

Supplementary materials

Table 1. Confusion matrix of human visualization compared to real land cover for the 2018 image.

| Kappa:<br>0.88 |                              | Validation |       |            |             |       |                   |
|----------------|------------------------------|------------|-------|------------|-------------|-------|-------------------|
| Predicted      | Overall accuracy (%)<br>95.8 | Fish pond  | Urban | Vegetation | Watercourse | Other | User accuracy (%) |
|                | Fish pond                    | 215        | 0     | 0          | 2           | 0     | 99.1              |
|                | Urban                        | 1          | 299   | 0          | 0           | 0     | 99.7              |
|                | Vegetation                   | 12         | 0     | 314        | 0           | 0     | 96.3              |
|                | Watercourse                  | 36         | 0     | 0          | 200         | 5     | 83                |
|                | Other                        | 0          | 0     | 0          | 0           | 249   | 100               |
|                | Producer accuracy (%)        | 81.4       | 100   | 100        | 99          | 98    |                   |

Table 2. Confusion matrix of supervised land cover classification for 1986 image.

| Kappa: 0.85 |                            | Validation |       |            |             |       |                   |
|-------------|----------------------------|------------|-------|------------|-------------|-------|-------------------|
|             | Overall accuracy (%): 87.8 | Fish pond  | Urban | Vegetation | Watercourse | Other | User accuracy (%) |
| Predicted   | Fish pond                  | 55         | 0     | 3          | 5           | 0     | 87.3              |
|             | Urban                      | 0          | 53    | 2          | 2           | 4     | 86.9              |
|             | Vegetation                 | 0          | 1     | 60         | 1           | 2     | 93.8              |
|             | Watercourse                | 5          | 2     | 0          | 42          | 0     | 85.7              |
|             | Other                      | 0          | 5     | 4          | 0           | 49    | 84.5              |
|             | Producer accuracy (%)      | 91.7       | 86.9  | 87.0       | 84.0        | 89.1  |                   |

Table 3. Confusion matrix of supervised land cover classification for 1995 image.

|           |                       | Validation |       |            |             |       | User accuracy (%) |
|-----------|-----------------------|------------|-------|------------|-------------|-------|-------------------|
|           |                       | Fish pond  | Urban | Vegetation | Watercourse | Other |                   |
| Predicted | Fish pond             | 47         | 2     | 0          | 12          | 0     | 77.0              |
|           | Urban                 | 1          | 54    | 2          | 3           | 2     | 87.1              |
|           | Vegetation            | 0          | 0     | 57         | 1           | 2     | 95.0              |
|           | Watercourse           | 6          | 3     | 1          | 44          | 0     | 81.5              |
|           | Other                 | 0          | 5     | 0          | 0           | 53    | 91.4              |
|           | Producer accuracy (%) | 87.0       | 84.4  | 95.0       | 73.3        | 93.0  |                   |

Kappa:  
0.83

Overall  
accuracy  
(%): 86.4

Table 4. Confusion matrix of supervised land cover classification for 2018 image.

|           |                       | Validation |       |            |             |       | User accuracy (%) |
|-----------|-----------------------|------------|-------|------------|-------------|-------|-------------------|
|           |                       | Fish pond  | Urban | Vegetation | Watercourse | Other |                   |
| Predicted | Fish pond             | 42         | 3     | 2          | 13          | 0     | 70.0              |
|           | Urban                 | 0          | 62    | 1          | 6           | 2     | 87.3              |
|           | Vegetation            | 3          | 0     | 61         | 0           | 2     | 92.4              |
|           | Watercourse           | 16         | 3     | 1          | 40          | 0     | 66.7              |
|           | Other                 | 0          | 3     | 2          | 0           | 59    | 92.2              |
|           | Producer accuracy (%) | 68.9       | 87.3  | 91.0       | 67.8        | 93.7  |                   |

Table 5: Table showing bias-corrected area and uncertainty estimates for each land cover class in the Deep Bay area in 1986, 1995 and 2018. Adjusted estimates and uncertainties ( $\pm$ ) for producer accuracy (PA), user accuracy (UA) and overall accuracy (OA) are also presented. Figures are rounded to one decimal place.

|             |              | m <sup>2</sup> | m <sup>2</sup> $\pm$ | PA   | PA $\pm$ | UA   | UA $\pm$ | OA   | OA $\pm$ |
|-------------|--------------|----------------|----------------------|------|----------|------|----------|------|----------|
| <b>1986</b> | Fish pond    | 1091657.0      | 267277.5             | 91.7 | 12.4     | 70.9 | 11.3     | 88.7 | 3.6      |
|             | Urban        | 3750390.0      | 810768.6             | 86.9 | 6.1      | 89.3 | 7.8      |      |          |
|             | Vegetation   | 5071694.0      | 960982.6             | 87.0 | 4.4      | 96.0 | 4.8      |      |          |
|             | Water course | 1910357.0      | 496850.2             | 84.0 | 10.5     | 88.2 | 9.1      |      |          |
|             | Other        | 2288834.0      | 557641.4             | 89.1 | 11.4     | 77.2 | 10.9     |      |          |
|             |              |                |                      |      |          |      |          |      |          |
| <b>1995</b> | Fish pond    | 530510.2       | 139921.3             | 87.0 | 22.6     | 52.9 | 12.6     | 90.0 | 3.1      |
|             | Urban        | 4550245.0      | 921558.3             | 84.4 | 3.7      | 92.0 | 6.8      |      |          |
|             | Vegetation   | 5582790.0      | 1101596.0            | 95.0 | 3.5      | 98.3 | 3.3      |      |          |
|             | Water course | 1343133.0      | 326038.9             | 73.3 | 16.1     | 72.9 | 12.0     |      |          |
|             | Other        | 2051705.0      | 496014.7             | 93.0 | 13.4     | 84.3 | 9.4      |      |          |
|             |              |                |                      |      |          |      |          |      |          |
| <b>2018</b> | Fish pond    | 730322.5       | 179897.0             | 68.9 | 21.1     | 42.7 | 12.6     | 87.1 | 2.8      |
|             | Urban        | 4141230.0      | 812714.2             | 87.3 | 2.7      | 92.8 | 6.0      |      |          |
|             | Vegetation   | 6378461.0      | 1131667.0            | 91.0 | 2.2      | 98.7 | 2.8      |      |          |
|             | Water course | 1404938.0      | 342748.1             | 67.8 | 13.6     | 67.4 | 12.0     |      |          |
|             | Other        | 1294502.0      | 306802.9             | 93.7 | 18.9     | 76.8 | 10.4     |      |          |

Table 6: Table showing bias-corrected area and uncertainty estimates for each land cover class in Otter-persist areas in 1986, 1995 and 2018. Adjusted estimates and uncertainties ( $\pm$ ) for producer accuracy (PA), user accuracy (UA) and overall accuracy (OA) are also presented.

|             |              | m <sup>2</sup> | m <sup>2</sup> $\pm$ | PA       | PA $\pm$ | UA       | UA $\pm$ | OA       | OA $\pm$ |
|-------------|--------------|----------------|----------------------|----------|----------|----------|----------|----------|----------|
| <b>1986</b> | Fish pond    | 178742.9       | 38854.62             | 91.66667 | 7.136583 | 88.04746 | 8.075115 | 87.86847 | 3.875022 |
|             | Urban        | 157470         | 34710.75             | 86.88525 | 5.977529 | 91.84319 | 6.925706 |          |          |
|             | Vegetation   | 128275.3       | 27346.97             | 86.95652 | 8.447993 | 94.25563 | 5.745933 |          |          |
|             | Water course | 166653.1       | 40279.7              | 84       | 7.895324 | 87.46729 | 9.366573 |          |          |
|             | Other        | 24294.83       | 6355.254             | 89.09091 | 27.75103 | 51.54908 | 12.97419 |          |          |
|             |              |                |                      |          |          |          |          |          |          |
| <b>1995</b> | Fish pond    | 146995.1       | 34799.97             | 87.03704 | 5.98498  | 83.7792  | 9.327917 | 86.0638  | 3.698164 |
|             | Urban        | 202591         | 41559.9              | 84.375   | 4.588283 | 92.27214 | 6.701254 |          |          |
|             | Vegetation   | 157410         | 34992.46             | 95       | 5.560701 | 97.8578  | 3.694519 |          |          |
|             | Water course | 92200          | 21823.36             | 73.33333 | 13.54282 | 70.38212 | 12.29211 |          |          |
|             | Other        | 49501.55       | 12462.28             | 92.98246 | 18.25428 | 74.41214 | 11.32811 |          |          |
|             |              |                |                      |          |          |          |          |          |          |
| <b>2018</b> | Fish pond    | 134566         | 30343.96             | 68.85246 | 9.775013 | 68.55143 | 11.84783 | 81.10051 | 4.251957 |
|             | Urban        | 154590         | 31639.71             | 87.32394 | 6.449669 | 88.10442 | 7.584007 |          |          |
|             | Vegetation   | 182757.7       | 37421.66             | 91.04478 | 4.628434 | 95.39525 | 5.095254 |          |          |
|             | Water course | 138502.5       | 31635.78             | 67.79661 | 9.465991 | 67.81953 | 11.92075 |          |          |
|             | Other        | 44533.12       | 10699.22             | 93.65079 | 17.46426 | 77.67416 | 10.28319 |          |          |

Table 7: Table showing bias-corrected area and uncertainty estimates for each land cover class in Otter-loss areas in 1986, 1995 and 2018. Adjusted estimates and uncertainties ( $\pm$ ) for producer accuracy (PA), user accuracy (UA) and overall accuracy (OA) are also presented.

|             |              | <b>m<sup>2</sup></b> | <b>m<sup>2</sup><math>\pm</math></b> | <b>PA</b> | <b>PA<math>\pm</math></b> | <b>UA</b> | <b>UA<math>\pm</math></b> | <b>OA</b> | <b>OA<math>\pm</math></b> |
|-------------|--------------|----------------------|--------------------------------------|-----------|---------------------------|-----------|---------------------------|-----------|---------------------------|
| <b>1986</b> | Fish pond    | 146857.1             | 32657.34                             | 91.66667  | 9.419852                  | 84.79144  | 8.938822                  | 87.84559  | 3.937943                  |
|             | Urban        | 135060               | 30170.01                             | 86.88525  | 7.497782                  | 90.21039  | 7.519543                  |           |                           |
|             | Vegetation   | 124879.2             | 26496.89                             | 86.95652  | 7.383162                  | 94.13022  | 5.804452                  |           |                           |
|             | Water course | 187163.3             | 43674.02                             | 84        | 6.155031                  | 90.41525  | 8.328114                  |           |                           |
|             | Other        | 22388.79             | 5858.558                             | 89.09091  | 26.98892                  | 52.13888  | 12.96854                  |           |                           |
|             |              |                      |                                      |           |                           |           |                           |           |                           |
| <b>1995</b> | Fish pond    | 80575.08             | 20193                                | 87.03704  | 11.16787                  | 69.94668  | 11.60139                  | 87.47412  | 3.52618                   |
|             | Urban        | 176175.5             | 36723.14                             | 84.375    | 4.555937                  | 90.46044  | 7.371987                  |           |                           |
|             | Vegetation   | 204840               | 42635.67                             | 95        | 4.030697                  | 98.35673  | 3.244039                  |           |                           |
|             | Water course | 123133.3             | 28108.99                             | 73.33333  | 9.295315                  | 81.40597  | 10.47449                  |           |                           |
|             | Other        | 34170.52             | 8695.077                             | 92.98246  | 25.42024                  | 69.7742   | 11.92216                  |           |                           |
|             |              |                      |                                      |           |                           |           |                           |           |                           |
| <b>2018</b> | Fish pond    | 125294               | 28277.41                             | 68.85246  | 9.81186                   | 69.70932  | 11.72546                  | 81.81915  | 4.047831                  |
|             | Urban        | 138540               | 28547.01                             | 87.32394  | 6.290733                  | 88.53552  | 7.463509                  |           |                           |
|             | Vegetation   | 210014.5             | 41070.98                             | 91.04478  | 3.619151                  | 96.47467  | 4.483383                  |           |                           |
|             | Water course | 115109               | 26690.31                             | 67.79661  | 10.00086                  | 65.09173  | 12.16346                  |           |                           |
|             | Other        | 25987.5              | 6329.212                             | 93.65079  | 27.5698                   | 66.75051  | 11.63337                  |           |                           |

Table 8: Comparison of class area estimates for each land cover class in Otter-persist and Otter-loss areas for 1986, 1995 and 2018. Original and bias-corrected area estimates for the random forest classification are provided. Figures are rounded to the nearest integer.

|                  | Otter-persist                     |                                       |                                   |                                       |                                   |                                       | Otter-loss                        |                                       |                                   |                                       |                                   |                                       |
|------------------|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|
|                  | 1986                              |                                       | 1995                              |                                       | 2018                              |                                       | 1986                              |                                       | 1995                              |                                       | 2018                              |                                       |
| Land cover class | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) | Classified area (m <sup>2</sup> ) | Bias-corrected area (m <sup>2</sup> ) |
| Fish pond        | 187680                            | <b>178743</b>                         | 166050                            | <b>146995</b>                         | 132360                            | <b>134566</b>                         | 154200                            | <b>146857</b>                         | 91020                             | <b>80575</b>                          | 123240                            | <b>125294</b>                         |
| Urban            | 157470                            | <b>157470</b>                         | 196260                            | <b>202591</b>                         | 154590                            | <b>154590</b>                         | 135060                            | <b>135060</b>                         | 170670                            | <b>176176</b>                         | 138540                            | <b>138540</b>                         |
| Vegetation       | 118980                            | <b>128275</b>                         | 157410                            | <b>157410</b>                         | 180030                            | <b>182758</b>                         | 115830                            | <b>124879</b>                         | 204840                            | <b>204840</b>                         | 206880                            | <b>210015</b>                         |
| Water course     | 163320                            | <b>166653</b>                         | 82980                             | <b>92200</b>                          | 140850                            | <b>138503</b>                         | 183420                            | <b>187163</b>                         | 110820                            | <b>123133</b>                         | 117060                            | <b>115109</b>                         |
| Other            | 25620                             | <b>24295</b>                          | 50370                             | <b>49502</b>                          | 45240                             | <b>44533</b>                          | 23610                             | <b>22389</b>                          | 34770                             | <b>34171</b>                          | 26400                             | <b>25988</b>                          |
| $\Sigma$         | 653070                            | <b>655436</b>                         | 653070                            | <b>648698</b>                         | 653070                            | <b>654949</b>                         | 612120                            | <b>616348</b>                         | 612120                            | <b>618894</b>                         | 612120                            | <b>614945</b>                         |

Table 9: Logistic regression results investigating the relationship between habitat extents and extent of habitat change from 1995 to 2018 and otter persistence. No results were significant.

| Habitat variables (~otter persistence)             | AIC  | Estimate | Nagelkerke's R <sup>2</sup> | p    |
|----------------------------------------------------|------|----------|-----------------------------|------|
| Initial fishpond area (1995)                       | 48.8 | 0.00013  | 0.13                        | 0.07 |
| Initial urban area (1995)                          | 52.4 | 0.00002  | 0.00                        | 0.72 |
| Initial vegetation area (1995)                     | 50.8 | -0.00006 | 0.06                        | 0.21 |
| Initial watercourse area (1995)                    | 51.8 | -0.00004 | 0.03                        | 0.42 |
| Initial other area (1995)                          | 52.2 | 0.00005  | 0.01                        | 0.58 |
| Change in fishpond area (1995-2018)                | 48.0 | -0.00019 | 0.16                        | 0.11 |
| Change in urban area (1995-2018)                   | 52.4 | -0.00002 | 0.00                        | 0.76 |
| Change in vegetation area (1995-2018)              | 52.1 | 0.00004  | 0.02                        | 0.53 |
| Change in watercourse area (1995-2018)             | 50.7 | 0.00007  | 0.07                        | 0.21 |
| Change in other area (1995-2018)                   | 52.4 | 0.00004  | 0.00                        | 0.79 |
| Initial fishpond area * Change in urban area       | 52.8 | 0.00000  | 0.13                        | 0.98 |
| Initial fishpond area * Change in vegetation area  | 52.5 | 0.00000  | 0.14                        | 0.69 |
| Initial fishpond area * Change in watercourse area | 52.2 | 0.00000  | 0.15                        | 0.98 |
| Initial fishpond area * Change in other area       | 49.5 | 0.00000  | 0.24                        | 0.10 |

Table 10: Logistic regression results investigating the relationship between land cover extent in 2018 and otter spraint presence. Significant results are indicated with an asterisk.

| Land cover extent (~otter persistence) | AIC  | Estimate  | Nagelkerke's R <sup>2</sup> | p      |
|----------------------------------------|------|-----------|-----------------------------|--------|
| Initial fishpond area (2018)*          | 26.1 | 0.00090   | 0.72                        | 0.002* |
| Initial urban area (2018)*             | 48.4 | -0.00014  | 0.19                        | 0.04*  |
| Initial vegetation area (2018)         | 51.7 | -0.000068 | 0.08                        | 0.15   |
| Initial watercourse area (2018)*       | 28.8 | 0.001     | 0.67                        | 0.001* |
| Initial other area (2018)              | 46.4 | -0.00096  | 0.25                        | 0.06   |