

Report 4

ESTIMATING EGERIA DENSA ACREAGE AND PERCENT COVERAGE IN THE SACRAMENTO-SAN JOAQUIN DELTA DBW PRIORITY SITES

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This paper reports the methods used to estimate the acreage and percent coverage of the aquatic weed *Egeria densa* in the Sacramento-San Joaquin Delta. This information has been generated to support the EIR being prepared by the California Department of Boating and Waterways and to aid any subsequent control strategies to be implemented.

DATA AND METHODS

Data and Preliminary Analyses

The estimates reported here are based on color infrared (IR) aerial photography flown on 16 September 1997 at 1:24,000 scale. When color IR film is exposed, it detects reflected radiation in three spectral bands: green light, red light, and near IR (NIR) radiation. Traditional wisdom (Roller, 1977; Lee and Lunetta, 1995) indicates that aquatic submergent species are best discriminated, depending on depth, in either NIR (shallow depths) or visible (deeper depths) data.

The flight occurred between 8:59 am and 10:38 am during a low-tide period. Figure 1 shows the relationship between the amount of reflected solar radiation and the sun angle. The time of day for the flight was selected to be a trade-off between a low enough sun angle to provide more reflected sunlight and a high enough sun angle to minimize shadows from trees on the banks falling upon the water. The low-tide period was selected to optimize the detection of *Egeria* in the photography.

The airphotos were scan-digitized and color separated to create 3-band digital imagery at a nominal 2-meter spatial resolution. In other words, each picture element or pixel in the digital imagery represents approximately a 2m x 2m area on the ground. The data structure of the digital imagery is illustrated in Figure 2. In such a dataset, each pixel is represented by three digital numbers or DN values.

Ground survey information has been used in interpreting the imagery. This information has been particularly useful in determining *Egeria* patterns in areas affected by sun glint. To date ground surveys indicate that other submerged aquatic plants comprise less than 5 percent of the submergent species in the Delta. Since this amount is so small and since

discriminating differences between submergent species is difficult, no attempt has been made to adjust the estimates by removing acreage for other species.

The original plan was to geometrically correct the digital imagery to produce map accurate data that would overlay USGS base maps. Since the flight took place on a windy day, this task became very problematic and time-consuming. Consequently, these first estimates are based mostly on imagery which has not been geometrically corrected.

Preliminary image analyses showed that the visibility and spectral response pattern of Egeria vary under different conditions at the time of imaging. For example, Figures 3a and 3b illustrate the effects of turbidity on the DN values of Egeria and water. In Figure 3a, the 'typical case' in which no obvious turbidity is present, samples of Egeria and water have similar DN values in the red and NIR bands. It is only possible to discriminate Egeria from water in the green band. In Figure 3b, a case in which the water is turbid, Egeria may be discriminated from water in the red and green bands. However, the DN values of Egeria in the silty case overlap the DN values of water in the non-silty case. This condition complicates the use of automated multispectral classification methods. Changing sun angles, tide levels, water currents as well as turbidity affect spectral response patterns. Consequently, mapping Egeria in the Delta by traditional multispectral classification techniques was not practical.

Image-Processing Methods

It was determined during the preliminary analyses that Egeria is consistently darker than adjacent water areas in the green spectral band. It was also determined that, with few exceptions within local water areas, Egeria is the darkest subject in this band. The exceptions are small subjects like the shadows from docks or trees falling upon the water. A method was developed to make use of these characteristics and to map Egeria quickly. Acreage and percent coverage were calculated by the following steps:

- (1) *Cutting water bodies out of the imagery:* To avoid confusion with dark land subjects, each water body corresponding to a DBW Priority Site was cut out of the imagery and stored in a separate data file. Large sites often required several pieces and files.
- (2) *Highlighting Egeria pixels by density slicing the green band:* The whole color IR image was displayed and contrast stretched to enhance the visual interpretation of Egeria. At the same time, the green band of the cut-out water body was displayed on a second viewer. Digital numbers or gray tones in the green band were colored to match the pattern of Egeria in the color IR image. Since small pieces of imagery were used, the variations due to different conditions (sun angles, turbidity, etc.) were greatly reduced.

- (3) *Counting Egeria and water body pixels:* All pixels in the cut-out water body were summed. The highlighted or colored pixels in the density-sliced image were also summed.
- (4) *Calculating Egeria acreage and percent coverage:* Egeria acreage was calculated by assuming each pixel is equal to 2m x 2m on the ground: Egeria acres = (# Egeria pixels)*9.884/10000. Egeria proportions were calculated by dividing the number of Egeria pixels by the number of water body pixels.

RESULTS TO DATE

Rough estimates of *Egeria densa* acreage in the Delta DBW Priority Sites are provided in Table 1. Approximately 4000 acres of Egeria occupy the central Delta. The estimates of Egeria proportions are provided in Table 2. In Table 1, there is a column with comments. In this column, problems with poor imagery or other aspects of the interpretation are noted. Seven Priority Sites are not wholly covered by the September 1997 imagery and 5 Sites are not covered at all. This missing or partial coverage is also noted in the comments column.

The detailed data in the tables has been aggregated and mapped. Figure 4 depicts the Egeria acreage and indicates the highest amounts occur from Antioch east in the central part of the Delta. Figures 5 and 6 illustrate Egeria fractional coverage. These figures show that the highest proportions also occur in the central part of the Delta.

Some additional cleanup of the estimates is possible using postclassification and GIS techniques. The results of this processing will be reported at a later time.

ESTIMATIONS OF ERROR - IN PROGRESS

Three aspects of the image processing are being evaluated to determine the magnitude of error produced by each:

- (1) *Basing areal estimates on imagery that has not been geometrically corrected:* Imagery that has not been geometrically corrected will contain distortions and size changes due to camera geometry and aircraft attitude and altitude changes during flight. The nominal 2-meter spatial resolution will vary from one image to another and from side to side in the same image.
- (2) *Selecting 2-meter spatial resolution (2m x 2m pixels):* When geometrically corrected, imagery with 2-meter resolution will still degrade the resolving of objects. For example, a 1m x 1m patch of Egeria may not be well detected in 2-meter data.

- (3) *Using a default gray-tone range during scanning:* Using default settings during scanning may be inappropriate. It may be possible to alter the scanning parameters to produce greater radiometric definition (more gray tones) in the darker tones (the ones that discriminate Egeria from water).

To accomplish these evaluations, 9 grid points were selected by a systematic sampling of the flight grid, providing coverage from west to east and from north to south. Within the airphoto at each grid point, the highest Priority Site was selected for evaluation by three tests. Each site will be geometrically corrected, re-scanned to 1-meter spatial resolution, and re-scanned to attempt greater radiometric definition in the darker tones. In each case, the resultant imagery will be used to re-estimate the areal extent of Egeria. From these measurements, the variability and magnitude of error produced by each operation will be determined.

Two aspects of the Egeria environment at imaging are also being evaluated to determine the magnitude of error produced by each:

- (1) Depth of water above the Egeria canopy.
- (2) Thickness of the Egeria canopy.

To accomplish these evaluations, two Priority Sites, White Slough and Big Break, were selected for detailed ground surveys concurrent with new aerial surveys. Canopy thickness and depth were measured at intervals over patches of Egeria. From these measurements, the extent and magnitude of error due to the invisibility of the subject in the imagery will be determined.

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REFERENCES

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Roller, N.E.G., 1977. Remote Sensing of Wetlands, Environmental Research Institute of Michigan (NASA-CR-153282), Ann Arbor, MI.

Priority	Name of water body	# Egeria pixels	Egeria acreage	Comments
1	White Slough	70851	70.03	
2	7 Mile Slough	6351	6.28	
2b	7 Mile Slough-Part b	13621	13.46	poor imagery
3	Sandmond	42194	41.70	
3b	Sandmond-Part b	38957	38.51	
4	Big Break Marina	1544	1.53	underestimate
5	Franks Tract Treatment	8296	8.20	
6	Little Venice Island	50050	49.47	
7	Village West Pixley	3948	3.90	
7b	Pixley Slough	19703	19.47	
7c	Pixley Slough	3927	3.88	14 Mile?
8	Franks Tract	1267774	1253.07	some poor imagery
9	Big Break Wetlands	27247	26.93	Egeria under hyacinth
10	Big Break	457973	452.66	
10b	Big Break-Part b	7144	7.06	
11	Sherman Lake	374539	370.19	E of Kimball Is only
12	Donlon Island	70230	69.42	
13	Disappointment Slough	60990	60.28	underestimate
14	14 mile Slough	32772	32.39	poor imagery
15	Indian Slough	57916	57.24	poor img, underestimate
16	Dutch Slough	25154	24.86	poor img, underestimate
17	Coney Island	45184	44.66	
18	Rock Slough	23422	23.15	
19	Werner Dredger Cut	11976	11.84	
20	Pipers Slough	22073	21.82	poor imagery
21	Taylor Slough	44006	43.50	poor imagery
22	Quimby Island	66289	65.52	underestimate
23	Latham Slough	71027	70.20	poor imagery
24	Old River Del's	40025	39.56	poor imagery
25	Tom Paine Slough	0	0.00	narrow subject
26	Paradise Cut	20125	19.89	poor imagery
27	Old River Holland	13917	13.76	
28	Rhode Island	92516	91.44	
29	Old River Connection	37508	37.07	
30	Old River Orwood	69677	68.87	poor imagery
31	Old River Main	53855	53.23	
32	Middle River Jones	33374	32.99	

33	Middle River Bullfrog	36420	36.00	
34	Middle River Mildred	19291	19.07	
35	Bishop Telephone Cut	869	1.36	poor imagery
36	Antioch	16539	16.35	E of Kimble Is only
37	Sycamore Slough	26929	26.62	
38	Hog Slough	13785	13.63	
39	Beaver Slough	53	0.05	W half only, poor imagery
40	Lost Slough	0	0.00	missing imagery
41	Snodgrass Slough	0	0.00	missing imagery
42	Bacon Island	30381	30.03	
43	Topeka Santa Fe	15729	15.55	
44	Woodward Canal	5296	5.23	
45	Victoria Canal	11330	11.20	
46	Little Potato Slough	20403	20.17	
47	Potato Slough	34996	34.59	
48	Middle River Union	0	0.00	poor imagery?
49	Middle River Victoria	24839	24.55	
50	Fisherman's Cut	8807	8.70	
51	Whiskey Slough	22294	22.04	poor imagery
52	Trapper Slough	22086	21.83	Egeria under vegetation?
53	Circle Lake	0	0.00	missing imagery
54	Depue Ox Bow	0	0.00	missing imagery
55	River Club Ox Bow	0	0.00	missing imagery
56	Grant Line Canal	2152	2.13	
57	Hog Island	23954	23.68	poor imagery
58	Ward Island	64418	63.67	Egeria under vegetation?
59	Venice Cut	109832	108.56	
60	Hayes Reach	19698	19.47	
61	San Andreas Shoal	13442	13.29	
62	North Mokelumne	36298	35.88	S of pumping stat only
63	South Mokelumne	55351	54.71	S of Beaver Sl junction only
64	5 mile Slough	0	0.00	poor imagery?
65	Stockton Channel	15918	15.73	poor imagery
66	Turner Empire Cut	16719	16.53	poor imagery, underestimate
67	San Joaquine Bradford	24746	24.46	poor imagery
68	Burns French Camp	6171	6.10	W Walker Sl only, poor img, Egr under lit?
69	San Joaquin Roberts	0	0.00	
70	San Joaquin Mossdale	3273	3.24	W half only, poor imagery
71	3 Mile Slough	21331	27.55	odd Egeria?

Priority #	Name of water body	# Water body pixels	# Egeria pixels	# Egeria/# water
1	White Slough	396542	70851	0.1787
2	7 Mile Slough	105398	19972	0.1895
3	Sandmound	336551	81151	0.2411
4	Big Break Marina	6005	1544	0.2571
6	Little Venice Island	52193	50050	0.9589
7	Village West Pixley	230661	27578	0.1196
8	Frank's Tract	3693691	1267774	0.3432
9	Big Break Wetlands	69741	27247	0.3907
10	Big Break	1608456	465117	0.2892
11	Sherman Lake	1493289	374539	0.2508
12	Donlon Island	230441	70230	0.3048
13	Disappointment Slough	486320	68374	0.1406
14	14 Mile Slough	281956	32772	0.1162
15	Indian Slough	636228	57916	0.091
16	Dutch Slough	347314	25154	0.0724
17	Coney Island	320644	45184	0.1409
18	Rock Slough	105683	23422	0.2216
19	Werner Dredger Cut	143392	11976	0.0835
20	Pipers Slough	171529	22073	0.1287
21	Taylor Slough	155529	44006	0.2829
22	Quimby Island	980216	66289	0.0676
23	Latham Slough	678106	71027	0.1047
24	Old River Del's	285452	40025	0.1402
25	Tom Paine Slough	99386	0	0
26	Paradise Cut	190325	20125	0.1057
27	Old River Holland	214435	13917	0.0649
28	Rhode Island	307991	92516	0.3004
29	Old River Connection	199278	37508	0.1882
30	Old River Orwood	450278	69677	0.1547
31	Old River Main	354826	53855	0.1518
32	Middle River Jones	206245	33374	0.1618
33	Middle River Bullfrog	316658	36420	0.115
34	Middle River Mildred	259218	19291	0.0744
35	Bishop Telephone Cut	98438	869	0.0088

36	Antioch	2091151	16539	0.0079
37	Sycamore Slough	144940	26929	0.1858
38	Hog Slough	93485	13785	0.1475
39	Beaver Slough	28473	53	0.0019
42	Bacon Island	167309	30381	0.1816
43	Topeka Santa Fe	81538	15729	0.1929
44	Woodward Canal	110323	5296	0.048
45	Victoria Canal	205425	11330	0.0552
46	Little Potato Slough	281612	20403	0.0725
47	Potato Slough	425012	34996	0.0823
48	Middle River Union	113741	0	0
49	Middle River Victoria	141035	24839	0.1761
50	Fisherman's Cut	84572	8807	0.1041
51	Whiskey Slough	142033	22294	0.157
52	Trapper Slough	124523	22086	0.1774
56	Grant Line Canal	272416	2152	0.0079
57	Hog Island	392589	23954	0.061
58	Ward Island	403902	64418	0.1595
59	Venice Cut	887270	109832	0.1238
60	Hayes Reach	802380	19698	0.0245
61	San Andreas Shoal	818732	13442	0.0164
62	North Mokelumne	668078	36298	0.0543
63	South Mokelumne	674628	55351	0.082
64	5 Mile Slough	12194	0	0
65	Stockton Channel	699083	15918	0.0228
66	Turner Empire Cut	196600	16719	0.085
67	San Joaquin Bradford	2614006	24746	0.0095
68	Burns French Camp	207665	6171	0.0297
69	San Joaquin Roberts	232777	0	0
70	San Joaquin Mossdale	55102	3273	0.0594
71	3 Mile Slough	473457	21331	0.0451