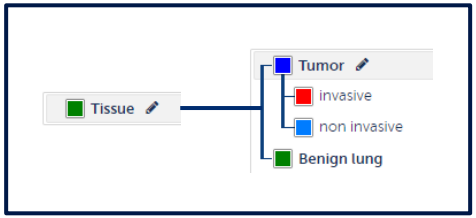
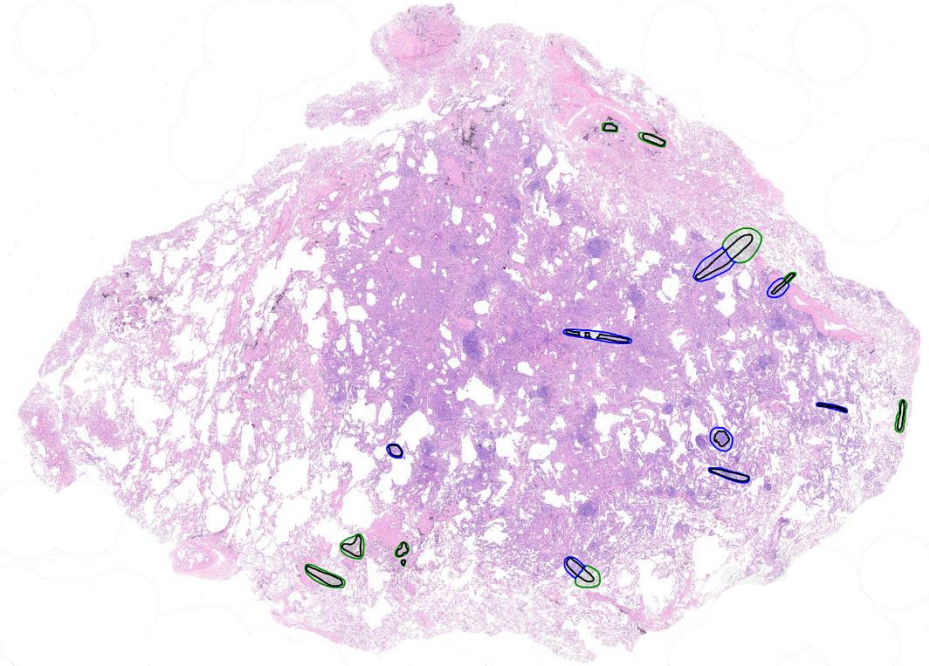
Model Creation

- Annotations were completed on the training set by 6 expert pulmonary pathologists
- Used to create a nested AI model





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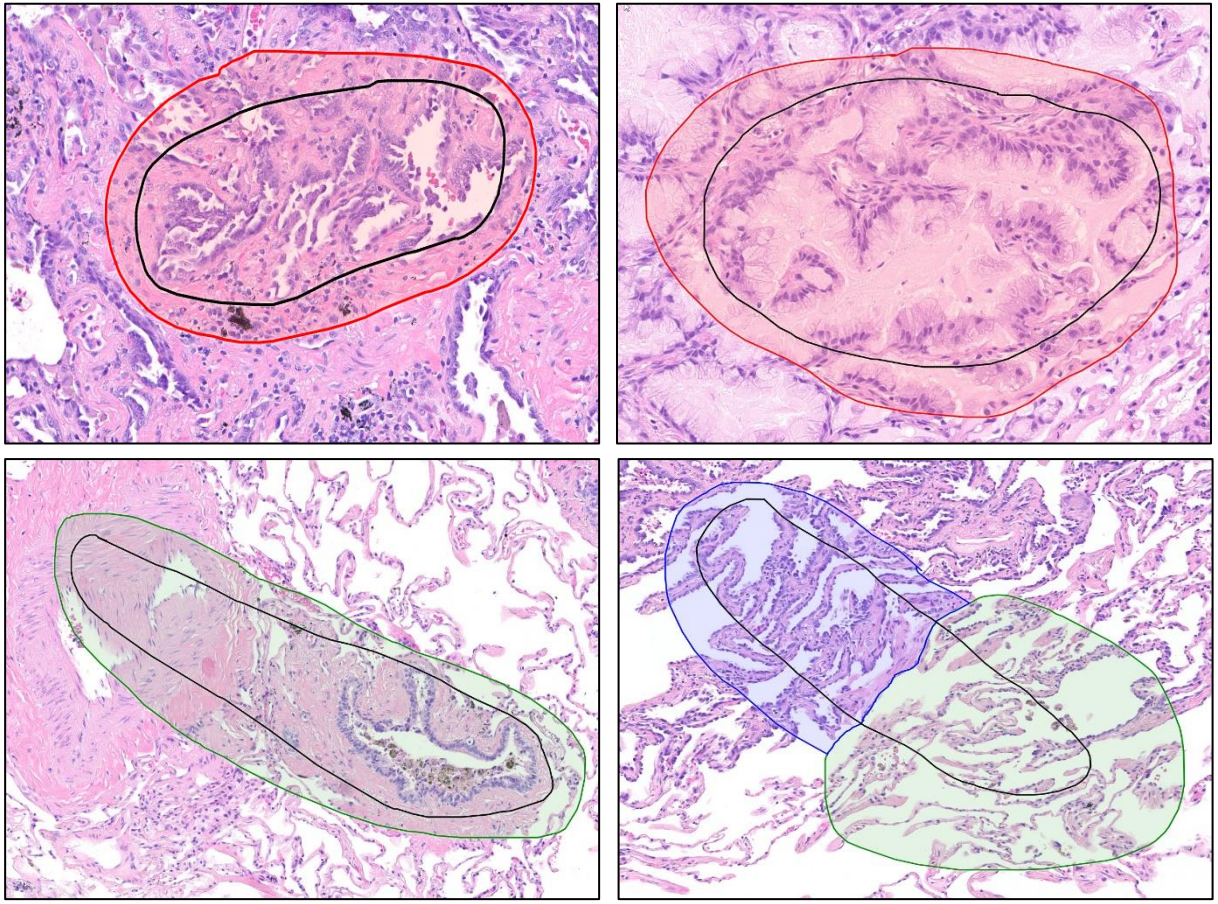

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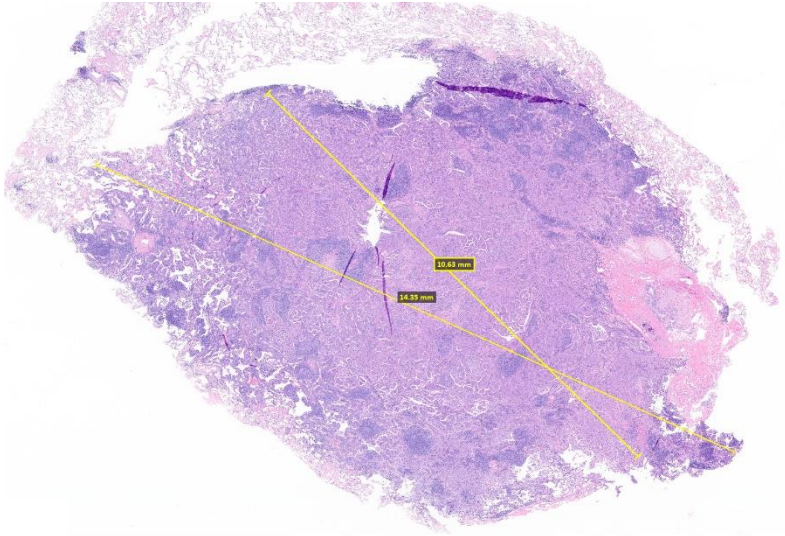
Design

- Manual measurements were performed by a pulmonary pathologist using a digital ruler
  - Largest tumor extent
  - Largest invasive size
  - % invasion
- Values compared to those generated by the AI model



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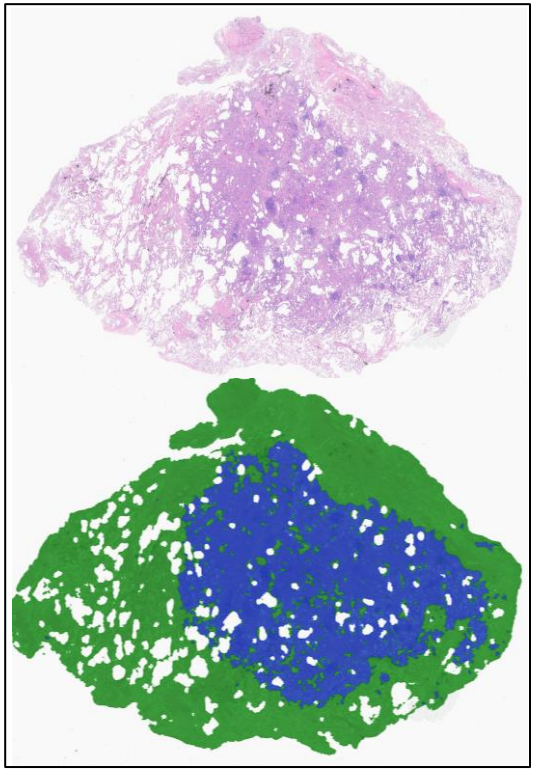
Results

Layer	Annotations	Total Area Error	False +	False -
Tissue	199	0.31%	0.16%	0.15%
Tumor	314	2.18%	0.53%	0.56%
Invasive	152	0.74%	0.07%	0.03%



Green=benign lung, blue=tumor

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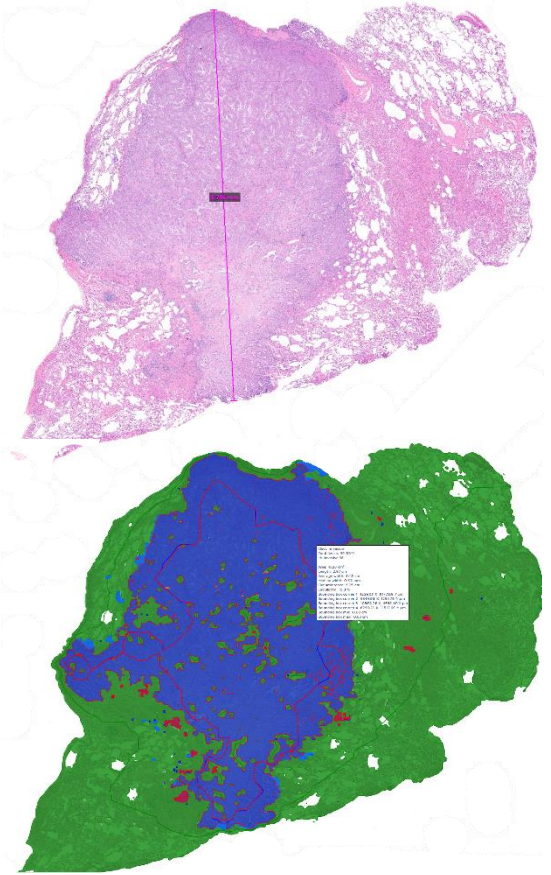
Results

- Final model was used to evaluate whole slide images of the training and validation sets
- Invasion assessments by the AI model were compared to those manually measured or estimated by a pulmonary pathologist



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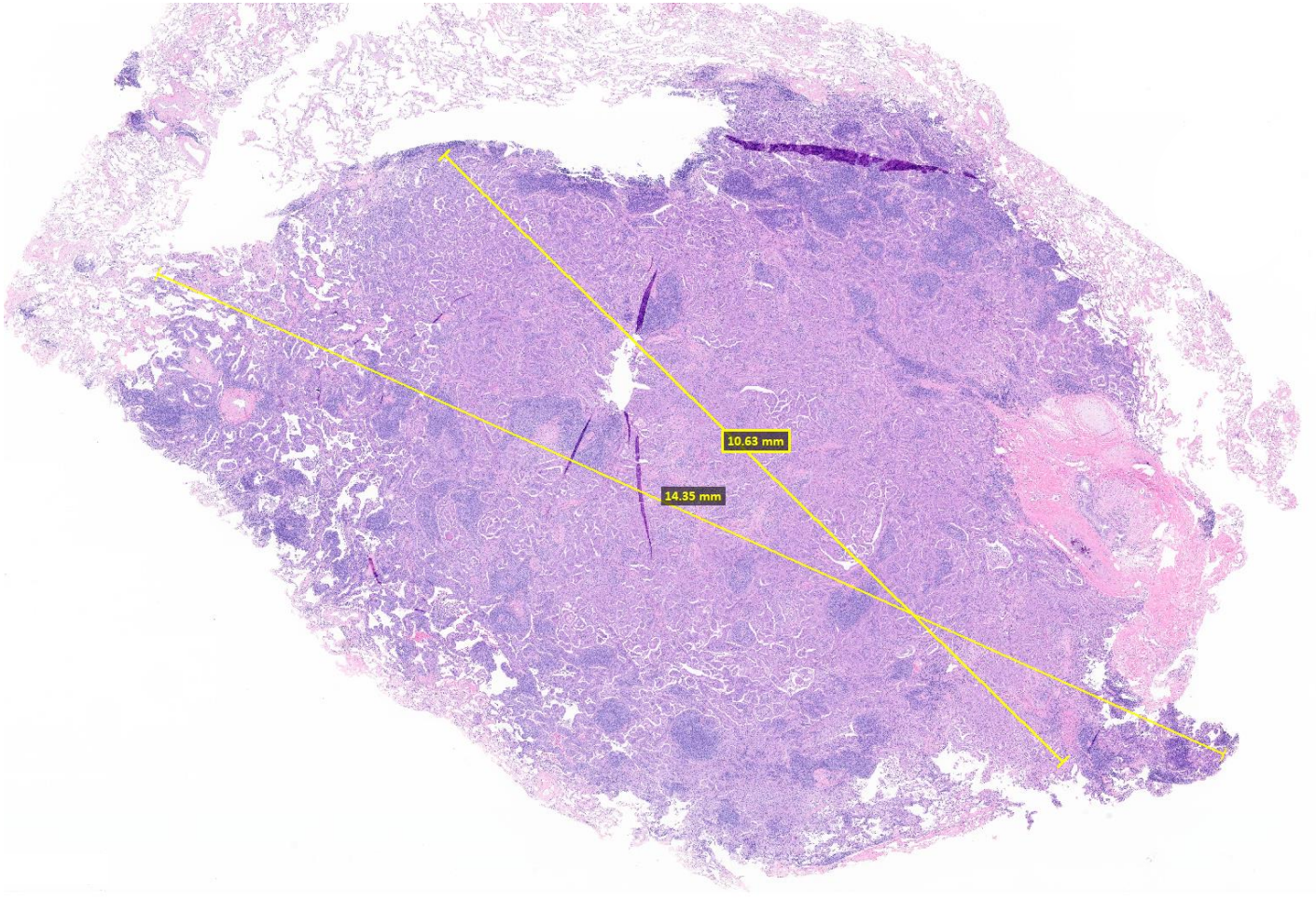

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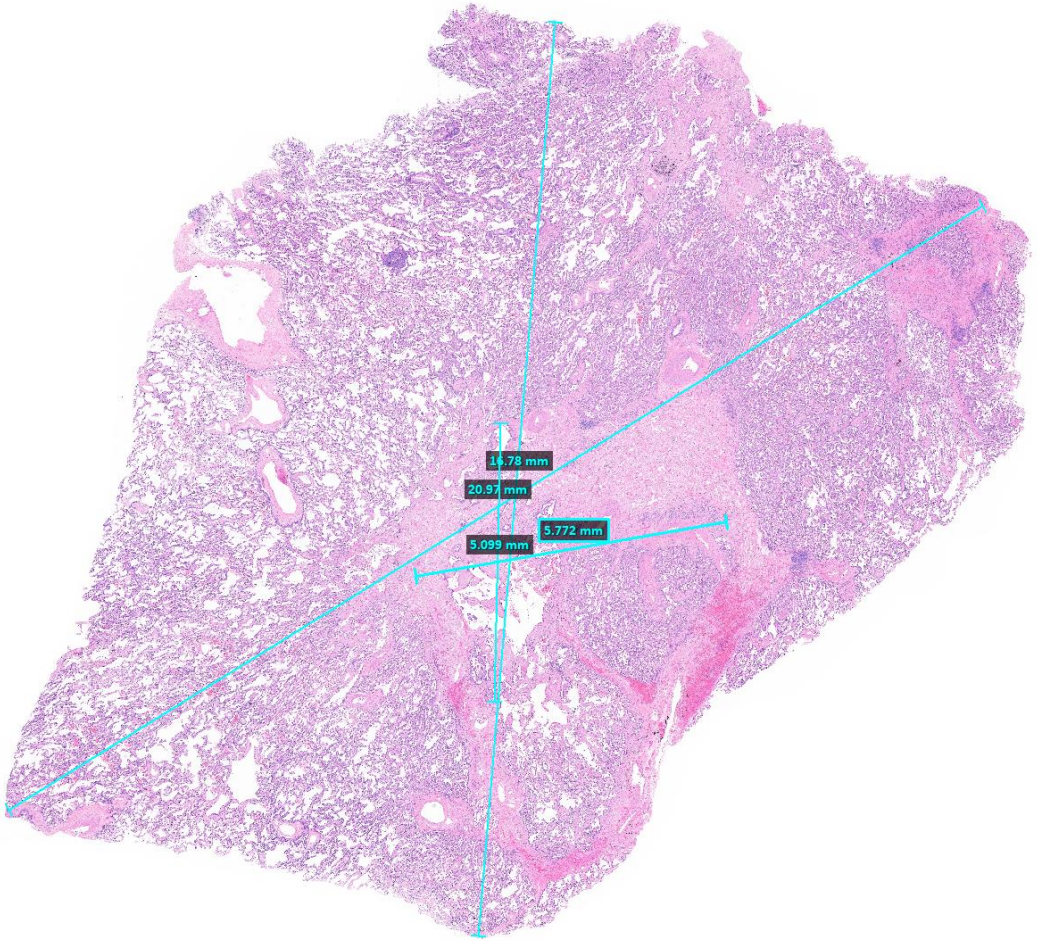

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Example Cases

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When things go well…

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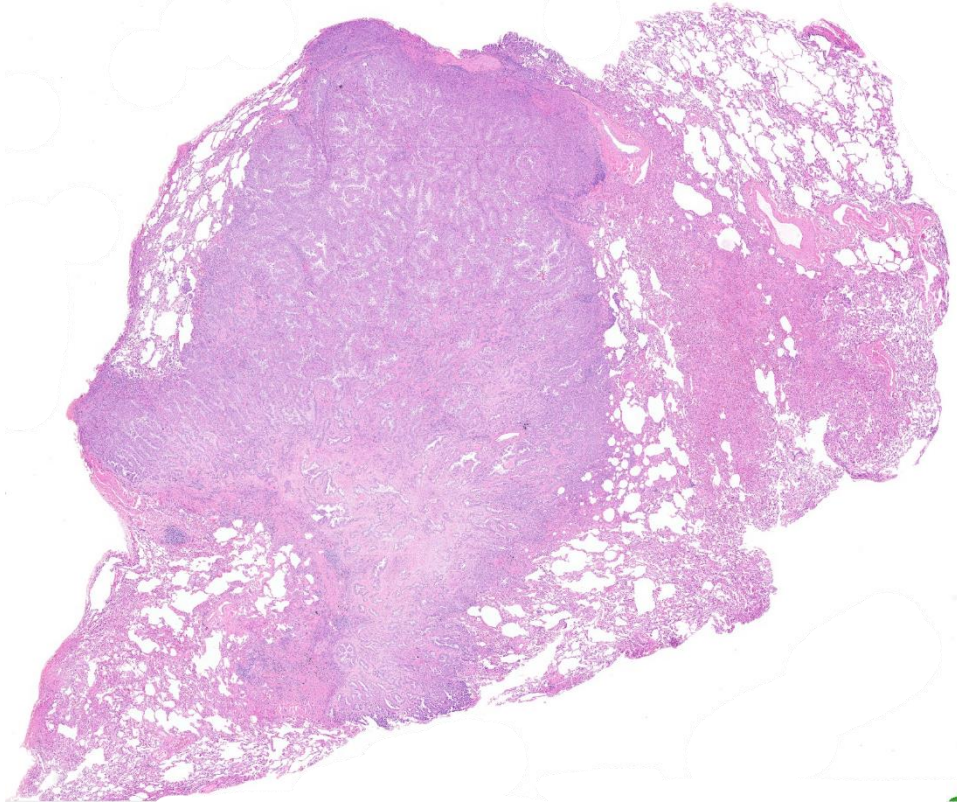
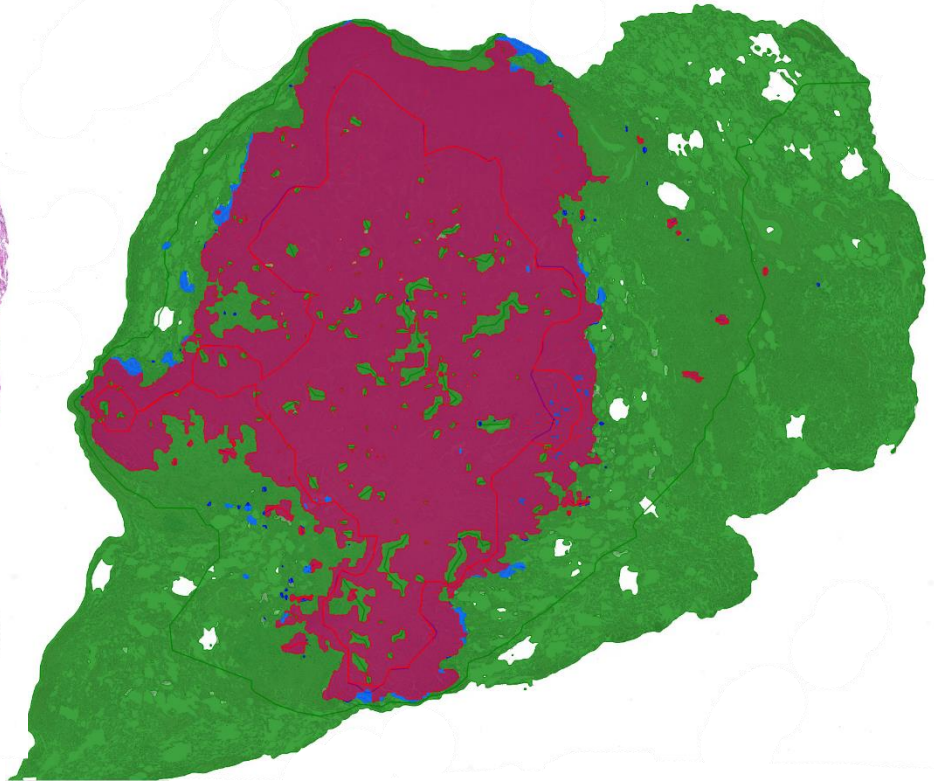


100% invasive



98% invasive

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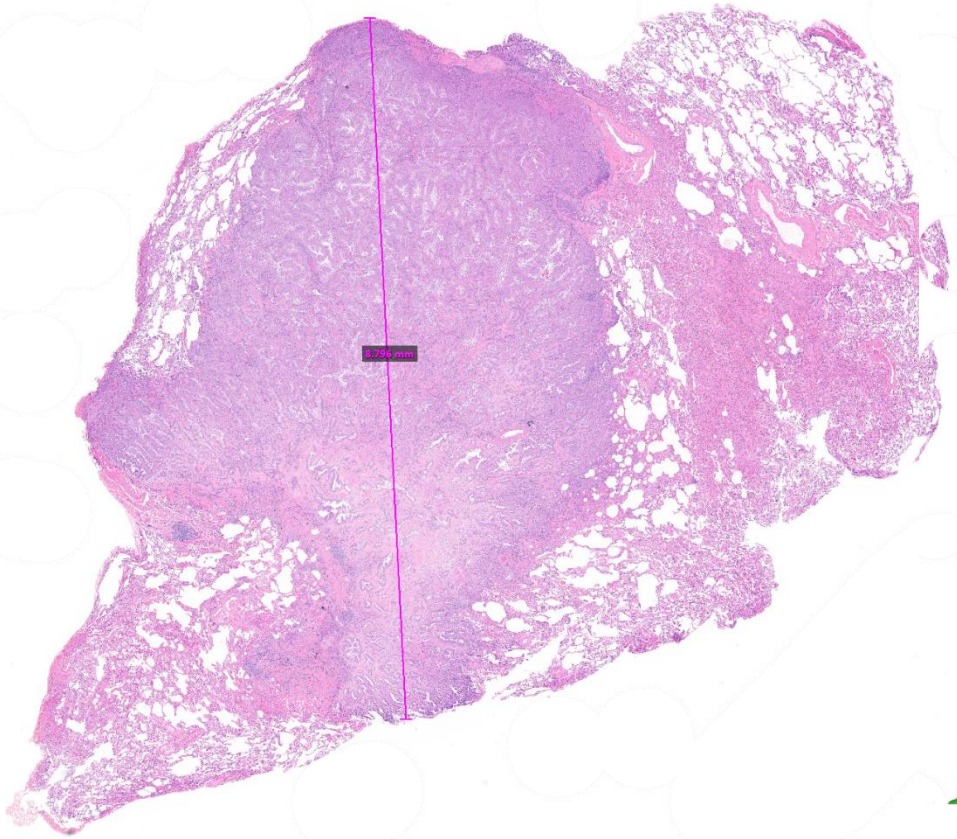
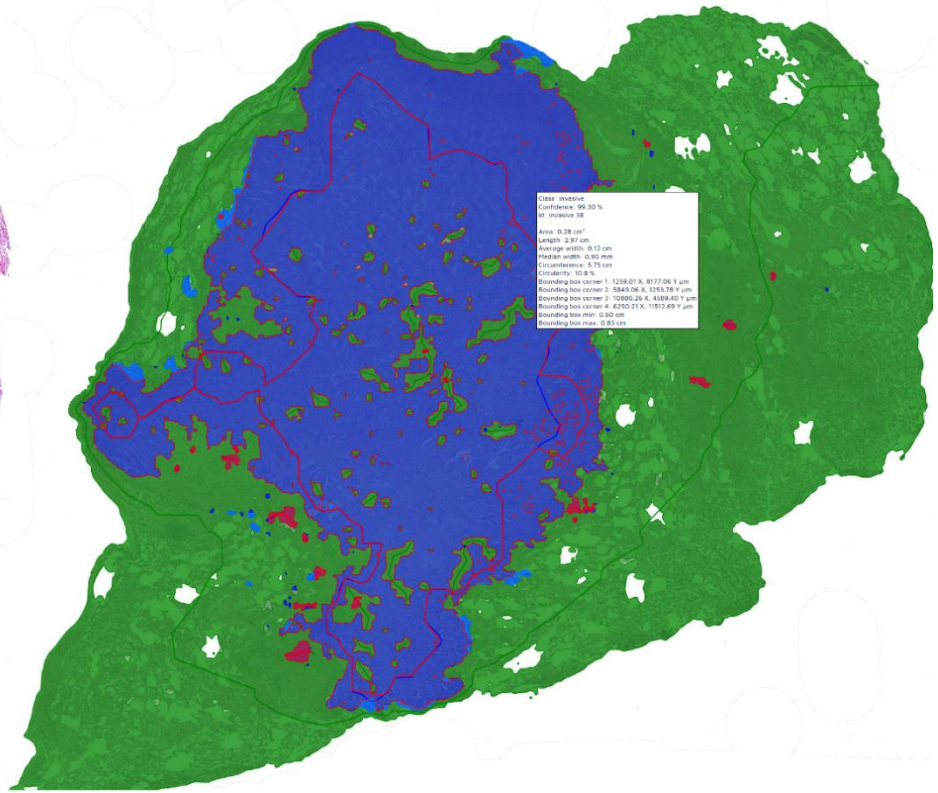

8.796 mm


Class: Invasive
Confidence: 99.30 %
Id: Invasive 38
Area: 0.28 cm²
Length: 2.97 cm
Average width: 0.12 cm
Median width: 0.90 mm
Circumference: 5.75 cm
Circularity: 10.8 %
Bounding box corner 1: 1259.01 X, 8177.06 Y µm
Bounding box corner 2: 5849.06 X, 1265.78 Y µm
Bounding box corner 3: 10880.29 X, 4589.40 Y µm
Bounding box corner 4: 6260.21 X, 11612.69 Y µm
Bounding box min: 0.60 cm
Bounding box max: 0.83 cm

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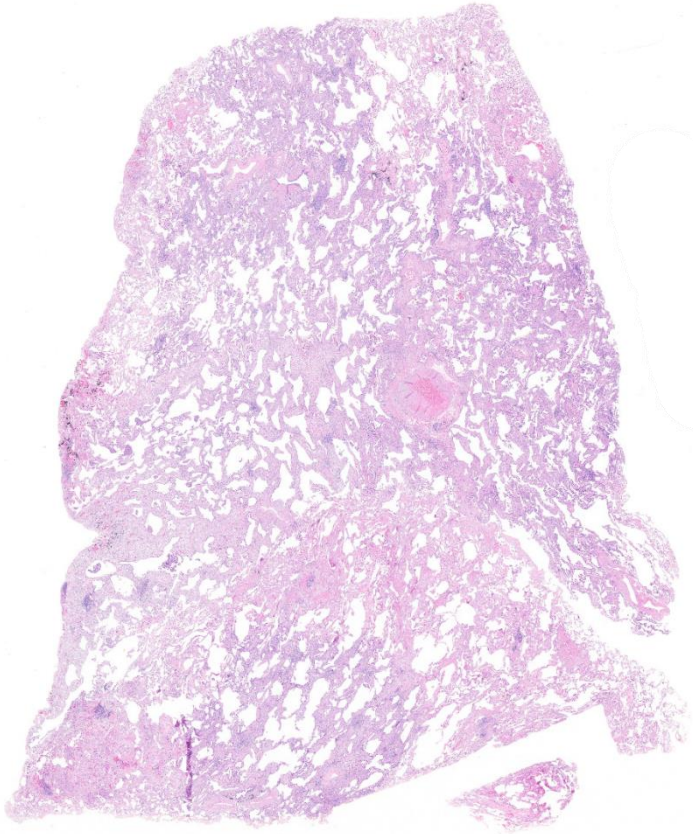
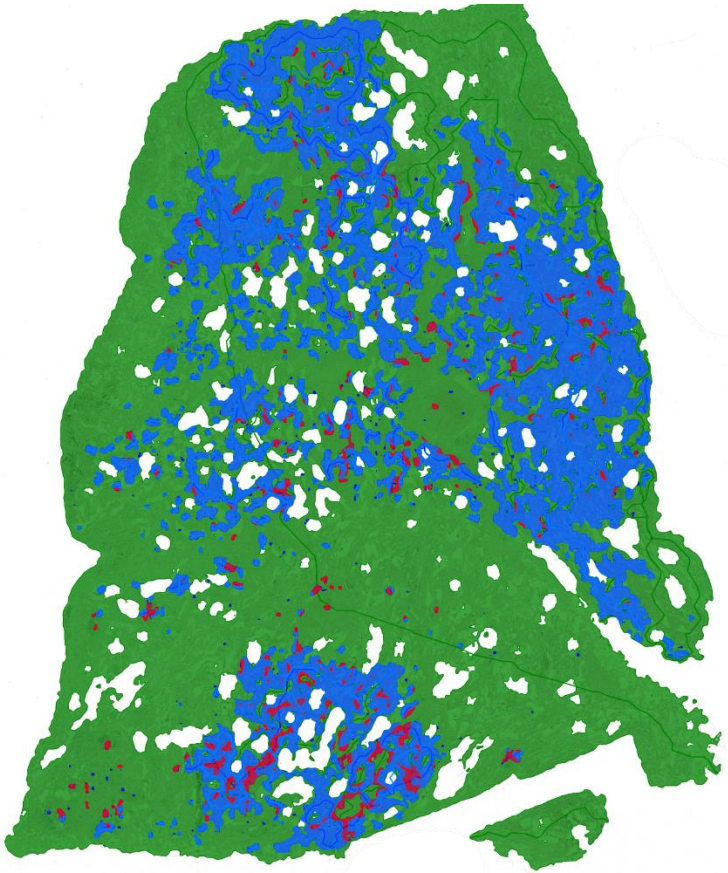


1% invasive



9% invasive

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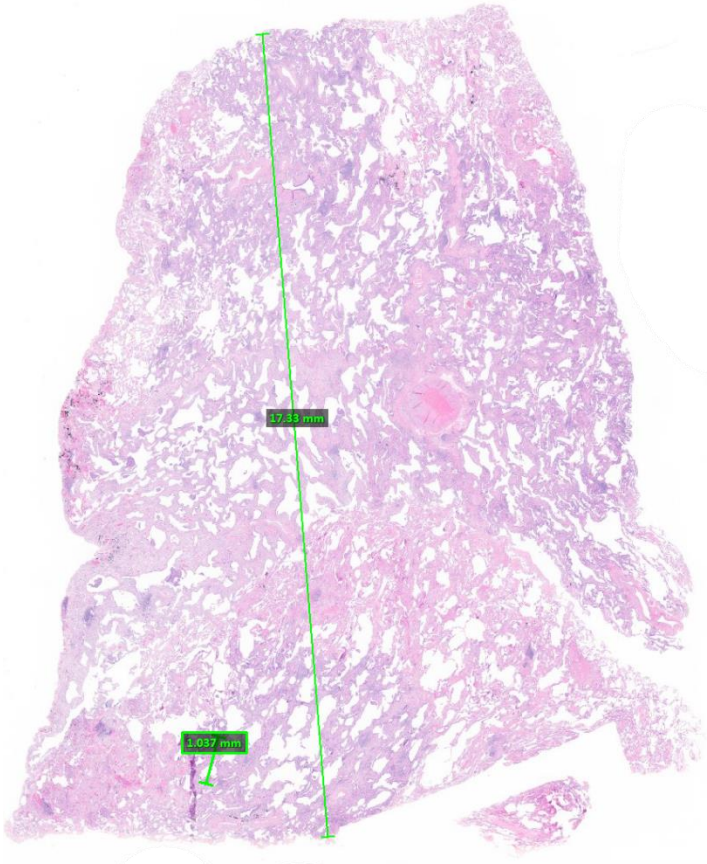
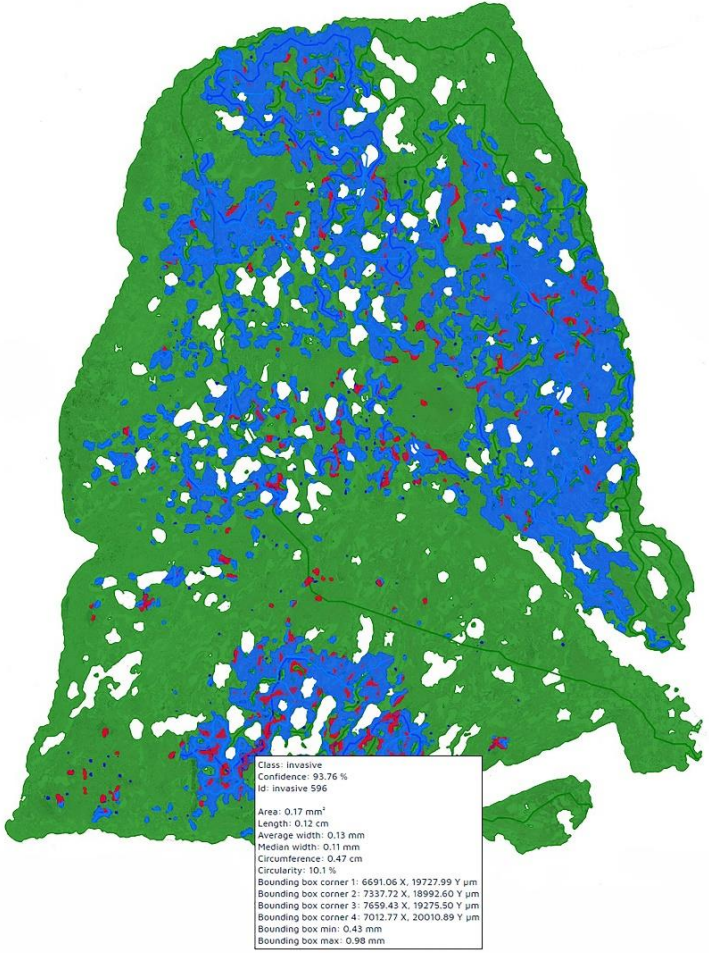

17.33 mm
1.037 mm


Class: invasive
Confidence: 93.76 %
Id: invasive 596
Area: 0.17 mm²
Length: 0.12 cm
Average width: 0.13 mm
Median width: 0.11 mm
Circumference: 0.47 cm
Circularity: 10.1 %
Bounding box corner 1: 6691.06 X, 19727.99 Y µm
Bounding box corner 2: 7337.72 X, 18992.60 Y µm
Bounding box corner 3: 7659.43 X, 19275.50 Y µm
Bounding box corner 4: 7012.77 X, 20010.89 Y µm
Bounding box min: 0.43 mm
Bounding box max: 0.98 mm

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When things don’t go so well…

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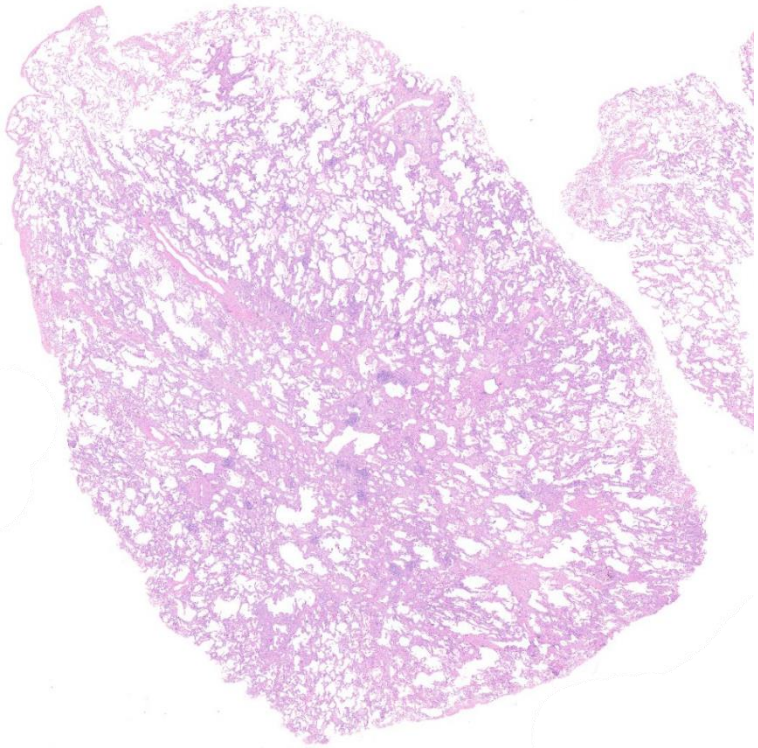
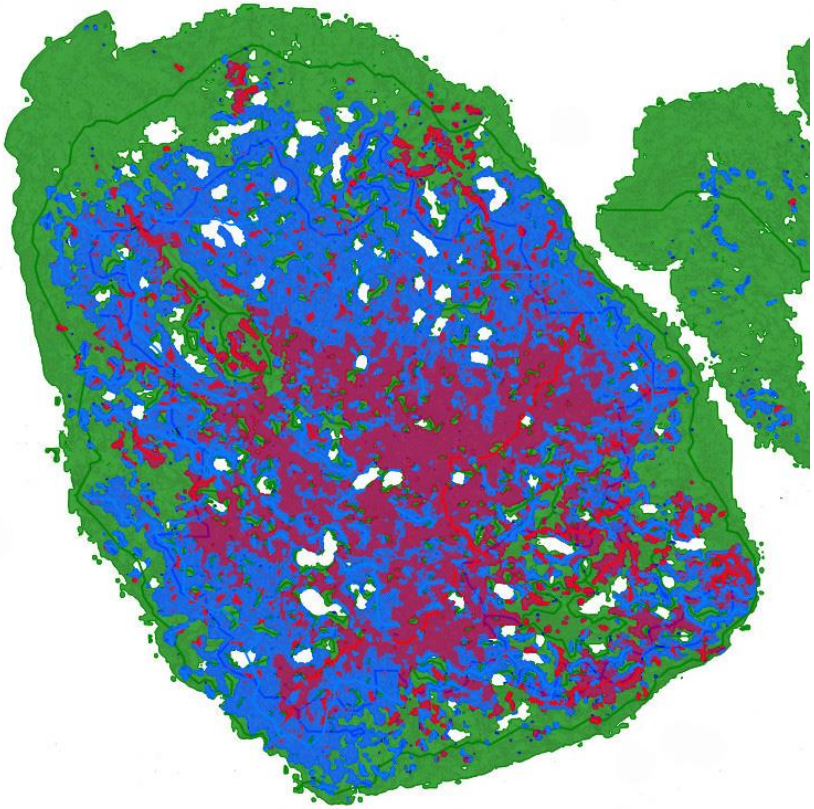
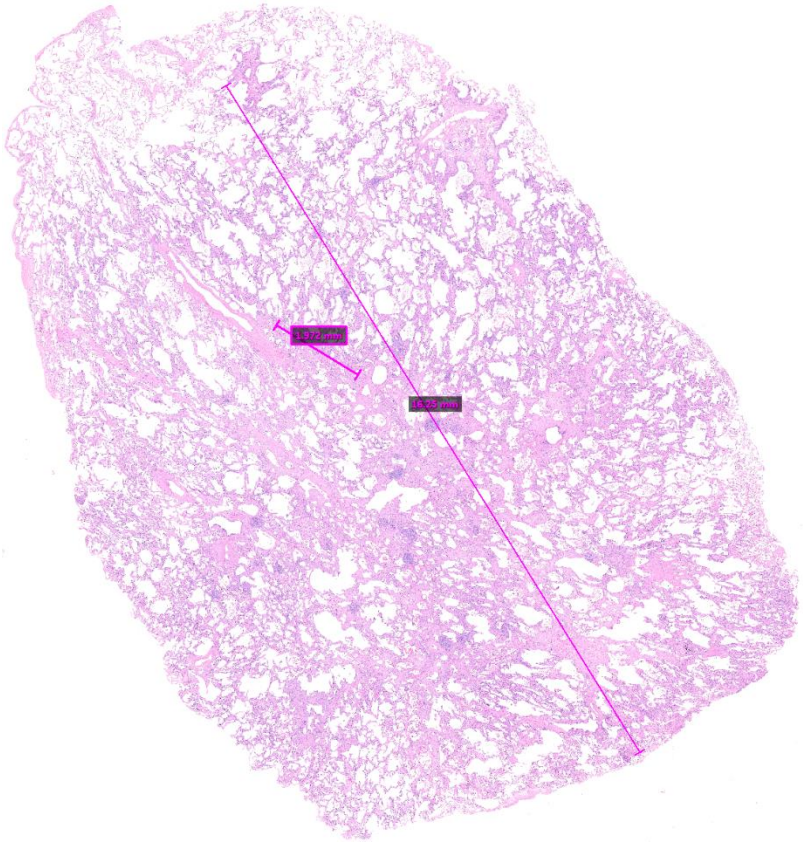
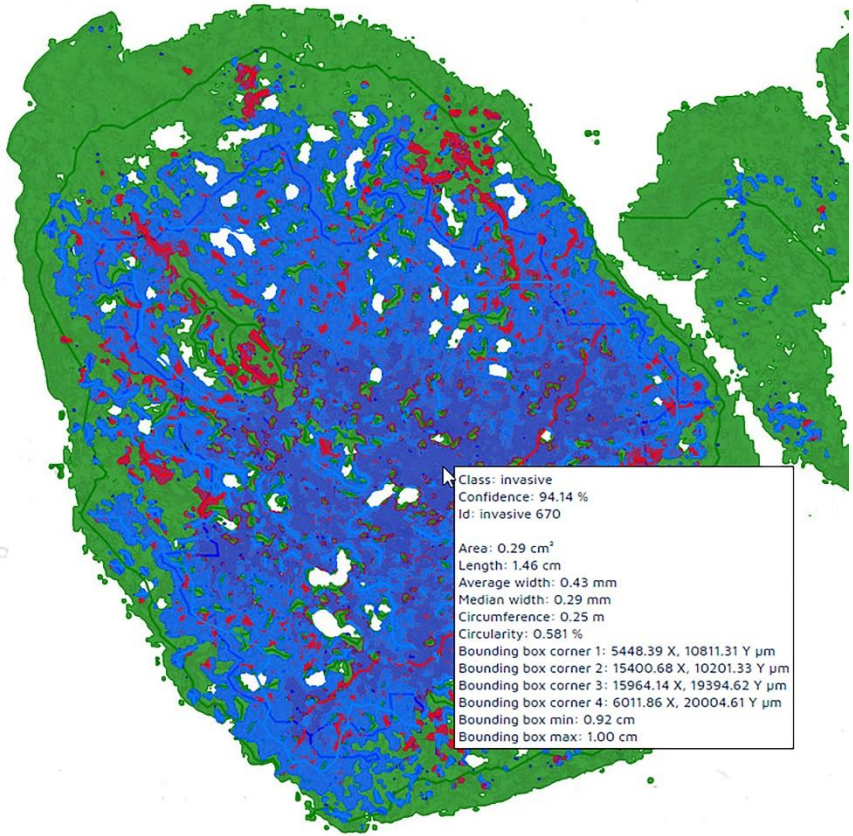


1% invasive



43% invasive




Class: invasive
Confidence: 94.14 %
Id: invasive 670
Area: 0.29 cm²
Length: 1.46 cm
Average width: 0.43 mm
Median width: 0.29 mm
Circumference: 0.25 m
Circularity: 0.581 %
Bounding box corner 1: 5448.39 X, 10811.31 Y µm
Bounding box corner 2: 15400.68 X, 10201.33 Y µm
Bounding box corner 3: 15964.14 X, 19394.62 Y µm
Bounding box corner 4: 6011.86 X, 20004.61 Y µm
Bounding box min: 0.92 cm
Bounding box max: 1.00 cm

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Manual Bridging

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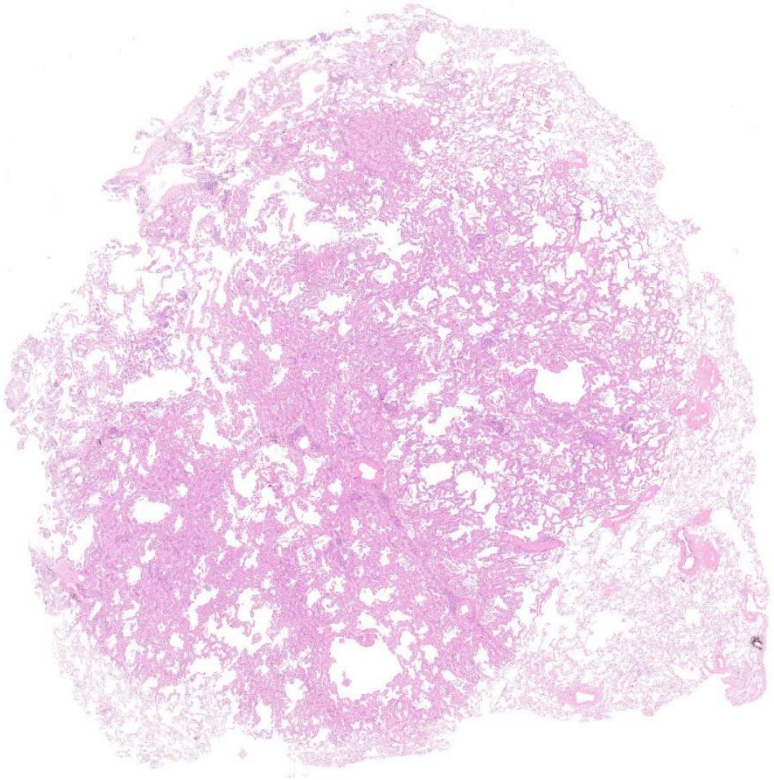
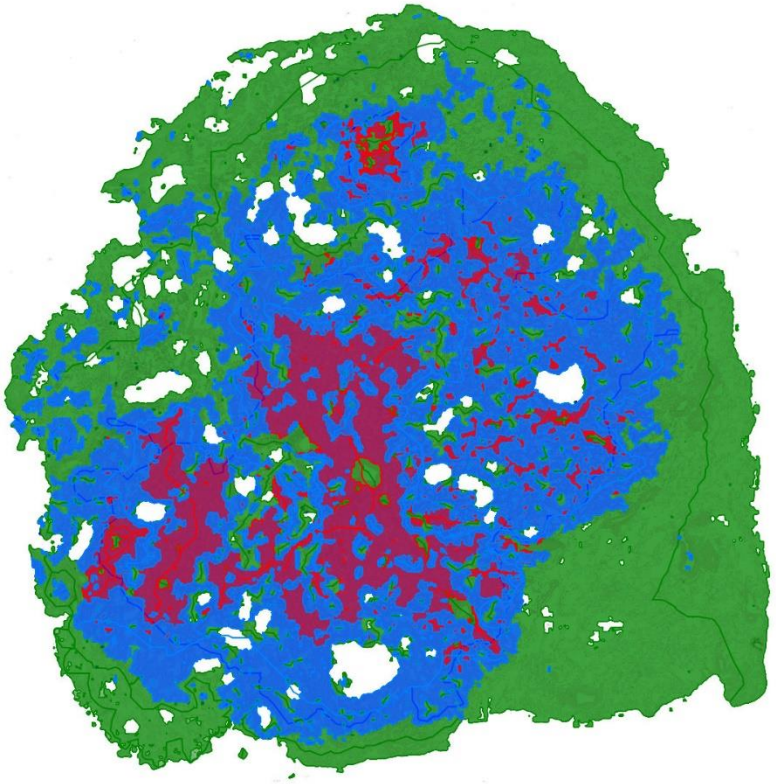


40% invasive



29% invasive

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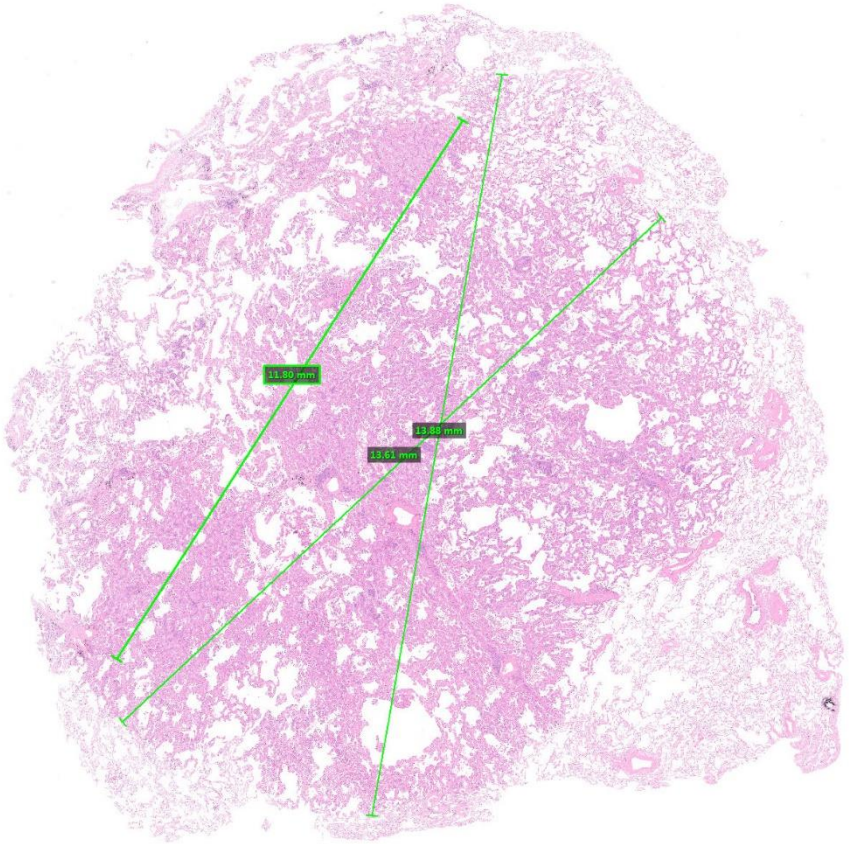

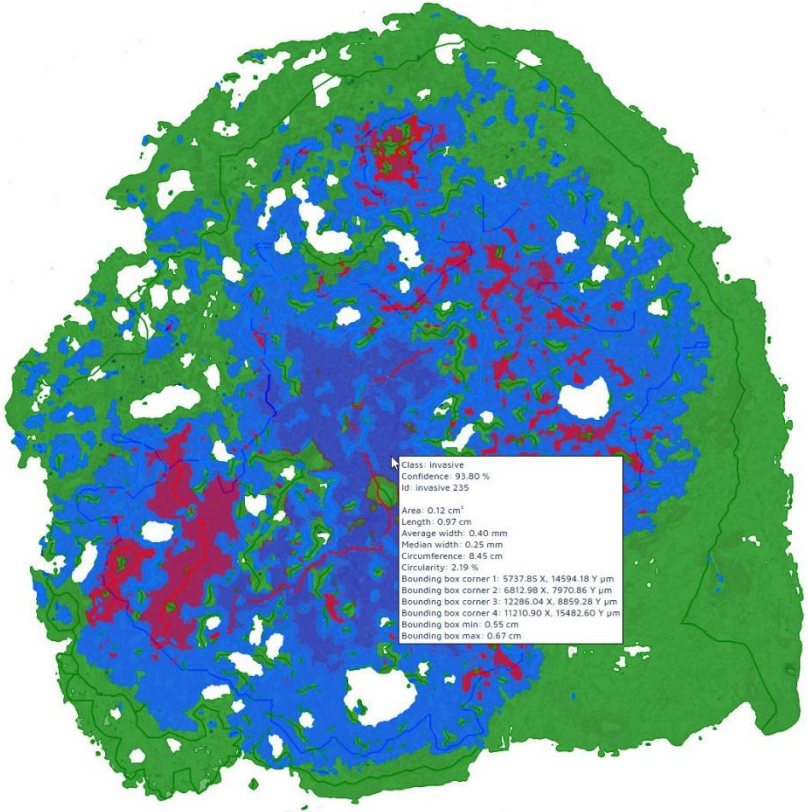

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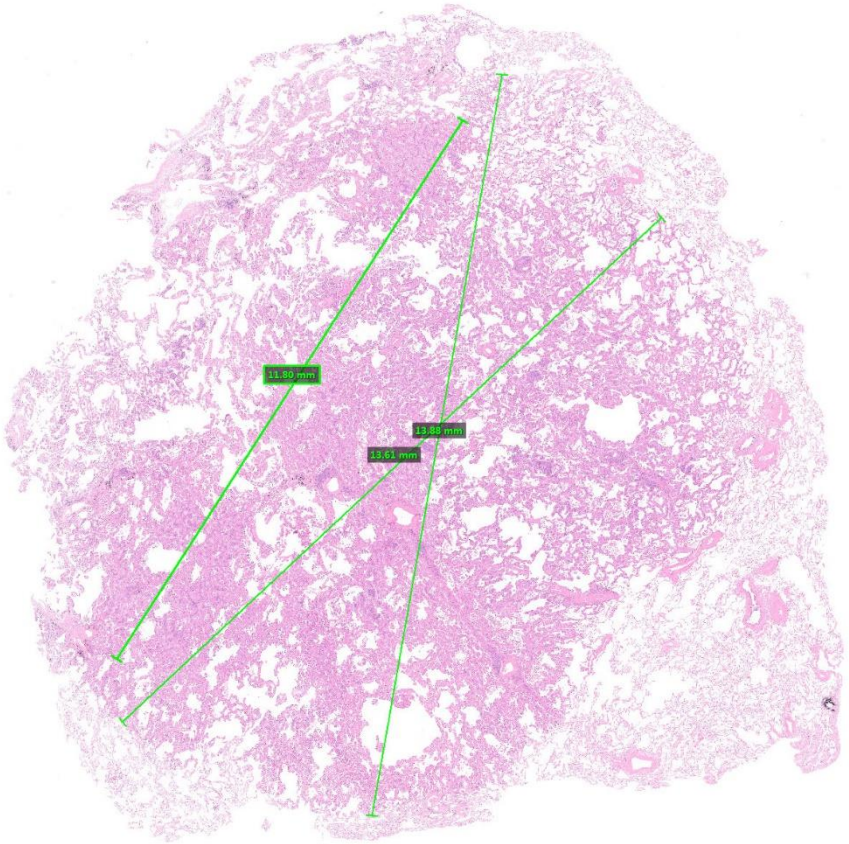
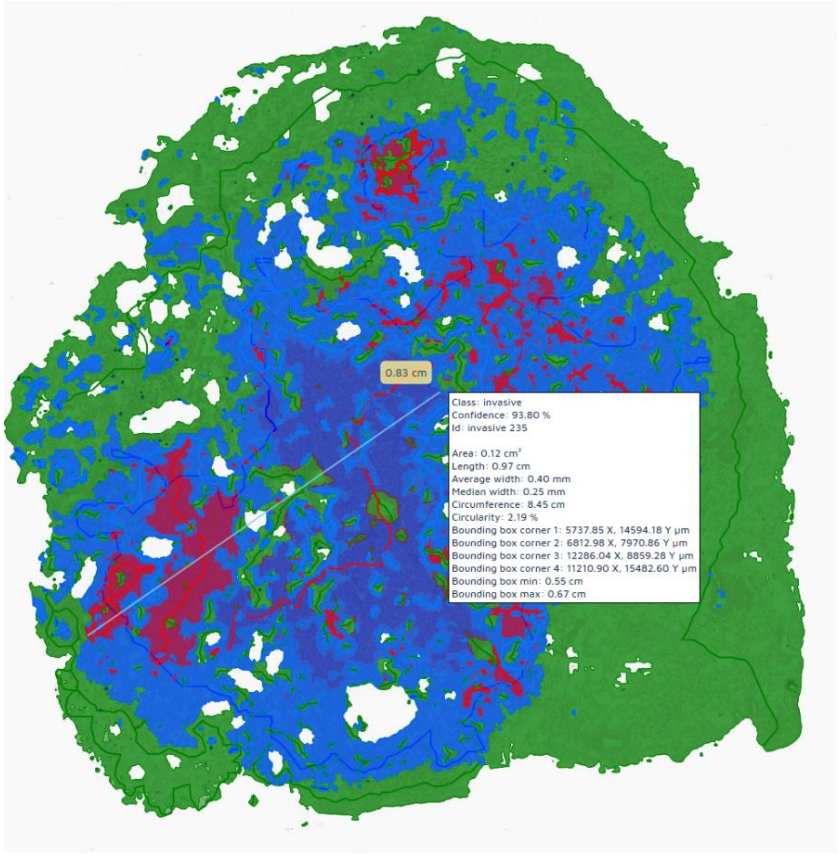
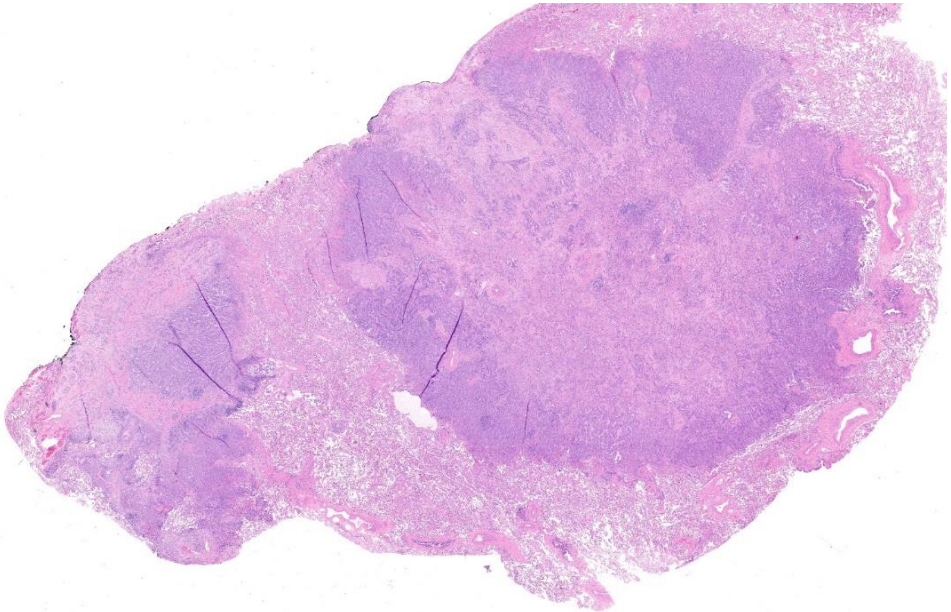
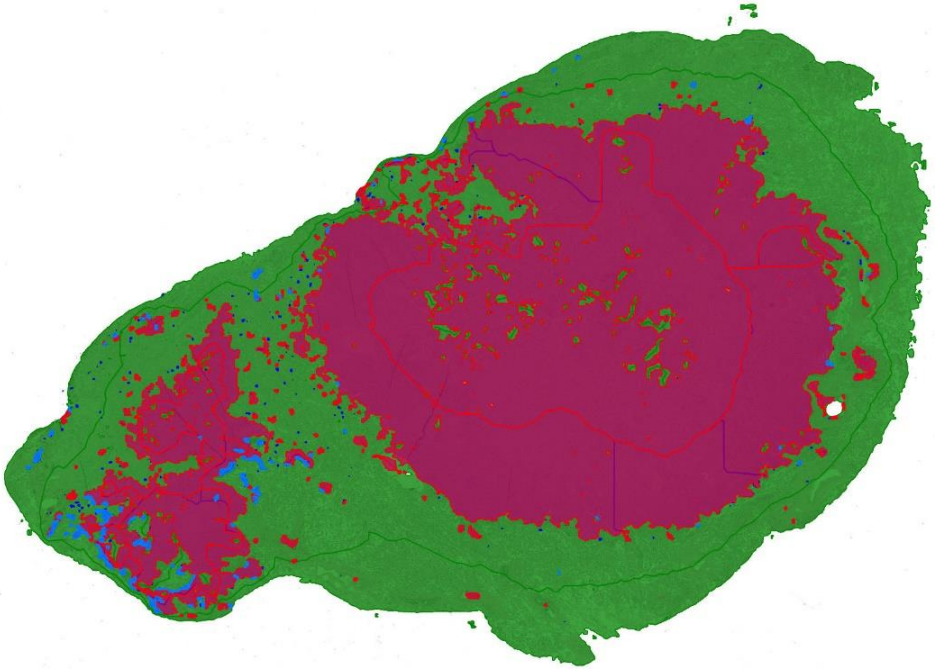

11.80 mm
13.88 mm
13.61 mm

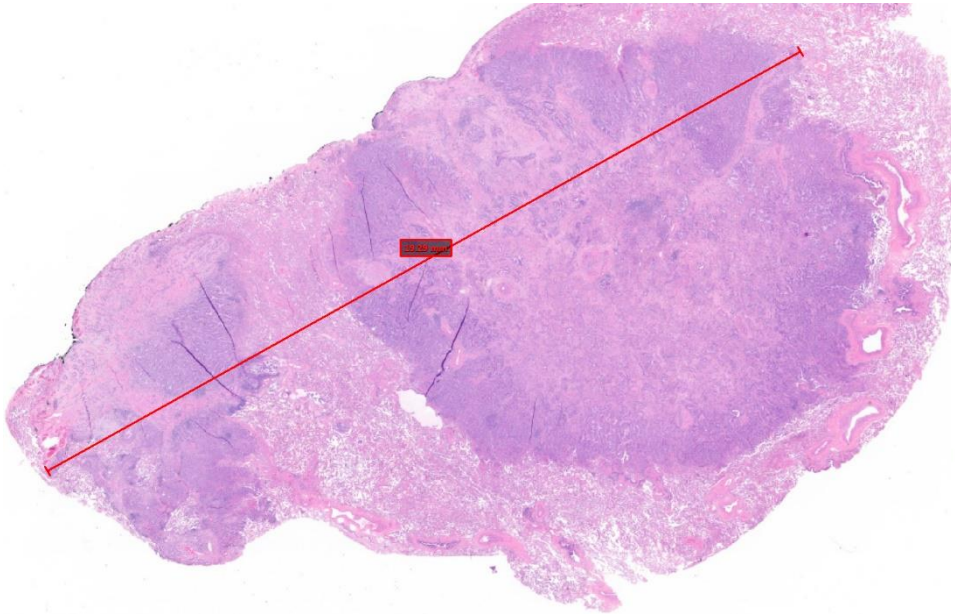

0.83 cm
Class: invasive
Confidence: 93.80 %
Id: invasive 235
Area: 0.12 cm²
Length: 0.97 cm
Average width: 0.40 mm
Median width: 0.25 mm
Circumference: 8.45 cm
Circularity: 2.19 %
Bounding box corner 1: 5737.85 X, 14594.18 Y µm
Bounding box corner 2: 6812.98 X, 7970.86 Y µm
Bounding box corner 3: 12286.04 X, 8859.28 Y µm
Bounding box corner 4: 11210.90 X, 15482.60 Y µm
Bounding box min: 0.55 cm
Bounding box max: 0.67 cm

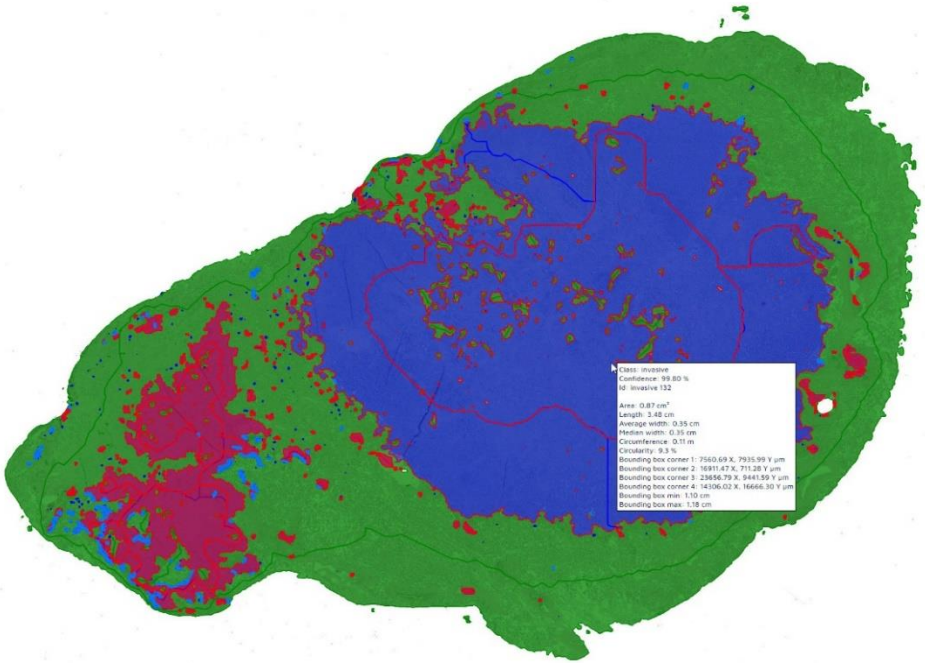


100% invasive



99% invasive




Class: invasive
Confidence: 99.80 %
Id: Invasive 132
Area: 0.87 cm²
Length: 3.48 cm
Average width: 0.35 cm
Median width: 0.35 cm
Circumference: 0.11 m
Circularity: 9.3 %
Bounding box corner 1: 7560.69 X, 7935.99 Y µm
Bounding box corner 2: 16911.47 X, 711.28 Y µm
Bounding box corner 3: 23656.79 X, 9441.59 Y µm
Bounding box corner 4: 14306.02 X, 16666.30 Y µm
Bounding box min: 1.10 cm
Bounding box max: 1.18 cm

Results

	Median Difference	Mean Difference	Difference Range	SD
Training Set				
Invasive %	9	11.7	1-35	9.7
Tumor Size (mm)	0.7	0.8	0-2.6	0.7
Invasive Size (mm)	1.5	1.6	0-4.7	1.5
Validation Set				
Invasive %	8	15.6	0-93	17.5
Tumor Size (mm)	0.4	0.8	0-6	1.1
Invasive Size (mm)	1	2	0-9.2	2.4

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Conclusions

- An AI model was successfully designed using expert pathologist annotations to aid in assessment of pulmonary adenocarcinoma invasion.
- Most invasive percentages generated by the AI model were within 10% of pathologist assessment, with tumor and invasive measurements typically within 1-2 mm.
- However, manual pathologist review and potential revision of the model assessments is necessary to ensure accuracy.

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Possible Future Directions

- Reduce the need for “bridging” measurements
- Recognition of invasive tumor patterns
- Interobserver variability studies
- More nuanced features
  - STAS
  - Pleural Invasion

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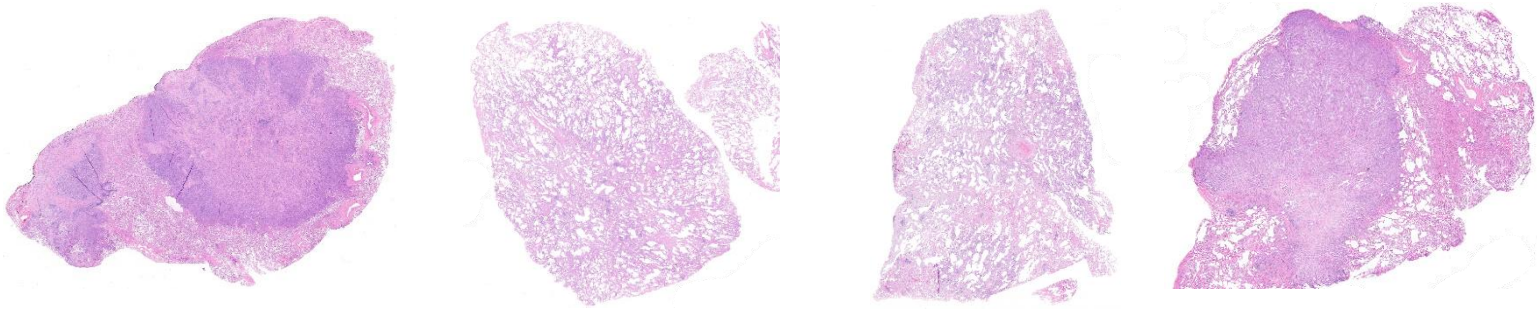
Questions and Discussion



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