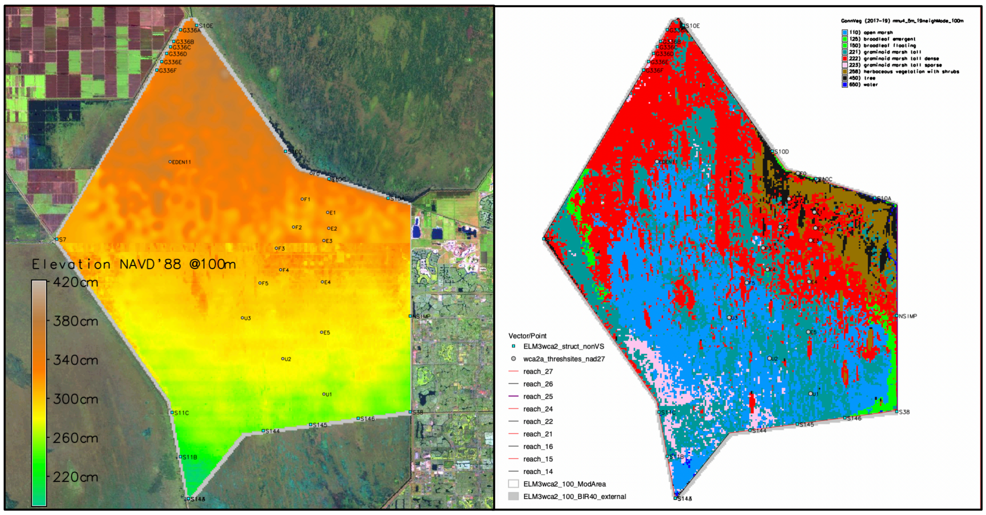
Everglades Landscape Model (ELM) Modeling in Support of Water Conservation Area 2A Flow Restoration: *Task2 Ground Elevation and Vegetation Data*



Submitted to the
Marsh Ecology Research Group
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1.0 TASK OVERVIEW

The Everglades Landscape Model (ELM, http://www.ecolandmod.com/) is a variable-scale, integrated ecological assessment tool designed to understand and evaluate the potential landscape responses to different water management scenarios in South Florida, USA (and elsewhere). The South Florida Water Management District (SFWMD) is interested in evaluating management alternatives for WCA-2A using the ELM as the primary tool to assess hydrologic and ecological responses to proposed water management strategies in northeastern WCA-2A.

For this data-focused **Task 2,** we evaluated available ground **elevation** and **vegetation** datasets that are fundamental "drivers" of the simulated flow regime. We then developed and/or aggregated spatial data, that result in the best available spatial data to meet this project's objectives @100 m grid resolution.

In particular, the best available recent/current elevation dataset required data interpolation and multi-scale refinement to ensure that ELM simulations are most useful to meet the Project objectives. Major airboat trails (i.e., in NE quadrant) have (elsewhere) been integrated into the model system as ("creek") vectors, and are (mostly) not part of the final 100 m grid raster elevation and vegetation data simply due to scale.

2.0 ELEVATION

In WCA-2A, land surface elevation has been measured by various investigators prior to the most recent effort (Gann et al. 2023). We don't summarize/review prior efforts at different scales and objectives, but later below we do provide those prior results that are relevant to this project.

The Gann et al. (2023) Digital Terrain Model (**DTM**), based on LiDAR data collected by others, was a major elevation-data-focus for this project's evaluations of current-day flows and hydro-ecological dynamics. Importantly, Gann et al. (2023) also conducted high-accuracy (real-time kinematic, RTK) point-based elevation surveys at a suite of locations distributed through the WCA-2A basin. Throughout this document, we assume the primacy, and accuracy, of those RTK surveys over the LiDAR-based (model assumptions of the) DTM elevation results.

Project goals related to elevation: quantify flow-effects of the engineered, biologically-enhanced (?) higher elevation ("berm") bordering the southern rim of the receiving canal of the S-10 inflow structures, and quantify those effects on downstream basin-wide flows and water quality.

Elevation data, final integration: **Three tiers of elevation data** were evaluated and integrated: 1) Northern basin elevation, in a region with well-defined vertical DTM discontinuities; 2) Southern basin elevation, with poorly-defined (horizontal) DTM discontinuities; and 3) Fine-scale berm elevation within the (model-constrained) 100 m swath of cells that receive S-10 inflows.

Final elevation product: meets the needs of Project objectives, regarding the local and basin-wide flow regime resulting from berm modification scenarios.

DTM: Basin-scale elevation

In WCA-2A, LiDAR sampling for DEM/DTM (models) was processed by [EDEN] Simons et al. (2024), and independently by Gann et al. (2023), the latter using water depth and vegetation attributes to model elevation bias reduction (vegetation described in later section of this report).

Elevation data development:

1. Major discontinuities/artifacts were clearly introduced by a) original flight LiDAR data acquisition/processing, and/or b) digital elevation/terrain model assumptions.
2. Rather than attempting to average/smooth out false data interspersed with “good” data (not defensible, given the major coverage of false data), a point-based sampling of the “good” Gann (2023) DTM data surface at useful (ca. 350m) point-spread spatial scales was used to create interpolated elevation surface(s).

Figure 1. DEM (EDEN)/DTM (Gann) results showing major vertical discontinuities to consider.

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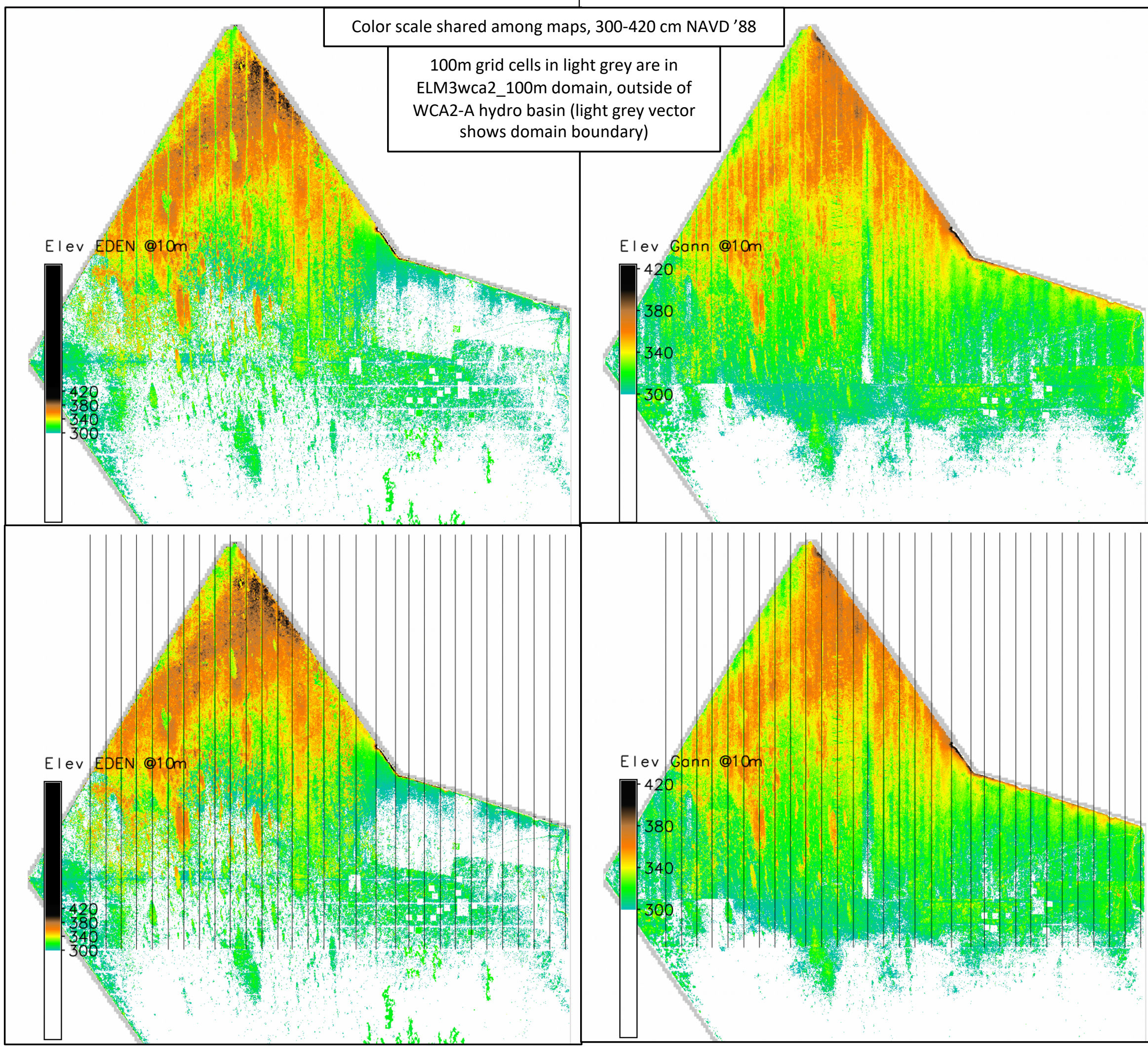
EDEN 2024 “BestElevation” @10m resolution	Gann 2023 “dtm_mdl_2.1” @10m resolution

Gann (2023) model modified the original LiDAR data/model used by EDEN (2024)

Those changes were made to improve a LiDAR-based elevation model, using corrections related to estimated water depths and estimated vegetation type/density



Note: the Gann map **added parallel, continuous vertical discontinuities**, ca. midpoint between many vertical lines

Note: the Gann map **added parallel, continuous vertical discontinuities**, ca. midpoint between many vertical lines

Vertical vectors were generally separated by ~700m; some lines were input via that calculation,and others were input by visual matching of map-discontinuities.

Best-estimate vertical discontinuity vectors overlain, same for both maps, mostly about 700m spacing.

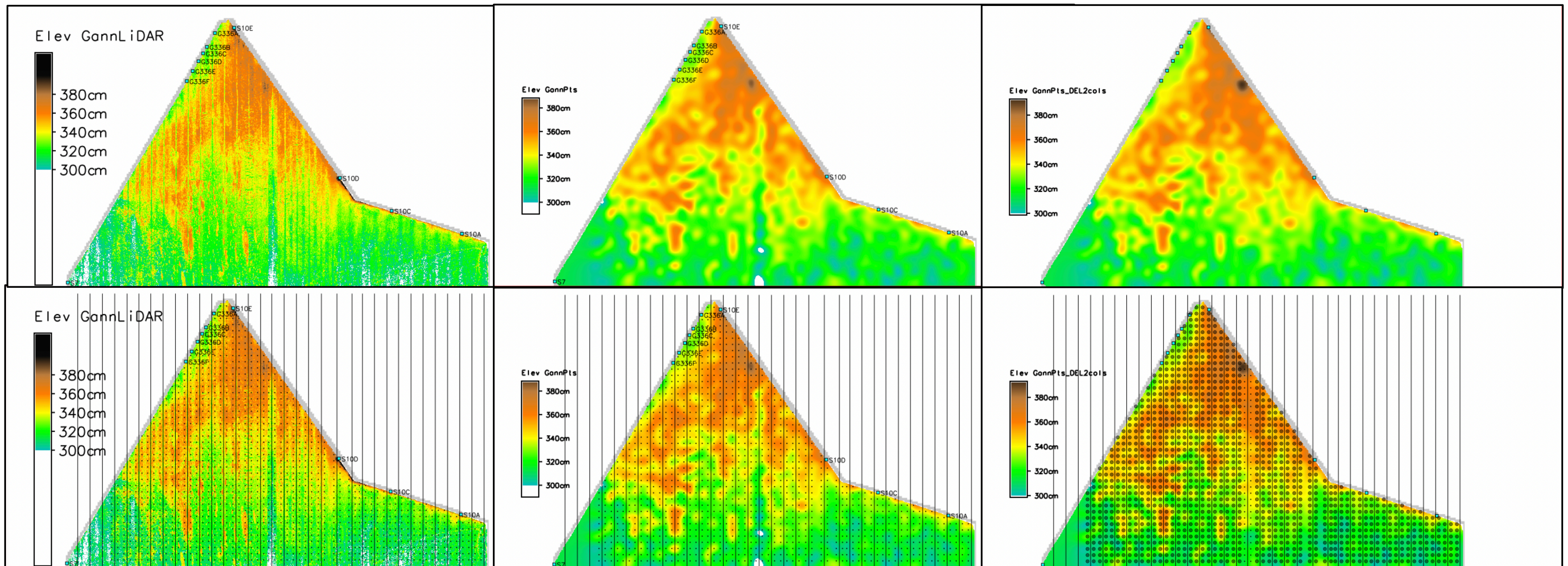
Figure 2. North WCA-2A elevation map, interpolated from useful Gann DTM points.
Shows selected points that were considered to be outside of vertical discontinuities from LiDAR based Gann DTM. Selected points were interpolated within North mask, using GRASS 7.8 GIS, Regularized Spline with Tension method.

Figure follows on next page, with notations that self-document the information.

Elevation Gann LiDAR @10m

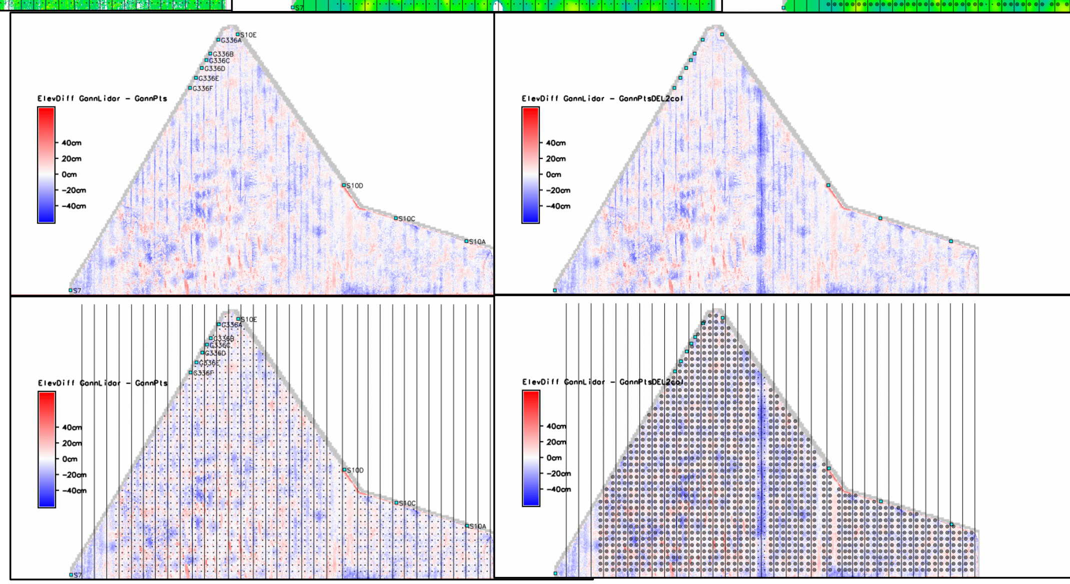
Elevation Gann LiDAR point-sampled, interpolated @10m

Elevation Gann LiDAR point-sampled, DELeted 2 point cols, interpolated @10m



Points generated from spreadsheet containing coords of lines, w/ pts 175m to either side of lines (limited due to finding that mid-point between lines held additional vertical discontinuities).

Thus, points spaced at, usually, ~350m regular grid spacing



Points in “DEL2cols” mapset removed more vertical extreme anomolies, as visually evident.

Figure 3. Points used in generating elevation surfaces.
Older source is USGS's HAED (High Accuracy Elevation Dataset) (Desmond 2003). HAED (2003) survey points (black, ~400 m spacing), and Gann (2023) DTM-sampled points (red, 350 m spacing), for visual comparative reference

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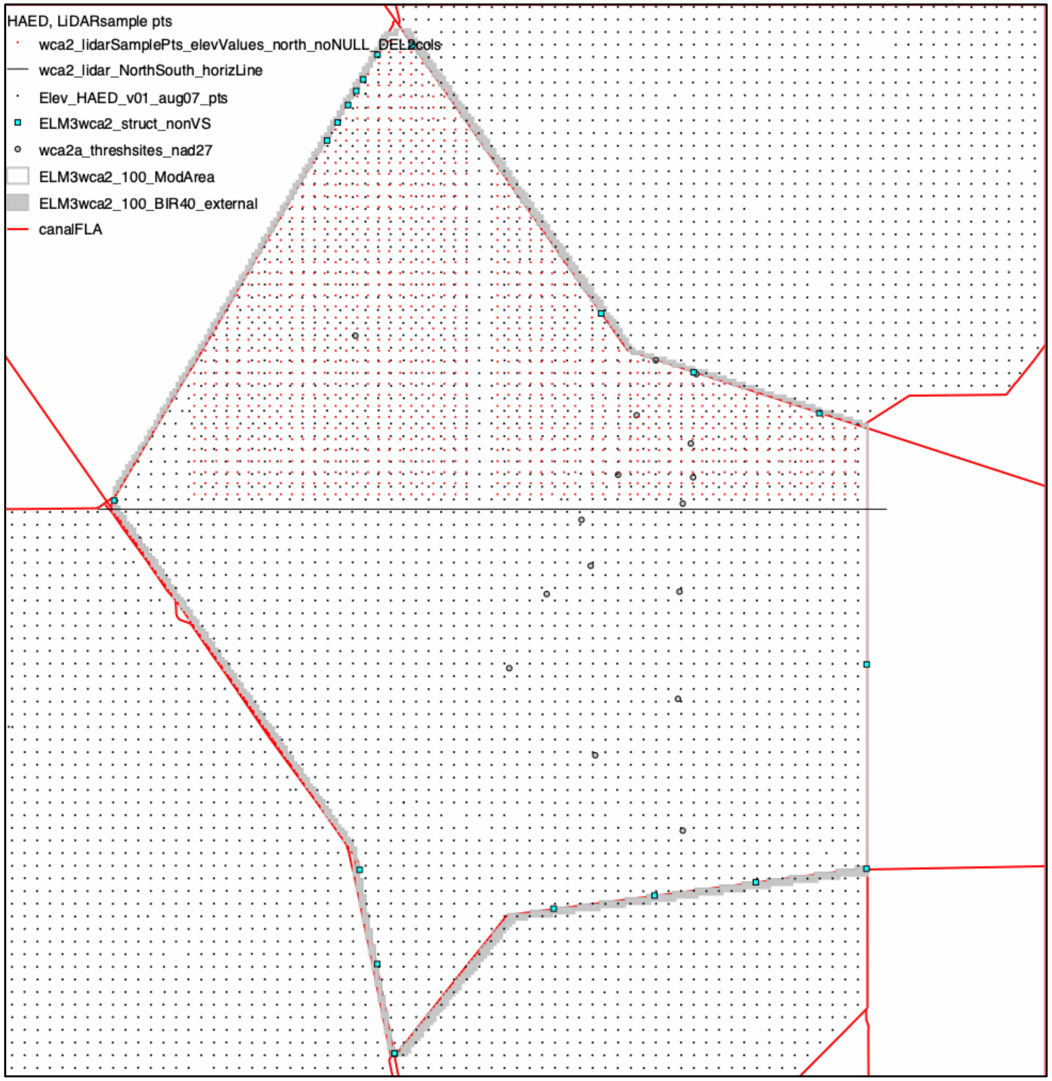
HAED, LiDARsample pts
wca2_lidarSamplePts_elevValues_north_noNULL_DEL2cols
wca2_lidar_NorthSouth_horizLine
Elev_HAED_v01_aug07_pts
ELM3wca2_struct_nonVS
wca2a_threshsites_nad27
ELM3wca2_100_ModArea
ELM3wca2_100_BIR40_external
canalFLA

Figure 4. Near-final elevation @100m,
map is “Gann 2023 modified”, shown on bottom right of figure. The split between North and South sections of basins is shown by horizontal line.

Top Row of maps (@10m resolution):
North WCA-2A section: (@10m) original DEM (EDEN) and DTM (Gann) sources; on right is Gann modified (2023) interpolated elevation surface, from selected DTM points, shown in prior Figure (version DEL2cols)

South WCA-2A section: (@10m) EDEN (2024) original DEM; original Gann (2023) DTM surface for both (middle and right) Gann maps

Bottom Row of maps (@100m resolution):
Aggregation to 100m: HAED 2003 (left) is RST interpolation of original points @100m. Both Gann maps are aggregated via a) @10m grid, smoothing via moving window neighbor, 9 cell neighborhood centered on cell, median cell values; b) resampled @100m, median values.

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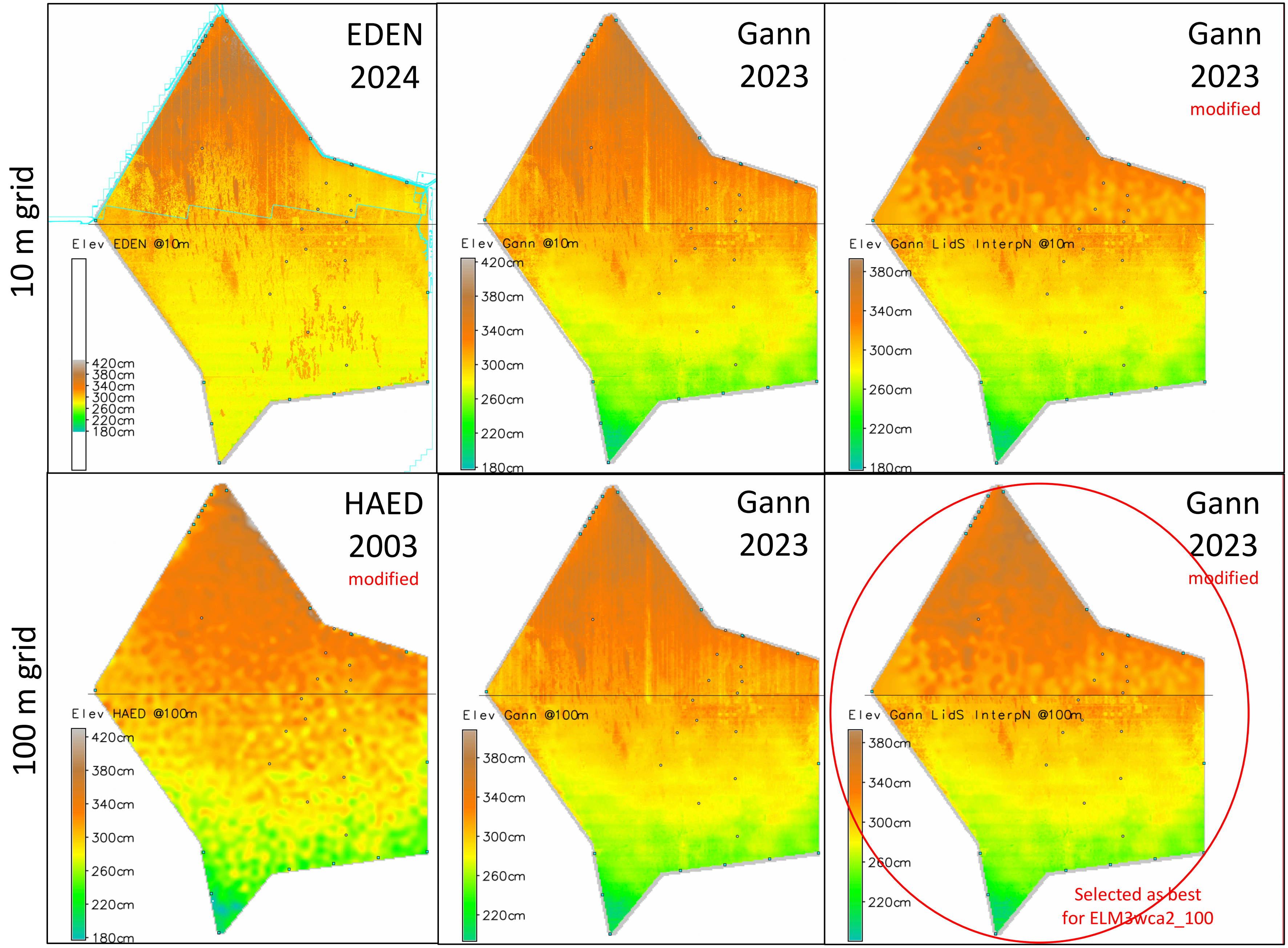
10 m grid
100 m grid
EDEN 2024
Elev EDEN @10m
420cm
380cm
340cm
300cm
260cm
220cm
180cm
Gann 2023
Elev Gann @10m
Gann 2023 modified
Elev Gann LidS InterpN @10m
HAED 2003 modified
Elev HAED @100m
Gann 2023
Elev Gann @100m
Gann 2023 modified
Elev Gann LidS InterpN @100m
Selected as best for ELM3wca2_100

Figure 5. Cumulative flow paths, at 100 m resolution.
GRASS v7.8 GIS r.watershed model applied to elevation maps. Used here as simple visualization tool to show (cumulative cell->cell) flows along drainage basin paths. For relative comparison, older elevation map introduced here, showing elevation and flow paths for 1993 survey. Used to drive hydro-ecological dynamics by Fitz and Sklar (1999).

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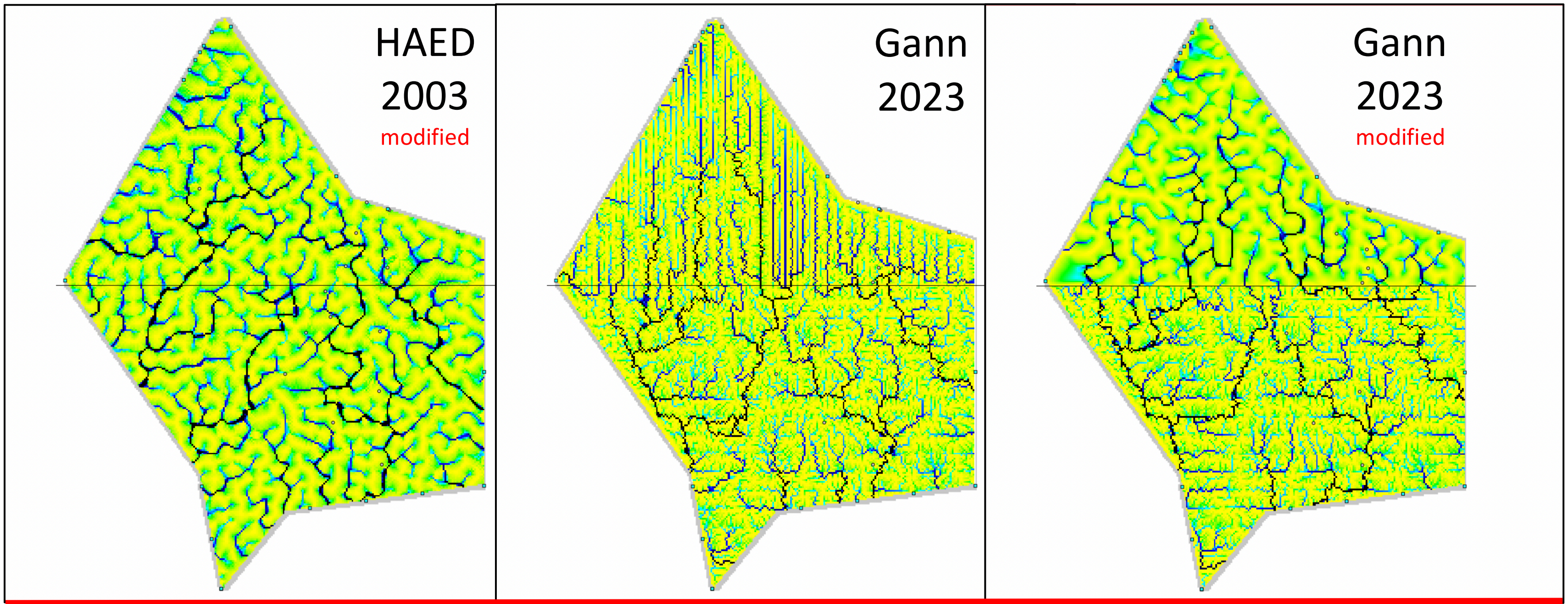
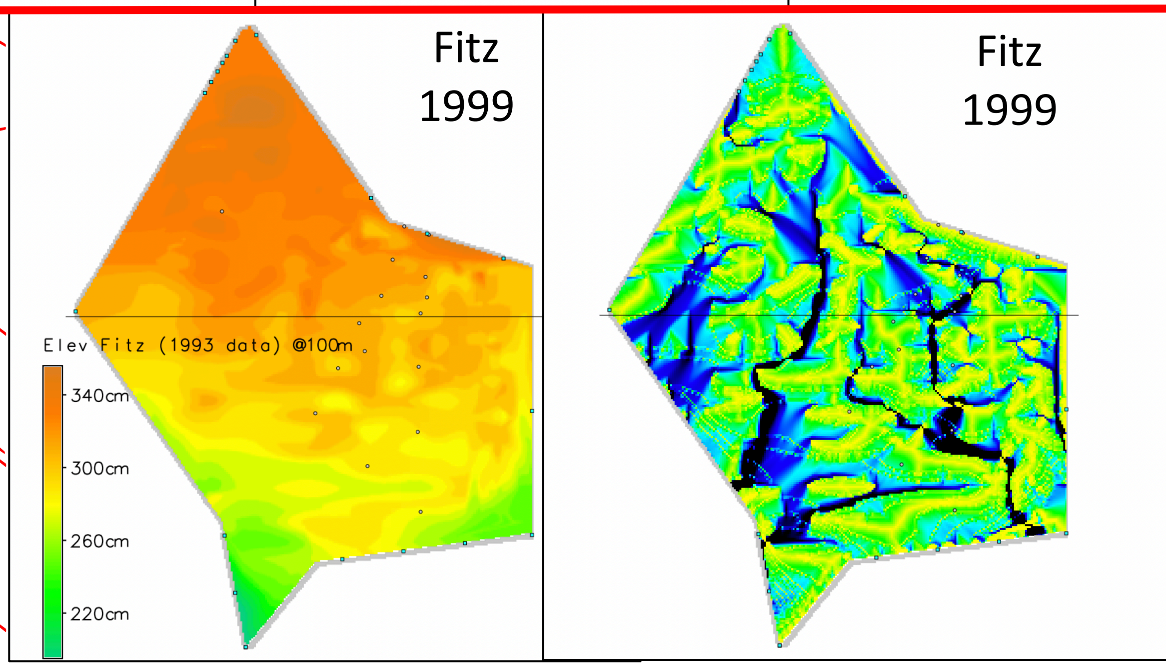


1993 Elevation (NAVD'88), point survey by Keith & Schnars (1993), interpolated by K. Rutchey, used by Fitz & Sklar (1999)



DTM & RTK: Local, Berm-scale elevation

For this project, we are especially focused on the flow dynamics associated with the S-10 (A,C,D) inflow structures, which introduce new water into the WCA-2A basin via their delivery into a borrow canal within the basin (just south of the Hillsboro Canal Levee). To the south along much of the borrow canal, there currently exists an elevation "berm", with higher elevation relative to the adjacent marsh. Understanding flow paths, over and/or around of, that high-elevation barrier into the marsh is fundamental to the goals of this project.

Thus, we used two current sources of elevation data that provided fine-scale information about the berm elevation in this northeast subregion of the basin, hereafter referred to as "**NEberm**". This fine-scale information ultimately must be constrained/rescaled by the 100 m grid resolution (ELM3_wca100) application created specifically for this project.

Figure 6. NEberm subregion, showing ELM-calculated surface water flow allowances in grid cells that interact with canal vector(s)..

Figure follows on next page, with notations that self-document the information.

Cyan grid cells may exchange surface flow with WCA-2A basin; red grid cells in this (geometry) location are outside of basin (defined by black canal/levee ~straight-line-vectors).

A 100m grid-cell mask was created, defined by the irregular dark-grey vector. This is on margin of WCA-2A hydro basin, and includes (almost) all Gann berm survey points (black dots).

Grid-cell mask extends beyond cyan cells to yellow in 6 instances in order to include additional survey points within mask.

Light grey vector is model domain boundary.

NEberm subregion, showing ELM vector-calculated surface water flow allowances in grid cells that interact with canal vector(s).

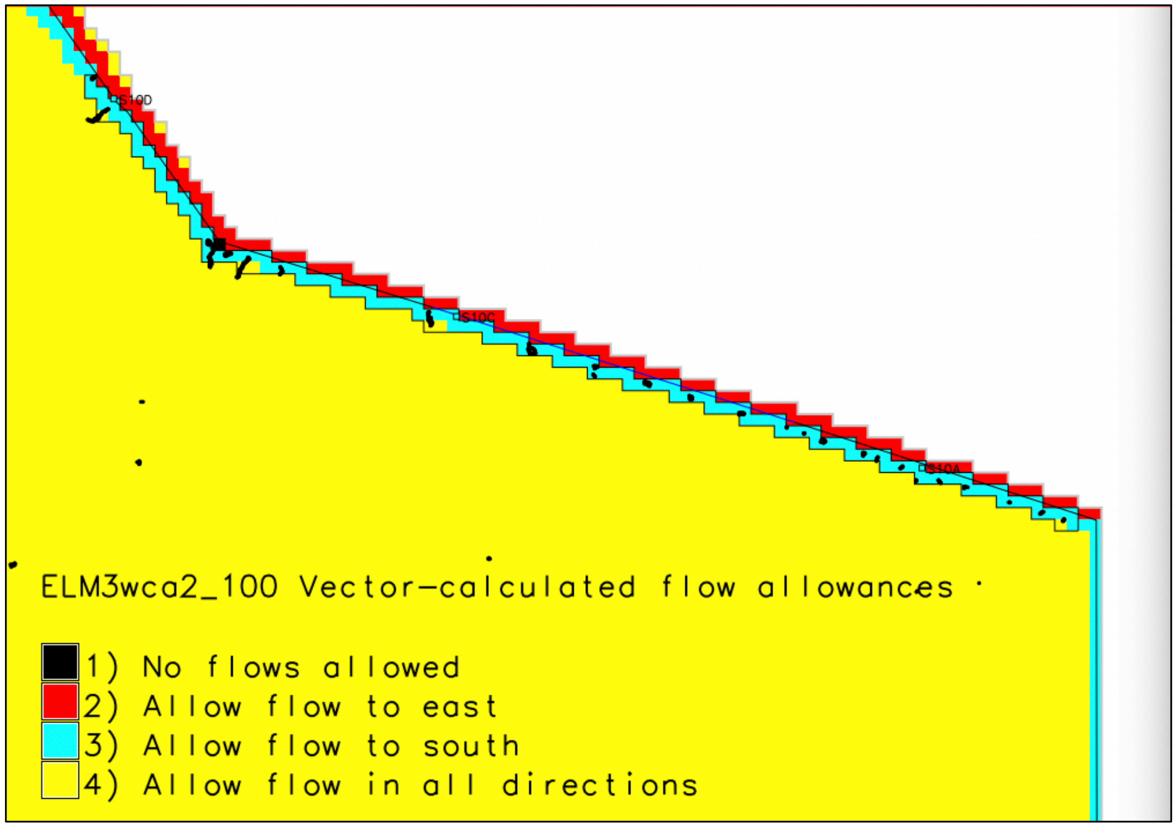


Figure 7. Elevation results within the NEberm GIS mask.
Left side: Gann (2023) DTM @10m; EDEN (2024) DEM @10m, and Gann (2023) survey's point-interpolated elevation surface, using RST interpolation method @10m. Right side shows 100m resampling, using maximum-value of all 10m cells contained within each 100m cell. All operations operated within the NEberm GIS mask. The interpolated surface is considered to be best elevation for this local area, given (above) DTM discontinuities.

Figure follows on next page, with notations that self-document the information.

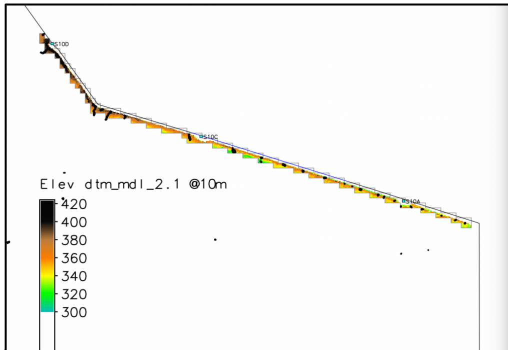
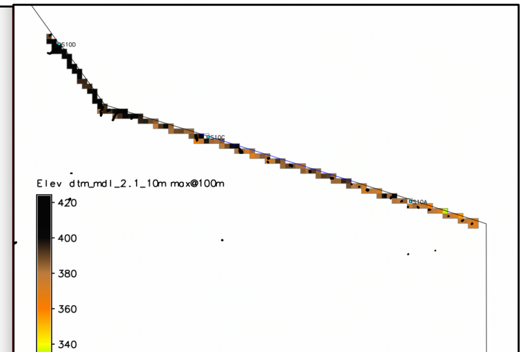
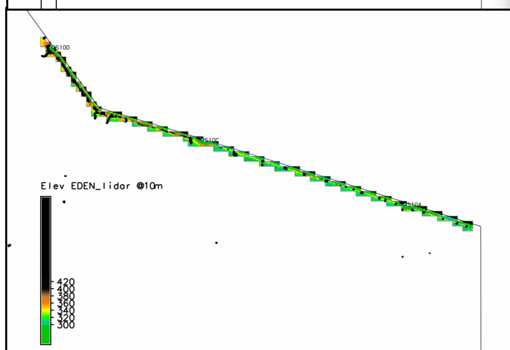
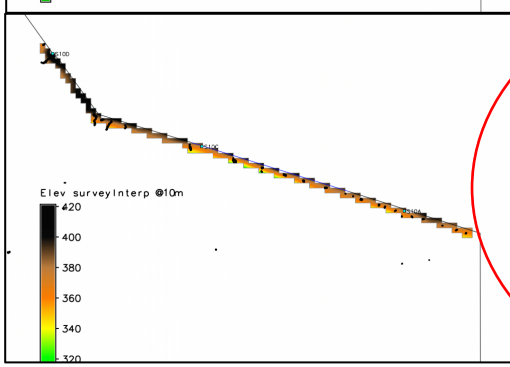
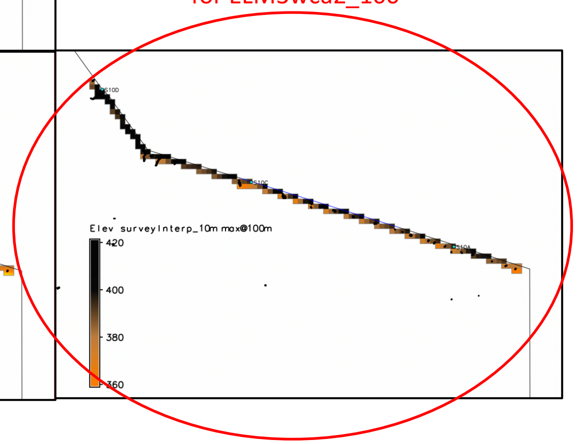
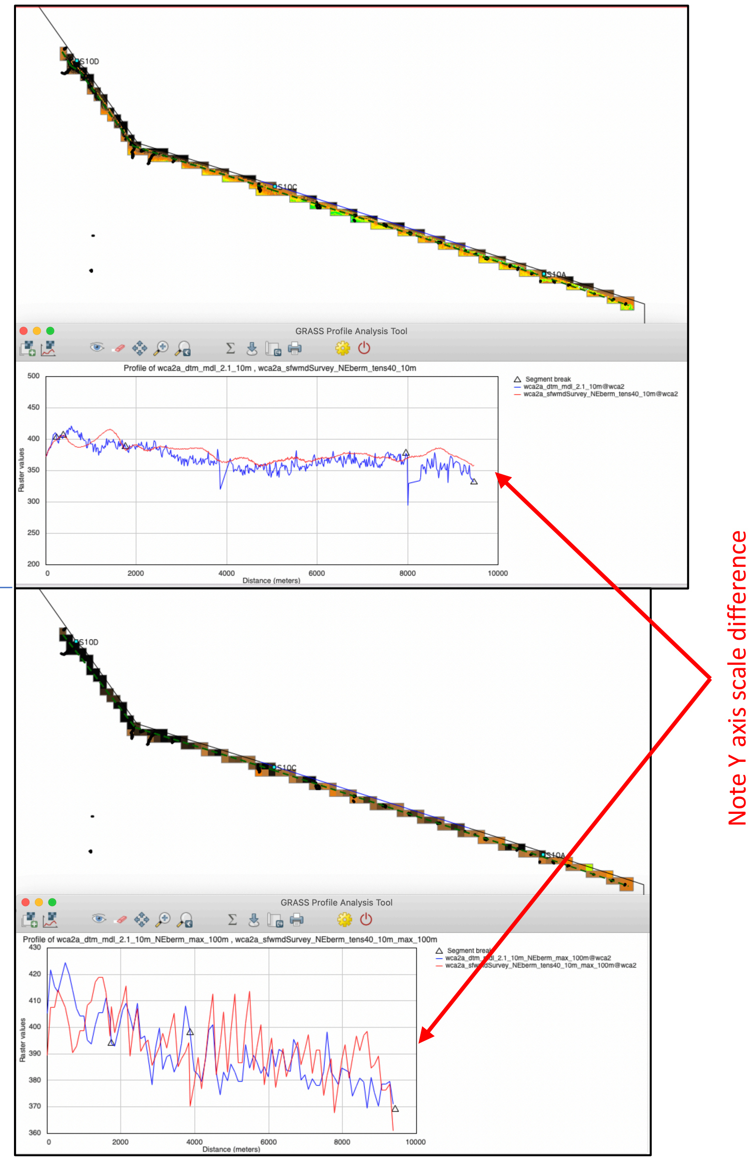
	10 m grid original data	100 m grid resampled, max10m cell in larger cell
Gann (2023) (dtm_mdl_2.1). Note that original 10m data excludes borrow canal, does not extend to Hillsboro levee.		
EDEN (2024) (EDEN_lidar). Note that original 10m data extends to Hillsboro levee (and beyond within this mask).		
ELM RST-interpolation of all Gann (2023) berm survey data within mask (i.e., excluding points shown outside of mask)		Selected as best for ELM3wca2_100 

Figure 8. Raster elevation profiles, along NEberm grid-mask, NW->SE.
Comparing the original (LiDAR-based) Gann DTM and the interpolated results of the Gann survey points, all within the NEberm grid-mask.

Figure follows on next page, with notations that self-document the information.

NEberm Elevation (cm NAVD'88): Gann LiDAR vs. within-mask interpolated Gann survey points

Raster elevation profiles, along NEberm grid-mask, NW->SE



@10m grid resolution
--original LiDAR,
--original interpolated survey
(raster showing Gann LiDAR)

@100m grid resolution
LiDAR & survey, resampled Max-values in included 10m cells
(raster showing Gann LiDAR)

Figure 9. Comparison of NEberm subregion elevation,
without and with above NEberm-specific (local mask) elevation data (top). Bottom, the minor, but observable, flow path differences.

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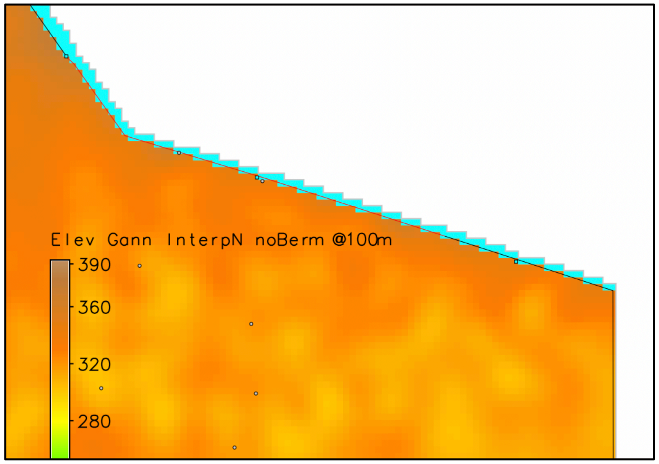
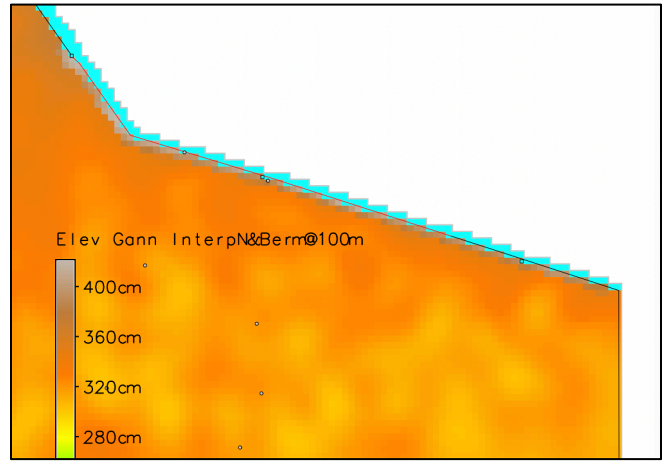
Elevation, interpolated Gann LiDAR pts, w/o Berm Survey interpolated pts

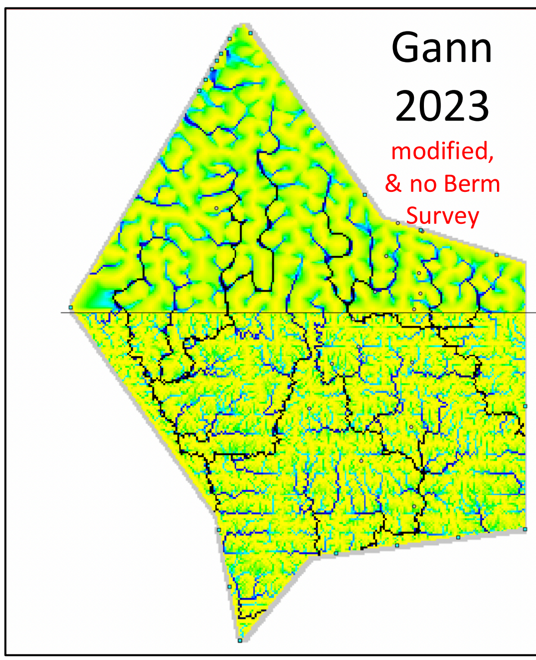


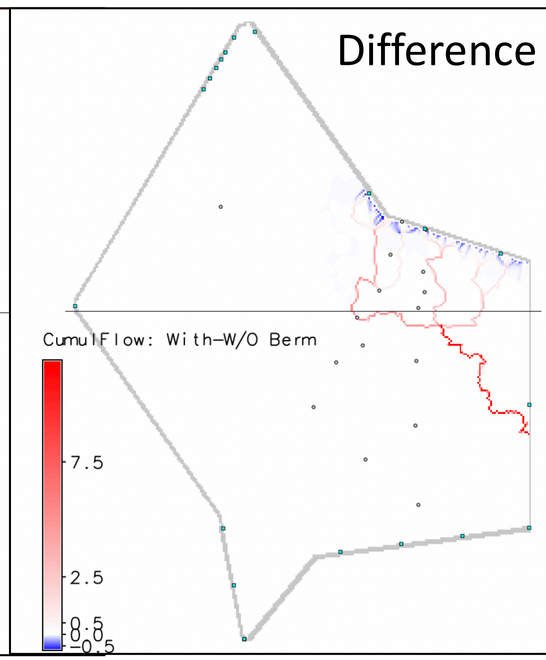
Cyan cells external of WCA-2A model basin

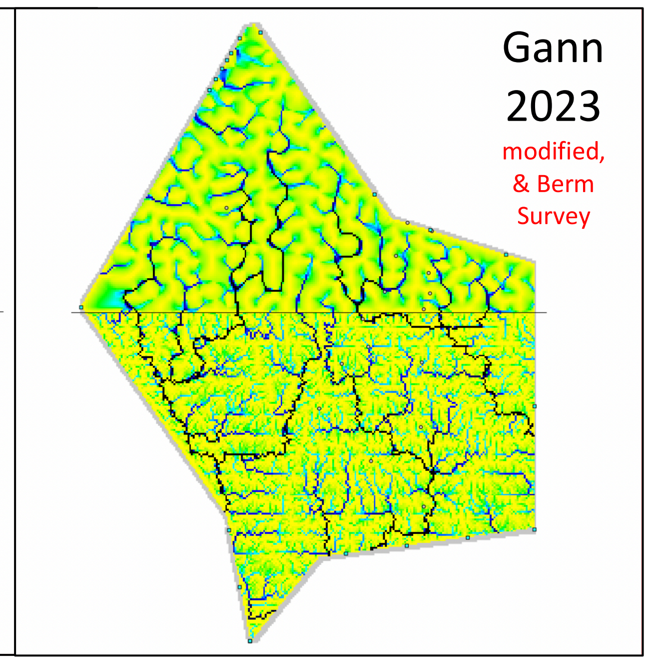
Elevation, interpolated Gann LiDAR pts, with Berm Survey interpolated pts



Cumulative flow paths @ 100 m resolution







Basin-scale: Final elevation maps

Current elevation:

Early on in this evaluation and development process, we rejected the EDEN (2024) LiDAR based DEM, as it had significant (LiDAR flight path related) vertical and horizontal discontinuities (Figure 1), and it was uncorrected for water depth and vegetation biases from LiDAR data interpretation/modeling. The Gann (2023) LiDAR based DTM was documented to have modified the above water depth and vegetation biases, but introduced new vertical discontinuities between those of the EDEN (2024) DEM (Figure 1).

The LiDAR flight paths of two independent (different vendor) data collection efforts split the WCA-2A basin into two subregions, North and South; the North subregion was sampled via north-south flight paths, while the South subregion was sampled via east-west flight paths. The North region had significant vertical discontinuities that were relatively easy to quantify. The South region's horizontal discontinuities were less observable.

For the North subregion, we used data from the Gann (2023) DTM, and made detailed efforts to select point DTM values that were separate of the vertical discontinuities. Those points were interpolated at 10m and 100m resolutions, resulting in the best-available elevation surface(s), Gann (2023) "modified".

For the South region, the horizontal discontinuities in the Gann (2023) DTM were more difficult to fully discern, and subjective; thus, we used the Gann (2023) DTM results directly, and resampled the 10m DTM to a 100m resolution DTM surface.

This project's objectives focus on the flow regime associated with the NE berm, which is along the southern edge of the borrow canal receiving S-10A,C,D structure inflows. Understanding the berm elevation was a fundamental aspect of the current modeling project. Gann (2023) conducted extensive RTK elevation surveys along the NE berm.

Masking (via GRASS GIS) the 100m grid cells associated with the berm, we interpolated all available RTK survey points, resulting in characterization of the berm at 10m resolution within the 100m mask. We similarly captured the Gann (2023) DTM elevations at 10m within the mask. Resampling the maximum of all 10m elevation values from both sources within the mask, the 100m resolution result was similar between both sources, albeit with some spatial differences as one transits along the berm extent. Because those survey points were free of potential LiDAR-based DTM discontinuities, we used the RTK survey interpolations for elevation of the NE berm mask.

For the final elevation map product for "current" day, we overlaid the NE berm mask interpolated elevation over the basin-scale Gann (2023) ("modified") combined North DTM point interpolations and South DTM data, at 100m resolution.

Historical elevation:
ca. 1993. Fitz and Sklar (1999) used an elevation survey from Keith and Schnars (1993), interpolated by K. Rutchey (*pers. comm.* 1997) to simulate hydro-ecological dynamics in WCA-2A. The original data, at 20m resolution, were resampled here to 100m resolution.

ca. 2003. Desmond (2003) described the initial surveys used in the USGS High Accuracy Elevation Dataset (HAED). That effort covered most of the Everglades wetlands, and is the basis for the USGS Everglades Depth Estimation Network (EDEN) water surface interpolations at 400m resolution (Jones and Price 2007). The ELM, and other modeling efforts, have made extensive use of the HAED point data (multiple citations). Here, we interpolated the original 2004 point survey data, collected at 400m regular grid spacing, and produced a new 100m resolution HAED elevation surface.

Figure 10. Elevation (cm NAVD'88): time series, 1993-2004-2018.

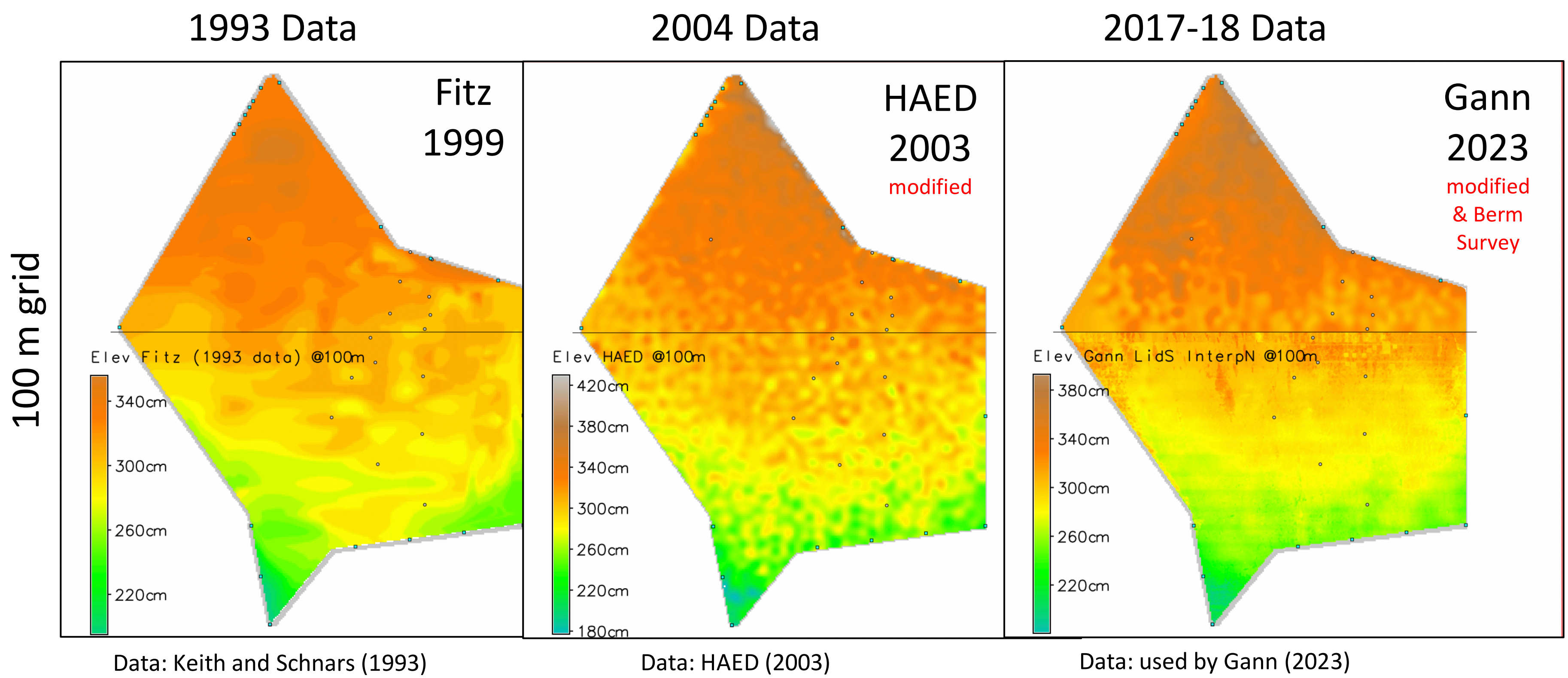
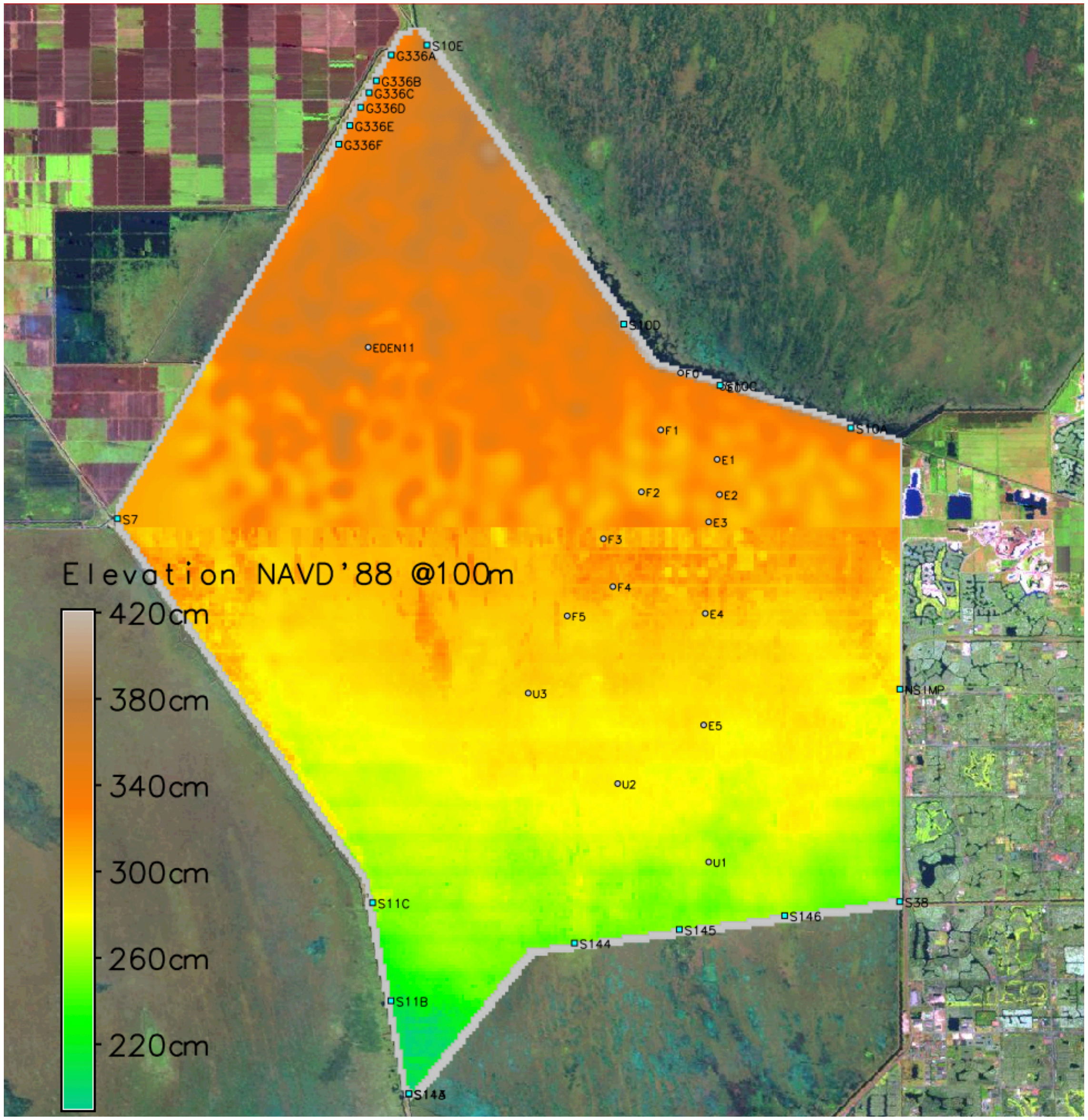


Figure 11. Final elevation data surface for "current" (2017-2018) status (100m grid, NAVD'88 cm).



Basin-scale: elevation uncertainty

The LiDAR based Gann (2023) DTM, both original and modified, introduces some uncertainties that should be considered during the progression of the current ELM project. Assuming that the HAED (2003) and modified-Gann (2023) DTM elevation data have similar accuracies, Figure 12 shows high rates of soil accretion and soil losses in the ~12 years between HAED and Gann-DTM, in the NE and NW subregions (and elsewhere, to some extent). Soil accretion rates of 4-8-higher mm/yr in the northwest are more indicative of 1980's-high P loading etc. Soil loss rates of 4-8-higher mm/yr in the northeast are large even in the driest environments. Multiple citations could be made, but the rates are not specifically relevant for this purpose of understanding the above basin-scale patterns of soil gain and loss. And the potential, relative, uncertainty of the current elevation map.

[Information, peripherally related]: Desmond (2003) reported that, for the HAED, the USGS Aerial Height Finder (helicopter platform) compared repeated GPS elev values to 1st order benchmarks, resulting in an RMSE of 4.1 cm. Though not explicitly stated, this is most likely similar to the airboat platform sampling, which may be even more accurate. This met the +15 cm accuracy specification (expectation, and what appears to be most often reported regarding the HAED elev dataset). WCA-2A surveys were conducted by (all, or mostly?) airboat platforms, later in 2004.]

Figure 12. Elevation difference between the 2017-18 modified-Gann and 2004 HAED elevation maps. 100m resolution. Note the calculated rates of elevation (soil) gain/loss associated with the differences. Brief metadata on methods shown in upper area of Figure.

Comparison of HAED vs. modified-Gann LiDAR DTM elevation (NAVD'88), for basin of WCA-2A

a) HAED (2003) survey points interpolated at 100 m resolution (Fitz, described elsewhere)

Survey (in this location) spanned months of May to Dec, 2004 — CollectDate: 8/15/04

b) modified-Gann (2023) DTM at 100 m resolution (Fitz, described elsewhere -- interpolated select Gann DTM points North, original Gann DTM South);

LiDAR flight data collection, separate vendors, Jan 2017 and Nov 2018 — CollectDate: 1/4/17 11/29/18 (south)

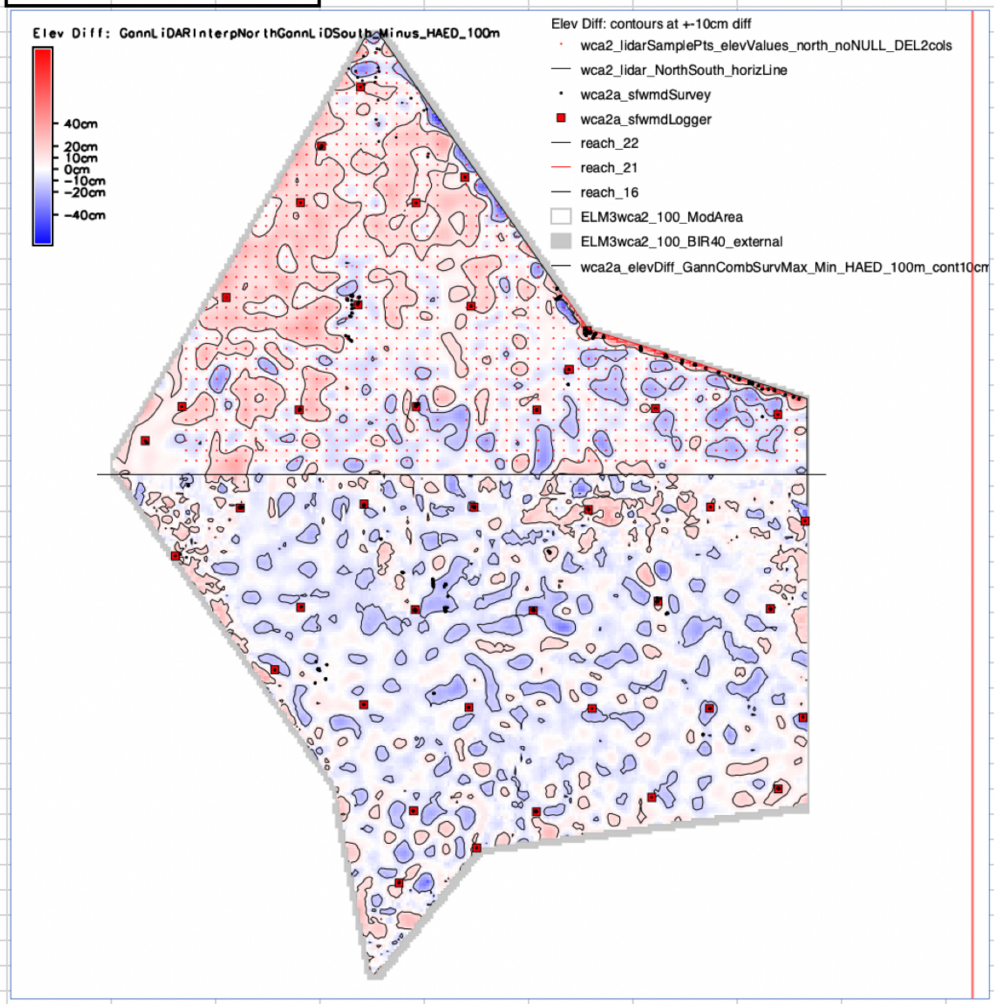
Methods: NorthTimeDiff: 12.4 years

1) at 100 m resolution, get difference of **modifGann minus HAED**

2) visualizations, including contours at **-10cm, and +10cm,** differences

Results:

ElevDiff (cm)	TimeDiff (yr)	SoilAccrete (mm/yr)
5	12.4	4.0
10	12.4	8.1



We evaluated the observed (surveyed) vs. modeled (DTM) elevation data of Gann (2023) in subregions of WCA-2A. Because the primary ELM project focus was on the inflow regions of the northeast, and to a somewhat lesser extent, the northwest, additional model-observed evaluations distributed throughout the WCA-2A basin were not considered to be as important to our ELM project objectives.

In subregions near the NE berm, and in the NW, we compared Gann (2023) DTM and RTK survey data. The original (unmodified) Gann (2023) DTM data at 10m resolution was compared to the original Gann (2023) RTK survey point data. Due to the vertical discontinuities (shown above in earlier section), we only used survey points (assemblages) that were reasonably distant from the discontinuities (with poor/unreliable data). This somewhat limited the available survey points that could be compared to original DTM cell values. *Note: for these comparisons, we did not use the berm-specific RTK survey points; berm RTK survey data were used in an earlier section (on assessing berm elevation).*

For each assemblage of points, all survey points found within DTM 10m grid cells (excluding cells in discontinuity zones) were sampled, and survey values were compared to the elevation value of the enclosing DTM grid cell. The number of elevation survey points within a DTM 10m cell ranged from 1 to 4.

Figure 13. Comparison of Gann observed (survey) vs Gann modeled (DTM) elevation : NE region. 10m resolution. Mean survey elevation was 9 cm higher than DTM elevation; minimum, maximum difference= 4, 15 cm, respectively.

Comparisons of Gann survey vs. Gann LiDAR DTM elevation (NAVD'88), for NE region of WCA-2A:

a) Gann (2023) original Digital Terrain Model (DTM) at 10 m grid resolution ("wca2a_dtm_mdl_2.1_10m")
b) Gann (2023) high-accuracy elevation (RTK) survey points

Methods:

1) project Gann "wca2a_dtm_mdl_2.1_10m" to ELM projection (UTM-UTM, trivial coordinate re-projection)
2) project Gann survey point locations to ELM projection (UTM-UTM, trivial coordinate re-projection)
0) zoom to NEberm location
3) for each assemblage of survey points in a specific location, [to define-isolate 10m grid cells needed] report single-sample of surveyed elevation points within 10m grid cells encompassing the set of points, "wca2a_sfwmdSurvey_North_10m", (values in Col G in "Survey_LiDAR_NEberm_data" spreadsheet tab)
4) for each assemblage of survey points in a specific location, report values of each (1 to many) point survey elevation values in each relevant 10 m grid cell (same as defined above); calculate each cell's median
5) for each assemblage of survey points in a specific location, report values of DTM elevation values in each relevant 10 m grid cell (same as defined above), (values in Col G in "Survey_LiDAR_NEberm_data" spreadsheet tab)
6) for each assemblage of survey points in a specific location, calculate median of all Gann survey cells
7) for each assemblage of survey points in a specific location, calculate median of all Gann DTM cells
8) for each assemblage of survey points in a specific location, compare median cell values of a) Gann survey and b) Gann DTM

Results:

Evaluated six assemblages of survey points (see Fig) in the NE region of WCA-2A (excluding sites along the NE berm, addressed elsewhere in elev development for ELM berm proj)

See "Survey_LiDAR_NEberm_data" spreadsheet tab of this .xlsx file for detailed results; summary is below

0.04	**MinDiff (m), Survey minus DTM**
0.15	**MaxDiff (m), Survey minus DTM**
0.09	**MeanDiff (m), Survey minus DTM**

Near P907X	
4	cells
7	points
0.10	SurvPts-DTM (m)

Near Marsh4	
2	cells
2	points
0.05	SurvPts-DTM (m)

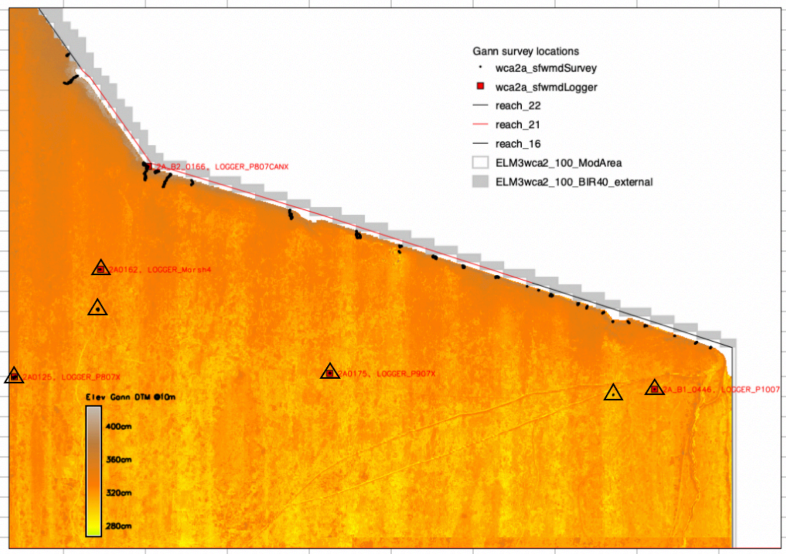
Near 0.5km S of Marsh4	
6	cells
9	points
0.15	SurvPts-DTM (m)

Near P807X	
10	cells
12	points
0.04	SurvPts-DTM (m)

Near P1007X	
1	cells
1	points
0.12	SurvPts-DTM (m)

Near 0.5km WSW of P1007X	
2	cells
2	points
0.07	SurvPts-DTM (m)

△ =SurveyPointAssemblage



Note: this (0.5km WSW of P1007X) is the only point assemblage thatlies very close to vertical discontinuity; others reasonably distant from major & minor vertical discontinuities.

Figure 14. Comparison of Gann observed (survey) vs Gann modeled (DTM) elevation : NW region. 10m resolution. Mean survey elevation was 8 cm lower than DTM elevation (-8 cm negative difference); minimum, maximum (negative) difference= 0, -23 cm, respectively.

Comparisons of Gann survey vs. Gann LiDAR DTM elevation (NAVD'88), for NW region of WCA-2A:

a) Gann (2023) original Digital Terrain Model (DTM) at 10 m grid resolution ("wca2a_dtm_mdl_2.1_10m")
b) Gann (2023) high-accuracy elevation (RTK) survey points

Methods:

... Below are the steps that **were used** in evaluating differences in the NEberm region (not NW region here).
... However, in this NW region, there are few locations that are not co-located with either the primary or secondary vertical discontinuities/artifacts.
... Thus, Fitz only looked at a few examples that may provide useful information (uninfluenced by discontinuites).
1) project Gann "wca2a_dtm_mdl_2.1_10m" to ELM projection (UTM-UTM, trivial coordinate re-projection)
2) project Gann survey point locations to ELM projection (UTM-UTM, trivial coordinate re-projection)
0) zoom to NW location
3) NOT DONE: for each assemblage of survey points in a specific location, [to define-isolate 10m grid cells needed] report single-sample of surveyed elevation points within 10m grid cells encompassing the set of points...
4) for each assemblage of survey points in a specific location, report values of each (1 to many) point survey elevation values in each relevant 10 m grid cell (same as defined above); calculate each cell's median
5) for each assemblage of survey points in a specific location, report values of DTM elevation values in each relevant 10 m grid cell (same as defined above), (values in Col G in "Survey_LiDAR_NWberm_data" spreadsheet tab)
6) for each assemblage of survey points in a specific location, calculate median of all Gann survey cells
7) for each assemblage of survey points in a specific location, calculate median of all Gann DTM cells
8) for each assemblage of survey points in a specific location, compare median cell values of a) Gann survey and b) Gann DTM

Results:

Evaluated 5 assemblages of survey points (see Figure below) in the NorthWest region of WCA-2A
See "Survey_LiDAR_NWregion_data" spreadsheet tab of this .xlsx file for detailed results; summary is below

-0.23	**MinDiff (m), Survey minus DTM**
0.00	**MaxDiff (m), Survey minus DTM**
-0.08	**MeanDiff (m), Survey minus DTM**

△ =SurveyPointAssemblage

Contours in Figure below are **for reference-only,** being the 10cm differences between the modified-Gann and HAED, visualized in separate spreadsheet tab.

Near	
0.5 km NW of P610X	
1	cells
1	points
-0.23	SurvPts-DTM (m)
Near	
0.3 km NW of P610X	
1	cells
1	points
-0.04	SurvPts-DTM (m)
Near	
0.15 km NE of P610X	
1	cells
1	points
-0.04	SurvPts-DTM (m)
Near	
0.5 km NE of P610X	
1	cells
1	points
-0.12	SurvPts-DTM (m)
Near	
P508X	
1	cells
1	points
0.00	SurvPts-DTM (m)

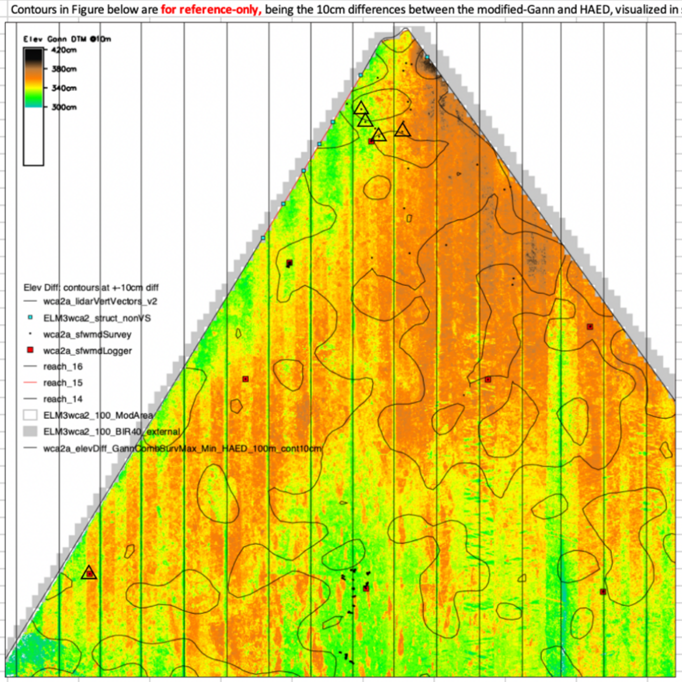
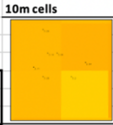


Figure 15. Example of cell-specific comparison of Gann observed vs. modeled elevation : NE region. For one point assemblage near SFWMD "Logger" site P907X, one of 6 assemblages of survey points in NE region

- below graphics contain (tiny font) survey points and their elevations
- upper-left-side graphic shows ELM3wca2_100 (100m) cell encompassing the DTM 10m cells and survey points
- upper-right-side graphic shows the 10m cells that contain the (DTM and) survey points, with color-values indicative of a survey-single-point-sampling within cells ("wca2a_sfwmdSurvery_North_10m"); these cell color values not needed, but cells **simply used to define cells containing survey points**
- lower graphic shows the DTM values ("dtm_mdl_2.1_10m") in the same 10m cells
- "Calculated median PointValues in 10m cell" contain cell-specific median values of (1 to 4) point survey observations, shown at far right
- Values in red font, upper: median of all survey points in assemblage (3.16) (meters)
- Values in red font, lower: median of all survey DTM cells in assemblage (3.07) (meters)
- Values in red font, lower left: difference of median, survey minus DTM (0.10) (meters); display rounding of all values shown resulted in display decimal difference

** ***All details in*** "wca2a_elev_surveyPoints_vs_dtm_vs_HAED.xlsx", available in SFWMD WCA2A_ELM_Modelling SharePoint

Comparisons of Gann survey vs. Gann LiDAR DTM elevation (NAVD'88), for NE region of WCA-2A: data for 6 assemblages of survey points
ALL ELEVATION DATA ON THIS PAGE ARE M NAVD '88 (NOT CM, USED IN OTHER MAP SURFACES)

GannSurvey Minus Gann DTM	Survey: Encompassing 100m grid cell	Survey: 10m cells	near_Logger	ElevFrom GRASS_fname "wca2a_sfwmdSurvey_North_10m"	CellValue (point-to-cell, cells W->E, then N->S, from N)	Calculated median PointValues in 10m cell	PointValue in 10m cell	PointValue in 10m cell	PointValue in 10m cell	PointValue in 10m cell	PointValue in 10m cell
			P907X	1 0f 4 cells	3.14	3.13	3.26	3.14	3.04	3.11	
				1 0f 4 cells	2.94	2.94	2.94				
				1 0f 4 cells	3.28	3.28	3.28				
				1 0f 4 cells	3.20	3.20	3.2				
			Median of 10m cells:		3.17	3.16					
		Gann dtm_mdl_2.1_10m: 10m cells	near_Logger	ElevFrom GRASS_fname "wca2a_dtm_mdl_2.1_10m"	CellValue (same cell locs as above survey-cells)						
			P907X	1 0f 4 cells	3.07						
Near P907X				1 0f 4 cells	3.10						
				1 0f 4 cells	3.06						
4	cells			1 0f 4 cells	2.98						
7	points		Median of 10m cells:		3.07						
0.10	SurvPts-DTM (m)										

Uncertainty conclusions:

The above **comparisons of Gann (2023) observed survey and modeled (original, unmodified) DTM elevation** data were limited to the marshes of the upper NE and NW subregions, both of which are receiving marshes of new water flowing into the WCA-2A basin. We were constrained by the DTM vertical discontinuities in this area, and thus not all survey points could be compared to DTM marsh cells.

An overall pattern is apparent in these limited comparisons. It appears that the DTM trended to elevation underestimates in the NE, and to overestimations in the NW (magnitudes ca. 10 cm).

In what may not be a coincidence, the difference-maps of the modified-Gann (2023) DTM and modified HAED (2003) interpolated elevations showed that, likewise, the Gann results exceeded the HAED results in the NW, and were less than the HAED in the NE.

While not definitive, this NW-NE spatial pattern trend in Gann (2023) DTM estimates should be considered in modeling water flows in the northern basin.

3.0 VEGETATION

In WCA-2A, vegetation/habitats have been mapped by various investigators prior to the most recent effort of Gann et al. (2023). We don't summarize/review prior efforts at different scales and objectives, and focus solely on this latest effort. Gann et al. (2023) used World View 2&3 satellite observations to classify WCA-2A vegetation at very fine scale (2 m). They employed 9 classes of vegetation that were different from the South Florida Natural Areas classification system (usually) used in past efforts. The Gann et al. (2023) vegetation classes were specifically designed to aid in assessing the vegetation canopy densities that can bias LiDAR DEM/DTM modeling, and they used their vegetation map to adjust for bias in their DTM (referred to in above ELEVATION section).

For our future-scenario-based hydro-ecological modeling of WCA-2A at 100 m resolution (ELM3wca2_100), we ultimately sought the most up-to-date vegetation map at that 100 m scale. Gann et al. (2023) produced an original 2 m resolution vegetation map, along with the equivalent aggregated to 4-cell minimum mapping units (4mmu) (also reported at 2 m resolution). That map "WCA2A_2019_vW123_vE113_mapMos_mmu4" is referred to here as the original data.

We further aggregated that product to a 5 m resolution grid scale (using modal frequency values), and resampled-projected to the ELMwca2_100 bounding UTM NAD'27 geographic coordinates. All spatial processing/analyses here used GRASS 7.8.

Aggregating the vegetation data further (towards a 100 m resolution), we used a (r.neighbors) moving window that created 5 m resolution cells with modal values across a 19 neighbor-cell moving window (centered on each individual cell in spatial passes).

Figure 16. Vegetation Gann et al. (2023), NE subregion, @5 m resolution, 19-cell modal filter. Because the NE subregion associated with the berm was a focus of this ELM project, here we separately show each of the 9 Gann classes in this subregion.

Figure follows on next page, with notations that self-document the information.

All Maps:

Original Data:

“WCA2A_2019_vW123_vE113_mapMos_mmu4”

@2 m resolution

Rescaled Original Data:

*“fileName*_5m”

@ 5 m resolution

Rescaled Original Data, neighborhood analysis:

*“fileName*e_5m_19neighMode”

@ 5 m resolution

-- GRASS “r.neighbors”, 19 neighbors, modal frequency

Results, this Fig, show individual vegetation classes,

@ 5 m resolution,

filtered across 19-cell moving window

(approximating 100 m resolution,

given center-cell odd# neighbor math)

Vegetation Gann (2023), NE, @ 5m res, 19-cell modal-filter

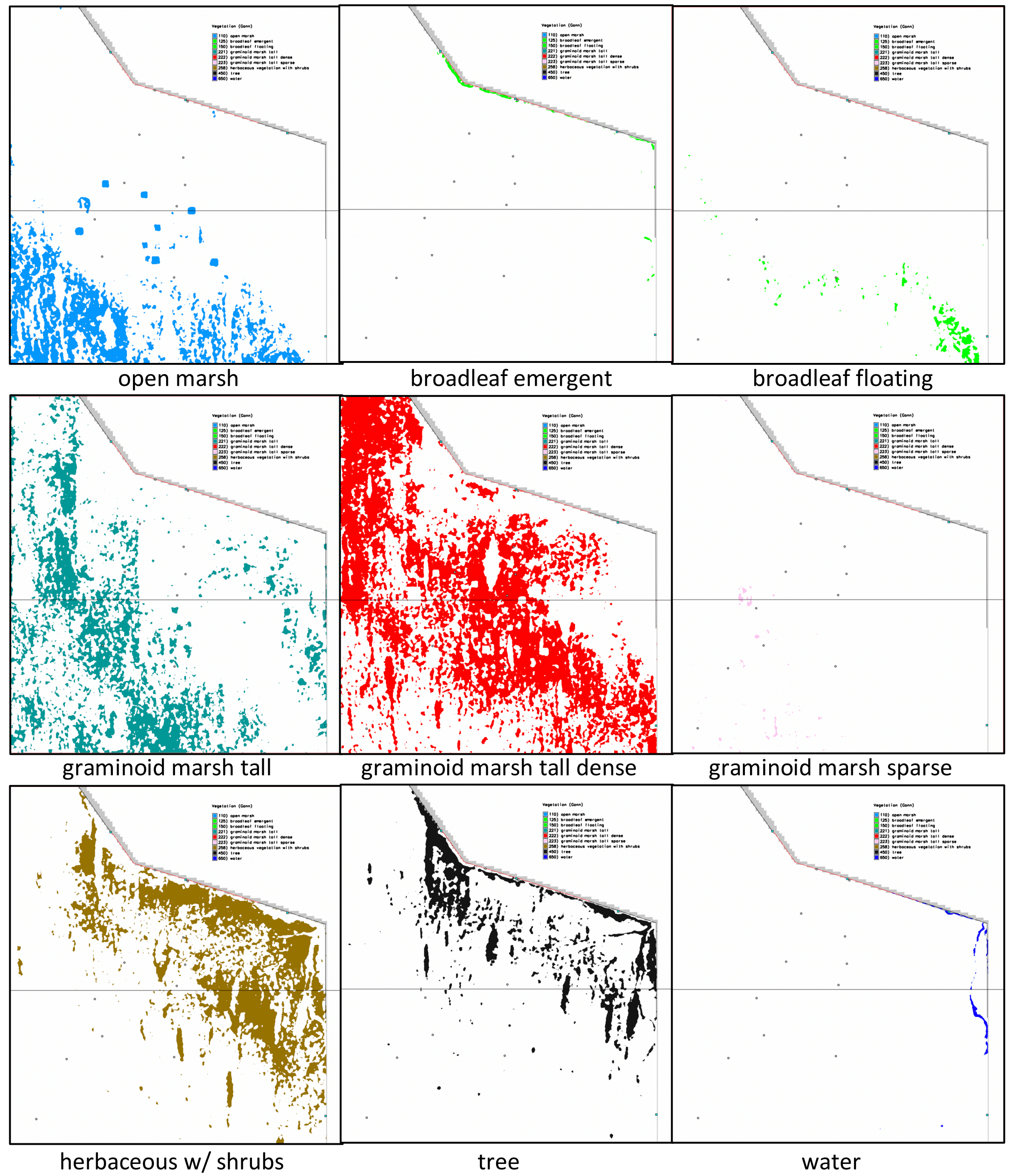


Figure 17. Vegetation Gann et al. (2023), NE subregion, multi-resolution. Tree, and Water, classes.
Visualization of results of aggregating original data with 19 neighbor filter, then resampling that at 100 m resolution.

NOTE: we use the vegetation class names in the data files provided by Gann; but Gann et al. (2023) figure vs. text vs. table variously refer to ***"Tree", or "Trees, Dense Shrubs & Tall Ferns", or "Trees, Shrubs & Tall Ferns"***

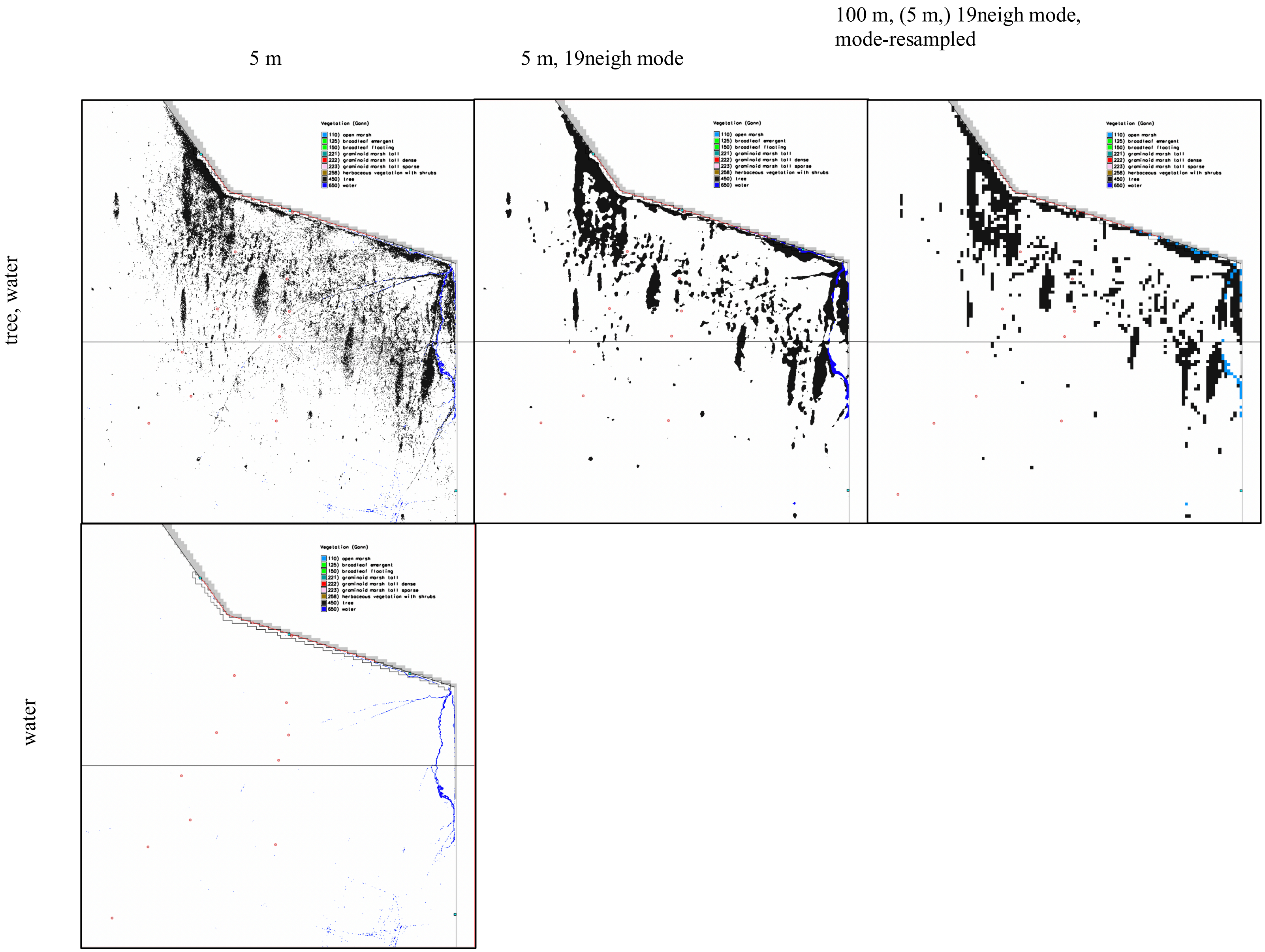


Figure 18. Vegetation Gann et al. (2023), all classes, multi-res at F3 vicinity (top) and at basin-scale (bottom). The 100 m model grid of ELM3wca2_100 is superimposed for reference.

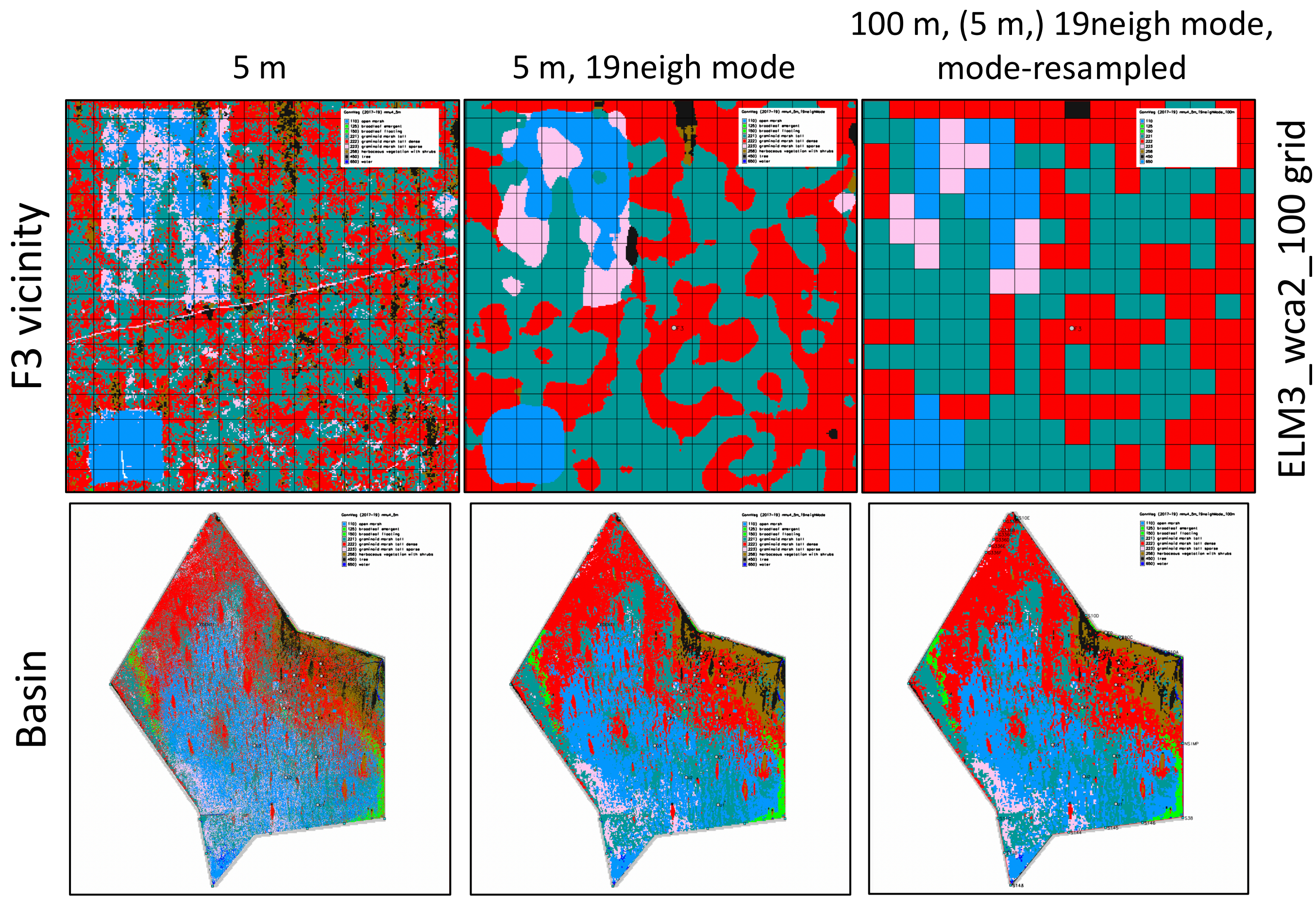


Figure 19. Vegetation Gann et al. (2023), all classes, at 100 m resolution, ELM3wca2_100 domain.
Showing cells external to model hydrologic basin (light grey), model canal reaches, water control structures, SFWMD "Threshold" research sites.

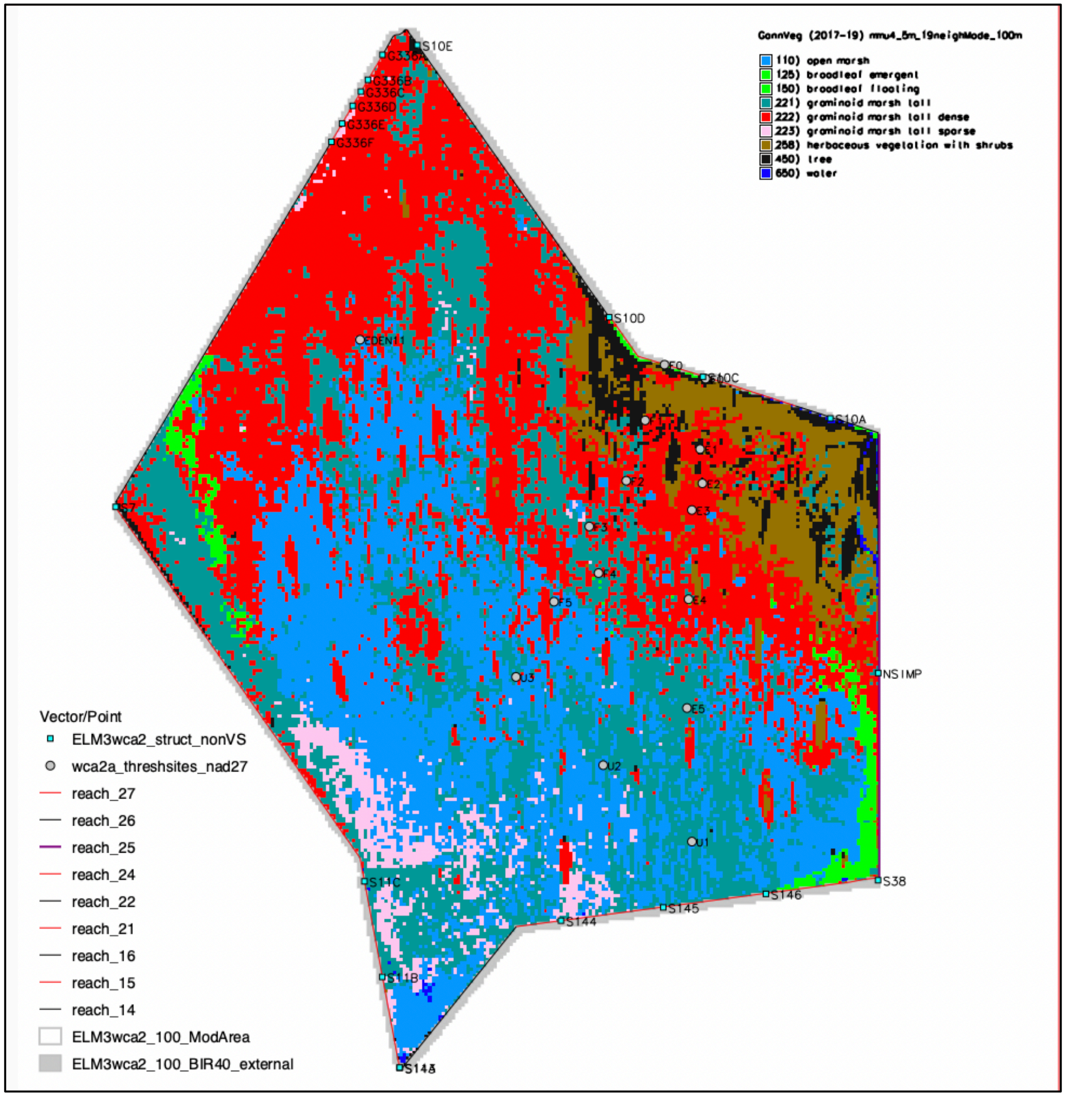


Figure 20. Vegetation/habitat class crosswalk between Gann et al. (2023), and ELM-standard (v2.5-3.x).
Gann veg_class_name, veg_cls, dominant genera (upper left box), from original data/metadata. Crosswalk reclass (upper middle box) has uncertain classes highlighted. ELM Hab classes (right box) used in multiple published (calibrated-validated-reviewed) hydro-ecological modeling applications throughout greater Everglades.

Gann WCA2A veg map classes (WCA2A_2019_vW123_vE113_mapMos, 6/27/23) — **## Gann-to-ELM reclass ##**

ID	veg_class_name	veg_cls, dominant genera	ELM_ID	ELM_cat
110	open marsh	(oM, dominant=Utricularia, Charra, Eleocharis)	4	Sawgrass Slough (deep)
125	broadleaf emergent	(blE, dominant=Colocasia)	22	Brush
150	broadleaf floating	(blF, dominant=Nymphaea, Nuphar)	10	Slough with Non-gramminoids
221	graminoid marsh tall	(gMT, dominant=Cladium, Typha)	2	Sawgrass Plain
222	graminoid marsh tall dense	(gMT__D, dominant=Cladium, Typha)	11	Cattail (high density)
223	graminoid marsh tall sparse	(gMT__S, dominant=Cladium, Typha)	7	Gramminoid Mix
258	herbaceous vegetation with shrubs	(hV_s)	12	Cattail (med density)
450	tree	(t)	16	Mixed Hardwood Forest
650	water	(zWtr)	1	Open Water

Gann WCA2A veg map classes (WCA2A_2019_vW123_vE113_mapMos, 6/27/23)

ID #	*description*	*hectares*	*# cells*	*% cover*
110	*open marsh . . . .*	*8542.21*	*854221*	*7.6*
125	*broadleaf emergent . . . .*	*150.12*	*15012*	*0.1*
150	*broadleaf floating . . . .*	*831.92*	*83192*	*0.7*
221	*graminoid marsh tall . . . .*	*11,652.28*	*1165228*	*10.4*
222	*graminoid marsh tall dense . . . .*	*12,278.29*	*1227829*	*10.9*
223	*graminoid marsh tall sparse. . . . .*	*4067.47*	*406747*	*3.6*
258	*herbaceous vegetation with shrubs. . . .*	*2790.61*	*279061*	*2.5*
450	*tree . . . .*	*1544.72*	*154472*	*1.4*
650	*water. . . . .*	*198.14*	*19814*	*0.2*
***	*no data. . . . .*	*70,144.24*	*7014424*	*62.5*
	Total	*112,200.00*	*11220000*	*100.0*

ELM Hab classes (v2.5-current)

ELM_ID	ELM_cat
1	Open Water
2	Sawgrass Plain
3	Sawgrass RS Pristine
4	Sawgrass Slough (deep)
5	Sawgrass RS Degraded
6	Sawgrass Marl Prairie
7	Gramminoid Mix
8	Wet Prairie
9	Slough with Gramminoids
10	Slough with Non-gramminoids
11	Cattail (high density)
12	Cattail (med density)
13	Cattail (low density)
14	Muhly Grass
15	Salt Marsh
16	Mixed Hardwood Forest
17	Cypress Swamp Forest
18	Mangrove Forest
19	Buttonwood Forest
20	Pineland Savannah
21	Cypress Savanna
22	Brush
23	Hardwood Scrub
25	Mangrove Scrub
26	Buttonwood Scrub
27	Brazilian Pepper
28	Melaleuca
29	Human Influence

4.0 CONCLUSIONS: ELEVATION AND VEGETATION

This ELM application project involves both: a) historical model performance assessment (aka, model-observed history matching, or calibration/validation), and; b) future scenario assessments of the hydro-ecological responses to modifications of the NE berm infrastructure, active marsh improvement, and related.

For the future scenario assessments, this Task 2 involved the development of the best available maps of "current-day" marsh elevation and marsh vegetation-class. Using the innovative, well-executed, results from Gann et al. (2023), we developed an aggregated-refined set of elevation and vegetation data for use in the ELM3wca2_100 (100 m resolution) future scenario applications.

These "current-day" data are not relevant to the above historical model performance assessments (that are constrained to only extend through Dec 2010 due to need of South Florida Water Management Model stage boundary conditions at the basin periphery). Historical elevation and vegetation data will be used in the historical model performance assessment.

While the aggregated-refined set of elevation and vegetation data for future scenario application may be the best available at this time, there remain a variety of uncertainties associated with those data. Among them:

- One question is whether the apparent pattern of differences in observed survey elevation vs modeled DTM elevation is real.
- A second question is how to best translate
    - o vegetation classes designed to capture plant canopy density for modeling reduction in vegetation-induced bias in LiDAR data, to
    - o vegetation classes designed to capture lower level plant stem density for hydrologic modeling in shallow wetlands.

Answers to those questions are difficult to come by, and it it likely we can only touch upon some aspects of them during the course of this project.

5.0 REFERENCES

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