References


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Appendices

Appendix A: Questionnaire used for large-scale growers’ survey (Chapter 1)

<table>
<thead>
<tr>
<th>Farm Name &amp; GPS:</th>
<th>Farmer name:</th>
<th>Date:</th>
<th>No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eldana habitat management project: Pre-introduction survey with large-scale/commercial farmers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PART 1: Demographic/Personal Profile Questions:**

<table>
<thead>
<tr>
<th></th>
<th>1. Male</th>
<th>2. Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender:</td>
<td>1. 18-30 years</td>
<td>2. 31-40 years</td>
</tr>
<tr>
<td>2. Age:</td>
<td>1. 18-30 years</td>
<td>2. 31-40 years</td>
</tr>
<tr>
<td>3. How long have you been farming sugarcane?</td>
<td>1. less than 5 years</td>
<td>2. 5-10 years</td>
</tr>
<tr>
<td>4. Do you have tertiary education?</td>
<td>1. yes</td>
<td>2. no</td>
</tr>
<tr>
<td>4.a. If yes, where did you study, and what course did you study?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Have you ever had additional training on farming?</td>
<td>1. yes</td>
<td>2. no</td>
</tr>
<tr>
<td>5.a. If yes, what topics were you trained in?</td>
<td>1. sugarcane farming</td>
<td>2. pest management</td>
</tr>
<tr>
<td>6. What is your relationship to this farm/land?</td>
<td>1. owner</td>
<td>2. manager</td>
</tr>
<tr>
<td>7. Which other crops or livestock do you farm on this land?</td>
<td>1. none</td>
<td>2. maize</td>
</tr>
</tbody>
</table>

**PART 2: General insect pest management questions:**

<table>
<thead>
<tr>
<th></th>
<th>1. soil</th>
<th>2. rainfall</th>
<th>3. insect pests</th>
<th>4. disease</th>
<th>5. frost</th>
<th>6. variety choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Which is the biggest problem affecting sugarcane yield on your farm? Please rank the following options from 1 to 6: 1 is the worst problem, 6 is the least problem.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Which pest and/or disease problems are the worst on your farm?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Which sugarcane insect pest is the biggest problem on your farm? Please rank the following options from 1 to 5: 1 is the worst problem, 5 is the least problem.</td>
<td>1. Eldana</td>
<td>2. white grub</td>
<td>3. Sesamia</td>
<td>4. thrips</td>
<td>5. aphids</td>
<td></td>
</tr>
<tr>
<td>11. Have you ever used insecticides on your sugarcane?</td>
<td>1. yes</td>
<td>2. no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. If you have used insecticides before, please describe which product you used, and which insects were causing the problem.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Please select which of these methods you use for insect pest control: rank the options from 1 to 5: 1 is the most used, 5 is the least used.</td>
<td>1. spraying</td>
<td>2. habitat management/pp</td>
<td>3. monitoring</td>
<td>4. cutting&amp;hygiene managmt</td>
<td>5. variety choice</td>
<td></td>
</tr>
</tbody>
</table>
## PART 3: Eldana pest management questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Have you heard of Eldana?</td>
<td>1. yes</td>
</tr>
<tr>
<td>15 Please identify Eldana and Eldana damage from these photos/specimens</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>16 Has Eldana ever been found on your farm?</td>
<td>1. yes</td>
</tr>
<tr>
<td>17 Do you know that the range of Eldana is spreading from the coast inland?</td>
<td>1. yes</td>
</tr>
<tr>
<td>18 Please choose your response to this statement: Eldana is currently a threat to sugarcane production in the Midlands North area.</td>
<td>1. strongly agree  2. agree  3. neutral  4. disagree  5. strongly disagree</td>
</tr>
<tr>
<td>19 Please choose your response to this statement: Eldana will be a threat to sugarcane production in the Midlands North area in the near future.</td>
<td>1. strongly agree  2. agree  3. neutral  4. disagree  5. strongly disagree</td>
</tr>
<tr>
<td>20 Are you worried about Eldana possibly affecting your sugarcane production in the future?</td>
<td>1. yes</td>
</tr>
<tr>
<td>21 How serious a problem is Eldana in sugarcane production on your farm at the moment? Please choose a number from 1 to 5: 1 is the most serious, 5 is the least serious.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>22 Why did you choose this option in the question above:</td>
<td></td>
</tr>
<tr>
<td>23 What do you do to control Eldana? Please rank these 5 control measures from 1 to 5: 1 is the one you use the most, 5 is the one you use the least.</td>
<td>1. spray  2. monitor  3. hygiene &amp; cutting  4. push-pull  5. variety choice</td>
</tr>
<tr>
<td>24 Have you heard of Integrated Pest Management as a method for controlling Eldana?</td>
<td>1. yes</td>
</tr>
<tr>
<td>25 Have you heard of ‘habitat management’ or ‘push-pull’ as a method for controlling Eldana?</td>
<td>1. yes</td>
</tr>
<tr>
<td></td>
<td>Question</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 26| Have you been involved in more positive or more negative discussions about habitat management/push-pull/IPM? | 1. positive  
2. negative  
3. positive and negative  
4. none |
| 27| Where did you first hear about IPM/habitat management/push-pull for Eldana control?          | 1. general reading  
2. other farmers  
3. MNP&D or Ecozone days  
4. SASRI information packs/pamphlets  
5. other: |
| 28| Do you know these plants (used for push-pull)? Please say yes/no/maybe for each one:         | 1. Melinis minutiflora/Molasses grass  
2. Bt maize  
3. sedges  
4. Cyperus papyrus  
5. Cyperus dives |
| 29| Do you know how Bt maize works? If so, please explain:                                       |                                                                       |
| 30| Do you know where you could get Bt maize seed?                                               |                                                                       |
| 31| Do you know where you could get Molasses grass seed/seedlings?                               |                                                                       |
| 32| Do you know where you could get sedges/Cyperus sp.?                                          |                                                                       |
| 33| Do you read the SASRI pamphlets and information packs that are sent to you?                  | 1. yes, always  
2. yes, mostly  
3. sometimes  
4. no, not much  
5. no, never |
| 34| Do you think push-pull/habitat management as part of an IPM approach is a good method for controlling Eldana? | 1. yes  
2. no  
3. maybe  
4. I don't know habitat management  
5. other: |
| 35| Do you know how to implement habitat management on your farm?                                 | 1. yes  
2. no |
| 36| Do you think that you understand the practical and cost implications of habitat management? | 1. yes  
2. no |
<table>
<thead>
<tr>
<th>Part 4: Questions about extension work/intervention:</th>
</tr>
</thead>
<tbody>
<tr>
<td>37 Is the information you receive about pest management from SASRI/the local Pest &amp; Disease office useful to you?</td>
</tr>
<tr>
<td>38 Are you interested in receiving more information on pest management than you currently receive?</td>
</tr>
<tr>
<td>39 Would you like to learn more about push-pull/habitat management for controlling Eldana?</td>
</tr>
<tr>
<td>40 How would you like to learn more about push pull and other methods for controlling Eldana? Please rank these options from 1 to 5: 1 is the one you would be most interested in, 5 is the one you would be least interested in.</td>
</tr>
<tr>
<td>41 How often would you like to receive information via workshop/pamphlet about pest management from SASRI/P&amp;D office:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>42 Are you willing to be involved in future research toward introducing push-pull for control of Eldana in this area?</td>
</tr>
<tr>
<td>43 How would you suggest we go about introducing a new method like push-pull for control of Eldana in the Midlands North area?</td>
</tr>
<tr>
<td>44 What do you see as the biggest barrier to us introducing a new method like push-pull for Eldana amongst farmers?</td>
</tr>
</tbody>
</table>
# Appendix B: Summary of data analysis methods (Chapter 2)

<table>
<thead>
<tr>
<th>Results Section</th>
<th>Data presentation &amp; analysis</th>
<th>Statistical tests reported</th>
<th>Tables and Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.3.1 Respondents’ profiles</strong></td>
<td>• Frequencies and percentages (descriptive statistics)</td>
<td>• No statistical tests</td>
<td>Table 2.1</td>
</tr>
</tbody>
</table>
| **2.3.2 General sugarcane and insect pest management & perceptions** | • Ranking data (median rank scores)  
• Contingency tables  
• Frequencies and percentages (descriptive statistics, pie charts and bar graphs) | • Wilcoxon signed ranks test ($p$-value, $Z$ statistic)  
• Chi squared ($\chi^2$, $p$-value, df)  
• effect sizes ($w$ statistic) | Appendix 3  
Figure 2.2, 2.4  
Figure 2.3 |
| **2.3.3 Knowledge, perceptions and practices of *E. saccharina*** | • Ranking data (median rank scores)  
• Contingency tables  
• Frequencies and percentages (descriptive statistics, bar graphs) | • Wilcoxon signed ranks test ($p$-value, $Z$ statistic)  
• Chi squared ($\chi^2$, $p$-value, df)  
• effect sizes ($w$ statistic) | Appendix 3  
Figure 2.5  
Figure 2.6 |
| **2.3.4 Knowledge and perceptions of push-pull and IPM** | • Contingency tables  
• Frequencies and percentages (descriptive statistics, bar graphs) | • Chi squared ($\chi^2$, $p$-value, df)  
• effect sizes ($w$ statistic) | Table 2.2  
Figure 2.7  
Figure 2.8 |
| **2.3.5 Dissemination of pest management information** | • Ranking data (median rank scores)  
• Frequencies and percentages (descriptive statistics, pie charts and bar graphs) | • Wilcoxon signed ranks test ($p$-value, $Z$ statistic) | Appendix 3  
Figure 2.9  
Figure 2.10  
Figure 2.11 |
Appendix C: Details of Wilcoxon signed rank tests for ranking questions (Chapter 2)

<table>
<thead>
<tr>
<th>Pairs of variables compared</th>
<th>p-value</th>
<th>Bonferroni corrected p-value</th>
<th>Z statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Sugarcane production constraints</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>soil and rainfall</td>
<td>0.137</td>
<td>2.055</td>
<td>1.486</td>
</tr>
<tr>
<td>soil and insect pests**</td>
<td>0.000</td>
<td>0.000</td>
<td>5.182</td>
</tr>
<tr>
<td>soil and disease**</td>
<td>0.000</td>
<td>0.000</td>
<td>4.481</td>
</tr>
<tr>
<td>soil and frost</td>
<td>0.945</td>
<td>14.175</td>
<td>0.070</td>
</tr>
<tr>
<td>soil and varieties**</td>
<td>0.000</td>
<td>0.003</td>
<td>3.725</td>
</tr>
<tr>
<td>rainfall and insects**</td>
<td>0.000</td>
<td>0.000</td>
<td>5.386</td>
</tr>
<tr>
<td>rainfall and disease**</td>
<td>0.000</td>
<td>0.000</td>
<td>4.219</td>
</tr>
<tr>
<td>rainfall and frost</td>
<td>0.149</td>
<td>2.235</td>
<td>1.443</td>
</tr>
<tr>
<td>rainfall and varieties**</td>
<td>0.000</td>
<td>0.002</td>
<td>3.852</td>
</tr>
<tr>
<td>insect pests and disease</td>
<td>0.010</td>
<td>0.153</td>
<td>2.570</td>
</tr>
<tr>
<td>insect pests and frost**</td>
<td>0.000</td>
<td>0.000</td>
<td>4.873</td>
</tr>
<tr>
<td>insect pests and varieties**</td>
<td>0.000</td>
<td>0.004</td>
<td>3.629</td>
</tr>
<tr>
<td>disease and frost**</td>
<td>0.000</td>
<td>0.003</td>
<td>3.713</td>
</tr>
<tr>
<td>disease and varieties</td>
<td>0.075</td>
<td>1.124</td>
<td>1.781</td>
</tr>
<tr>
<td>frost and varieties**</td>
<td>0.001</td>
<td>0.015</td>
<td>3.283</td>
</tr>
<tr>
<td><strong>B. Worst insect pests</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eldana and white grub</td>
<td>0.069</td>
<td>0.691</td>
<td>1.817</td>
</tr>
<tr>
<td>eldana and sesamia</td>
<td>0.444</td>
<td>4.440</td>
<td>0.765</td>
</tr>
<tr>
<td>eldana and thrips</td>
<td>0.575</td>
<td>5.754</td>
<td>0.560</td>
</tr>
<tr>
<td>eldana and aphids</td>
<td>0.499</td>
<td>4.990</td>
<td>0.676</td>
</tr>
<tr>
<td>white grub and sesamia</td>
<td>0.335</td>
<td>3.345</td>
<td>0.965</td>
</tr>
<tr>
<td>white grub and thrips</td>
<td>0.148</td>
<td>1.475</td>
<td>1.448</td>
</tr>
<tr>
<td>white grubs and aphids</td>
<td>0.059</td>
<td>0.592</td>
<td>1.887</td>
</tr>
<tr>
<td>sesamia and thrips</td>
<td>0.125</td>
<td>1.250</td>
<td>1.533</td>
</tr>
<tr>
<td>sesamia and aphids</td>
<td>0.124</td>
<td>1.235</td>
<td>1.540</td>
</tr>
<tr>
<td>thrips and aphids</td>
<td>0.529</td>
<td>5.290</td>
<td>0.629</td>
</tr>
<tr>
<td><strong>C. Eldana pest management activities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>insecticides and monitoring*</td>
<td>0.008</td>
<td>0.077</td>
<td>2.666</td>
</tr>
<tr>
<td>insecticides and cultural control*</td>
<td>0.008</td>
<td>0.077</td>
<td>2.666</td>
</tr>
<tr>
<td>insecticides and push-pull</td>
<td>0.012</td>
<td>0.117</td>
<td>2.521</td>
</tr>
<tr>
<td>insecticides and varieties</td>
<td>0.018</td>
<td>0.178</td>
<td>2.369</td>
</tr>
<tr>
<td>monitoring and cultural control</td>
<td>0.058</td>
<td>0.585</td>
<td>1.892</td>
</tr>
<tr>
<td>monitoring and push-pull</td>
<td>0.455</td>
<td>4.550</td>
<td>0.747</td>
</tr>
<tr>
<td>monitoring and varieties</td>
<td>0.889</td>
<td>8.889</td>
<td>0.140</td>
</tr>
<tr>
<td>varieties and cultural control</td>
<td>0.026</td>
<td>0.263</td>
<td>2.221</td>
</tr>
<tr>
<td>varieties and push-pull</td>
<td>0.313</td>
<td>3.130</td>
<td>1.010</td>
</tr>
<tr>
<td>push-pull and cultural control</td>
<td>0.022</td>
<td>0.217</td>
<td>2.296</td>
</tr>
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</table>
**D. Favoured extension methods**

<table>
<thead>
<tr>
<th>Method Combination</th>
<th>p-value</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm days and model farms</td>
<td>0.988</td>
<td>9.880</td>
<td>0.015</td>
</tr>
<tr>
<td>Farm days and pamphlets**</td>
<td>0.000</td>
<td>0.001</td>
<td>4.031</td>
</tr>
<tr>
<td>Farm days and workshops**</td>
<td>0.000</td>
<td>0.000</td>
<td>4.098</td>
</tr>
<tr>
<td>Farm days and personal visit</td>
<td>0.046</td>
<td>0.461</td>
<td>1.994</td>
</tr>
<tr>
<td>Model farms and pamphlets**</td>
<td>0.000</td>
<td>0.002</td>
<td>3.751</td>
</tr>
<tr>
<td>Model farms and workshops**</td>
<td>0.000</td>
<td>0.000</td>
<td>4.412</td>
</tr>
<tr>
<td>Model farms and personal visits</td>
<td>0.017</td>
<td>0.165</td>
<td>2.397</td>
</tr>
<tr>
<td>Pamphlets and workshops</td>
<td>0.606</td>
<td>6.055</td>
<td>0.516</td>
</tr>
<tr>
<td>Pamphlets and personal visits*</td>
<td>0.005</td>
<td>0.047</td>
<td>2.828</td>
</tr>
<tr>
<td>Workshops and personal visits**</td>
<td>0.001</td>
<td>0.014</td>
<td>2.467</td>
</tr>
</tbody>
</table>
Appendix D: Questionnaire used by Reunion island students (Chapter 3)

<table>
<thead>
<tr>
<th>Field</th>
<th>Question</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VARIETIES</strong></td>
<td>What variety do you grow ?</td>
<td>N 12, N 16, N 37, N 48 ...</td>
</tr>
<tr>
<td><strong>SOILS</strong></td>
<td>Are your fields soil sampled ? Why ?</td>
<td>&quot;No&quot; -&gt; 0 &quot;Yes, EO Advice&quot; -&gt; 1 &quot;Yes / explain&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>REPLANTING</strong></td>
<td>Have you ever replanted your sugarcane ? (double check with date of first plantation)</td>
<td>&quot;Don't know or No&quot; -&gt; 0 &quot;No but I know&quot; -&gt; 1 &quot;Yes/explain&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>FERTILISER</strong></td>
<td>Do you apply fertiliser ? Why ?</td>
<td>&quot;Don't know or No&quot; -&gt; 0 &quot;No but I know&quot; -&gt; 1 &quot;Yes/explain&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>PESTS</strong></td>
<td>Do you know what are the main pests in the area ? (2 names)</td>
<td>2 listed among : Eldana / Leaf eaters / soil pests / sap feeders</td>
</tr>
<tr>
<td><strong>DISEASES</strong></td>
<td>Have you seen eldana in your sugarcane ? How do we control it ?</td>
<td>2 listed among : Use healthy seedcane, use insecticide, survey method</td>
</tr>
<tr>
<td><strong>WEEDS</strong></td>
<td>Do you know what are the main weeds in the area ? (2 names)</td>
<td>2 listed among : Tufted &amp; creeping grasses / sedges / broad leaf</td>
</tr>
<tr>
<td><strong>HARVEST</strong></td>
<td>How many months after planting do you harvest ? (check with EO)</td>
<td>&quot;Don't know&quot; -&gt; 0 &quot;Wrong&quot; -&gt; 1 &quot;Right&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>ADVICES</strong></td>
<td>How many times do you get extension officers visits (numbers / year) ?</td>
<td>&quot;0 à 1&quot; -&gt; 0 &quot;2 à 3&quot; -&gt; 1 &quot;3 et +&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>ECONOMIC RESULTS</strong></td>
<td>Do you get other advice except from EO's ? Who from ?</td>
<td>&quot;Don't know&quot; -&gt; 0 &quot;No&quot; -&gt; 1 &quot;Yes&quot; -&gt; 2</td>
</tr>
<tr>
<td><strong>PROSPECT</strong></td>
<td>Do you know what is your SC income ? Explain us</td>
<td>&quot;Don't know&quot; -&gt; 0 &quot;I know/don't explain&quot; -&gt; 1 &quot;I know/explain&quot; -&gt; 2</td>
</tr>
<tr>
<td></td>
<td>What are your plans for SC and other production in the future ?</td>
<td>&quot;No plan&quot; -&gt; 0 &quot;Plan without details&quot; -&gt; 1 &quot;Plan and details&quot; -&gt; 2</td>
</tr>
</tbody>
</table>
Appendix E: Insect specimens and photographs used during focus group discussions about insect pests (Chapter 3)
### Appendix F: Questionnaire used for push-pull adoption telephone survey (Chapter 4)

<table>
<thead>
<tr>
<th>Questionnaire: LSG follow-up survey on push-pull implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have you had eldana on your farm?</td>
</tr>
<tr>
<td>2. What do you think of push-pull?</td>
</tr>
<tr>
<td>3. Please rate how effective you think push-pull, as part of IPM, is for controlling eldana:</td>
</tr>
<tr>
<td>0=not effective, 10=very effective</td>
</tr>
<tr>
<td>4. Please rate your knowledge of how to implement push-pull:</td>
</tr>
<tr>
<td>0=no knowledge, 10=excellent knowledge</td>
</tr>
<tr>
<td>5. Have you implemented push-pull on your farm?</td>
</tr>
<tr>
<td>6. Why/why not?</td>
</tr>
<tr>
<td>If yes: 7. Please explain how you did this:</td>
</tr>
<tr>
<td>8. Do you have suggestions for other farmers starting to implement push-pull?</td>
</tr>
<tr>
<td>9. Have you had any problems with implementing push-pull?</td>
</tr>
<tr>
<td>10. How much of a hassle is implementing push-pull, please rate from 0-10: 0= no hassles</td>
</tr>
<tr>
<td>10=a lot of hassle</td>
</tr>
<tr>
<td>If no: 11. What would have to happen for you to start implementing push-pull next week?</td>
</tr>
<tr>
<td>12. Please tell me how you would score eldana management in your management priorities, from 0 – 10 i.e. 0=no priority, 10=top priority:</td>
</tr>
<tr>
<td>13. Please indicate how important environmental matters are in your farm decision-making:</td>
</tr>
<tr>
<td>0=not important at all, 10=very important</td>
</tr>
</tbody>
</table>
Appendix G: Maps and summaries of WET-Health assessments (Chapter 6)

Assessment: The wetland at Cloudhill is a palustrine wetland with a channel. Large sections are overgrown with alien invasive plants or converted to pasture/small dams. Large woody invasive alien plants (IAPs) cause the channel to become more incised and erosion to increase (H1). The lower portion has a healthy patch of natural vegetation. Action: Immediate recommended action is to clear IAPs from accessible, priority areas (e.g. stream crossings) and establish *Cyperus papyrus* and *Cyperus dives* (V1&V2). These may need to be protected from grazing cattle. Long-term recommended action is to remove large woody IAPs from the channel (H1) and maintain the entire system free of IAPs.
Assessment: The wetlands at Waterfall are unchanneled palustrine wetlands. Due to extensive drains for crop lands, there are large hydrological impacts on this wetland. One large and two small dams have caused large vegetation impacts as well. Overall the size of the wetland is much reduced form its natural state. However, good control of invasive alien plants (IAPs) in the wetland means that there are areas with healthy natural vegetation, including sedges.

Action: continue with IAP management, slow flow in least used/functioning drains by planting *Cyperus dives* and *Cyperus papyrus* (H1). In the long-term, consider blocking other drains and taking one field entirely out of production, as it is within the wetland zone (H2).
Assessment: The two wetlands assessed at Tweefontein are hill slope seeps which are part of a larger stream channel which was not assessed. The vegetation in the two hill seeps is not modified much, although there is quite a bit of black wattle (Acacia mearnsii) encroaching on Wetland 2, and some Lantana camara encroaching on Wetland 1. There are hardly any hydrological impacts on these two wetlands, however invasive alien plants (IAPs) are having impacts on the larger stream channel. Action: IAPs should be cleared from the stream channel at crossings to allow establishment of Cyperus papyrus and Cyperus dives in accessible areas (V1, V2). IAPs must be kept out of the hill slope seeps. In the long-term, large woody IAPs should be removed from the stream channel (e.g. H1 H2) which will allow natural re-establishment of sedges in places.
Appendix H: “Push-pull wetland action plan”: A tool for farmers to assess wetlands and maximize efficacy as E. saccharina habitat (Chapter 6)

Wetland Action Plan for Push-Pull

Use soil auger to determine extent of wetlands i.e. grey/mottled soils indicate soils which are wet/temporarily wet etc. Map these and determine extent of cane which is growing in wetland areas. Where feasible, adjust land use plan.

Step 1: delineate and map wetlands

Step 2: determine wetland type

Type 2: Riparian wetland: concentrated flow, higher energy environments, alluvial soils, defined channel banks. In frost free areas mostly characterised by woody plants (trees)

Type 1: Palustrine wetland: diffuse flow, low energy environments, flat, open marshy areas or hill-slope seeps. Signs of soil wetness in top 50cm

Step 3: Assess impacts on wetland

Vegetation Impacts

Step 3A: Assess extent of Alien Invasive Plants (AIPs): map & identify key species

In palustrine wetlands, areas which have standing water for the longest periods throughout the year should be targeted for alien plant clearing and establishment of sedges

Step 4A: Determine priority areas for AIP clearing and re-establishment of indigenous tree/sedge species

In palustrine wetlands, alien plants which compete with sedges for habitat should be cleared first i.e. bramble.

Step 5A: Clear AIPs in priority areas & establish indigenous tree/sedge

Step 6: Maintain priority areas to keep clear of AIPs, monitor for natural re-establishment of sedges and plant sedges in suitably wet areas if necessary

Hydrological Impacts

Step 3B: Assess extent & effectiveness of drains: map

Step 4B: Determine priority drains suitable for rehab and establishment of sedges

Step 5A: Rehab priority drains: establish sedges

Broad recommendations for managing wetlands to optimise them as habitat for eldana

- Sedges grow in moist soils – prioritise these areas for alien invasive plant (AIP) clearing and establishment of sedges.
- Key sedge species to establish for eldana habitat: Cyperus dives (giant sedge) & Cyperus papyrus (papyrus). Cyperus latifolius can provide habitat as well, but is a lot less favoured than the other two.
- Use source material from natural sedge populations on the farm/neighbouring farms.
- Sedges can be transplanted: dig up rhizomes, split them, trim growth (leave ~30cm) and re-plant in wet areas. Transplanted sedges take 2-3 years to establish. They are fire and frost tolerant.
- Prioritise most natural areas for establishment of sedges and start with less infested areas to maximise effort.
- Look out for ‘wet spots’ in fields where a stand of sedge (e.g. papyrus) can be established.
- Establish a 1-2m buffer zone of natural vegetation alongside drains/riparian wetland areas. Ideally maintain indigenous vegetation in these buffer zones.
- Burning: reduce burning frequency and intensity, i.e. try to burn once every 2-3 years, when burning try to do a cool and/or patchy burn in wetland areas. Remember: frequent burning favours AIPs.
- The ideal is that all wetland areas be restored to their natural state, however this is often not economically viable. By managing wetlands with an emphasis on eldana habitat, one can take small achievable steps towards improving wetland management on a farm.

Background and motivation for managing wetlands for push-pull: Why optimise wetlands for eldana control?

Research has shown that eldana prefers wetland sedges (Cyperus dives & Cyperus papyrus) to sugarcane. Eldana is most effectively controlled naturally in sedges by its natural enemies (parasitoids). Field trials and farmers’ experiences have shown that well-managed cane adjacent to sedges growing in wetlands has lower infestations of eldana than cane which is not adjacent to sedges. Because they provide habitat and natural control for eldana (=a population ‘sink’), well-managed wetlands can be a valuable resource to farmers. ‘Habitat management’ means managing plant habitats to maximise their efficacy in controlling crop pests. In the push-pull system, which is recommended by SASRI as part of IPM for eldana control, wetland sedges can serve as a strong ‘pull’ for eldana.

Wetland management to maximise the beneficial ecosystem services which wetlands provide is becoming more and more important. Using push-pull as a motivation to approach wetland restoration and management can help to focus farmers’ efforts in rehabilitating their wetlands. Clearing alien plants can be costly but long term yield benefits will outweigh short term clearing costs.

The benefits of wetlands can be shared across farm boundaries. Farmers are encouraged to work together on area-wide IPM programmes when restoring their wetlands.
Appendix I: Accession numbers of stem borer and parasitoid specimens identified at the ARC-PPRI Biosystematics Division in Pretoria (Chapter 6)

<table>
<thead>
<tr>
<th>Sender's Accession Number</th>
<th>Our Accession Number</th>
<th>Family Name</th>
<th>Species Name</th>
<th>Determiner &amp; Date</th>
</tr>
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<tbody>
<tr>
<td>S.Ex 2219</td>
<td>AcP 9526</td>
<td>BRACONIDAE</td>
<td>Stenobracon sp.</td>
<td>G.L. Prinsloo, 2012</td>
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<td>S.Ex 2220</td>
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<td>AcP 9529</td>
<td>BRACONIDAE</td>
<td>Cotesia sp. probably sesamiae (Cameron)</td>
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<tr>
<td>S.Ex 2223</td>
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<td>BRACONIDAE</td>
<td>Undet. male specimens Probably Cotesia sp.</td>
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<td>Prob. Chilo partellus (Swinhoe) (Genitalia damaged on slide)</td>
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<td>S.Ex 2227</td>
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<td>PYRALIDAE</td>
<td>Eldana saccharina Walker Female</td>
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<tr>
<td>Sender's Accession Number</td>
<td>Our Accession Number</td>
<td>Family Name</td>
<td>Species Name</td>
<td>Determiner &amp; Date</td>
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<tr>
<td>S.Ex 2233</td>
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<td>VM Uys, 2012</td>
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<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
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<td>S.Ex 2238</td>
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<td>CRAMBIDAE</td>
<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
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<tr>
<td>S.Ex 2240</td>
<td>AcP 9522</td>
<td>CRAMBIDAE</td>
<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
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<tr>
<td>S.Ex 2241</td>
<td>AcP 9523</td>
<td>CRAMBIDAE</td>
<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
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<tr>
<td>S.Ex 2242</td>
<td>AcP 9524</td>
<td>CRAMBIDAE</td>
<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
</tr>
<tr>
<td>S.Ex 2243</td>
<td>AcP 9525</td>
<td>CRAMBIDAE</td>
<td>Chilo partellus (Swinhoe) female</td>
<td>VM Uys, 2012</td>
</tr>
</tbody>
</table>
Appendix J:

PHOTOGRAPHIC ESSAY

Sending Eldana Home

Moving eldana out of sugarcane back into its natural wetland habitat

Jessica Cockburn
Eldana saccharina is the most damaging pest of sugarcane in South Africa. It is estimated to cause up to R150 million in revenue loss to the industry annually. Eldana is an indigenous insect of wetlands. Destruction of wetland habitats to plant sugarcane is thought to have caused the insect to shift onto sugarcane as a new host. It reaches much higher populations in sugarcane than in its wild host plants and its natural enemies have not followed it into its new habitat. Worldwide, vast monocrops are recognised as unstable ecosystems prone to intensive pest infestations which are difficult to control.
Appendices

Research has shown that eldana prefers its indigenous host plants, the sedges *Cyperus dives* and *Cyperus papyrus*, to sugarcane. Thus they are recommended as ‘pull plants’ to attract eldana away from sugarcane back into its natural habitat. They grow naturally in wetlands in KwaZulu-Natal.

Genetically modified Bt maize can be used as a ‘dead end trap crop’ or a ‘pull plant’ for eldana: maturing maize has been shown to be more attractive to egg-laying eldana moths than sugarcane.

Molasses grass (*Melinis minutiflora*) has been used as a repellent ‘push plant’ against maize stem borers and has shown to effectively repel eldana from sugarcane and reduce damage.
Understanding farmers’ constraints and their knowledge and perceptions of *eldana* and push-pull: a key to successful implementation of knowledge intensive agricultural practices

A field visit to small-scale growers on the south coast to implement push-pull revealed that they did not know anything about *eldana* or how to manage it. We took a few steps back and discussed stem borers in maize, which the farmers were familiar with – this is a drawing of a stem borer by one of the participants.

Focus group discussions about insects elicited much interest and knowledge from farmers about insects. They know a lot of pests of food crops and have many innovative control measures for these. In contrast, they know little about sugarcane pests and their control. They don’t perceive sugarcane pests as a major constraint.

Participatory research tools, including sketch maps and matrix scoring, allowed farmers to explain what sugarcane means to them. This showed that sugarcane makes a large contribution to household food security and education costs. Many small-scale growers are women who are responsible not only for sugarcane farming but also for the well-being of their children on a daily basis.
Small group discussions with large-scale growers confirmed the findings of surveys and an exploratory network analysis of push-pull adoption: farmers recognise the benefits of this control strategy and are optimistic about it, but they are concerned about the hassles in implementing it which requires changes to farm management practices.

Model farms on which push-pull field trials were conducted doubled as sites for field days. Host farmers became push-pull experts and the strategy was adapted to suit their farming practices. ‘Learning by doing’ reduced farmers perceptions of push-pull as a hassle, and they could share advice on how best to implement it with visiting farmers.
Working together: participatory research and extension with farmers

Model farms provided opportunities for farmers, extension staff and researchers to work together on implementing push-pull for control of eldana, promoting participatory research and extension.

Experiential learning: planting push and pull plants together with farmers helps them to realise the value of biodiversity in agricultural systems. Push-pull is an inexpensive, low input strategy which can reduce the impact of eldana on sugarcane.
Looking ahead: implementation of push-pull in the Midlands North and beyond

Where farmers have planted sedges to pull eldana away from the cane, in combination with molasses grass as a push, they are noticing reductions in eldana damage. This only works in conjunction with good crop management in an integrated pest management (IPM) framework. Good wetland management is also crucial, and a tool has been developed to aid farmers in this.

Implementation of push-pull in the Midlands North is on track. Most farmers are enthusiastic about push-pull and IPM and realise the long-term benefits of such sustainable agricultural practices. Participatory approaches to research and extension, in which farmers’ constraints, perceptions and knowledge were investigated, have been a vital component of this success. Push-pull can help to reduce damage to crops from eldana and send it home!