Adaptive co-management for collaborative commercial pest management: the case of industry-driven fruit fly area-wide management

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Adaptive co-management for collaborative commercial pest management: the case of industry-driven fruit fly area-wide management

Heleen P. Kruger
School of Sociology, Australian National University, Canberra, Australia

ABSTRACT
Area-wide management is recommended for managing several mobile pests. With limited on-ground government assistance available, several Australian local industry groups drive such initiatives to minimise Queensland Fruit Fly impacts on production and market access. This qualitative study investigates how adaptive co-management thinking can assist industry-driven area-wide management. The concepts of social learning, communication, adaptive capacity, shared decision-making and shared authority can make valuable contributions to strengthening collaborative pest management. The tension between “top-down” market requirements and “bottom-up” adaptive co-management principles is best addressed if local industries focus primarily on minimising pest infestation and view market requirements as a bolt-on component.

KEYWORDS
Fruit fly; adaptive co-management; area-wide management; social learning; collaboration; market access

1. Introduction
When reliance on main pesticides is curbed by new restrictions and on-ground government support for pest control is dwindling, growers are in need of innovative pest management strategies. This is the challenge that many Australian horticulture growers face in relation to the pest Queensland Fruit Fly (Bactrocera tryoni (Frogatt)), or in short, QFly.

In the environmental sciences, adaptive co-management is a valuable approach to managing socio-ecological systems when uncertainty and complexity are high (Olsson et al. 2004; Charles 2007). Armitage, Plummer, et al. (2008, p. 96) define adaptive co-management as “a flexible system of resource management, tailored to specific places and situations, supported by, and working in conjunction with, various organizations at different scales.” Evidence of adaptive co-management thinking being applied to regional pest management is scant, especially in the context of supporting market access.

Local Australian horticulture industries are recommended to manage QFly on a long-term, area-wide basis (PHA 2008; Plant Biosecurity CRC 2015). Area-wide management (AWM) involves synchronised pest management implemented across a geographical area, often including non-commercial land and urban settings where the pest can reproduce (Vreysen et al. 2007).

This research article describes how adaptive co-management principles can assist in strengthening industry-driven fruit fly area-wide management (FF AWM) programmes. It extends the adaptive co-management literature to include considerations for commercial agriculture and in particular, managing biosecurity risks. This is timely as prevailing neoliberal paradigms and limited state budgets in several countries increasingly push local industries to be more self-reliant and less dependent on direct government support (Cheshire & Lawrence 2005).

1.1. QFly
QFly is one of Australia’s most destructive horticultural pests (Clarke et al. 2011). Many crops of Australia’s almost AUS$9 billion horticulture industry (ABS 2014) are susceptible to varying degrees (Plant Biosecurity CRC 2015).

The dynamics of QFly vary between regions depending on the local geography, the host range, the availability of moisture, temperature and the likelihood of infested fruit entering the region (Dominiak et al. 2006; Clarke et al. 2011). Recent years involved wet warm seasons in eastern Australia, resulting in expanded QFly populations (Dominiak & Ekman 2013). The vulnerability of horticulture industries to QFly in Australia’s southern states is forecasted to increase due to climate change (Sutherst et al. 2000).

1.2. The institutional context of QFly
The institutional context of QFly adds further layers of complexity and uncertainty to dealing with this pest.
Several state governments have reduced on-ground support for QFly management (for example, NSW DPI 2012), forcing local industries to be more self-reliant. Restrictions have recently been placed on two key pesticides, fenthion and dimethoate, which have traditionally been used to control the pest at low cost through a simple single-treatment approach (Dominiak & Ekman 2013).

A key concern of QFly is that it can restrict market access, even if production impacts are negligible. A strong export market is important for all growers of a particular industry by preventing oversupply in the domestic market. As QFly is unique to eastern Australia and some South Pacific islands (Clarke et al. 2011), importing countries can restrict trade or demand phytosanitary measures under World Trade Organisation (WTO) trade rules (Potter 2013). Although such measures benefit growers by enabling trade, they can impose significant cost as illustrated in Box 1. Finding less costly alternatives is a top priority for horticulture industries. There are non-protocol countries, but they tend to be oversupplied offering lower returns. Due to Australia’s high horticulture production costs, lucrative markets are important for many growers to remain profitable.

Internationally and nationally, there is pressure to harmonise phytosanitary measures (IPPC 2006; NFSS Implementation Committee 2009). Internationally, the International Plant Protection Convention (IPPC) oversees the development of international standards for phytosanitary measures (ISPMs) that are accepted by the WTO to underpin trade. Likewise, Australia’s domestic trade is underpinned by the interstate certification assurance (ICA) scheme involving various protocols to provide assurances to importing states that certain pest risks have been addressed following verifiable standard operating procedures, many relating to QFly. The QFly Code of Practice (CoP) is another example of harmonised pest management practices. The current Code (1997) is regarded as outdated partly because it does not make allowance for more recent measures such as maintaining areas of low pest prevalence that are typically underpinned by AWM. The Code contains detailed prescriptions, including the type of QFly monitoring traps required, their spacing specifications and thresholds for the number of flies caught per trap before corrective action is required.

In this context and following the restrictions on fenthion and dimethoate, a systems approach is seen as a suitable alternative approach to deal with QFly problems (PHA 2008; Dominiak & Ekman 2013), that is, applying two or more independent strategies that collectively ensure freedom from QFly in traded produce. An area of low pest prevalence is a promising strategy to be used in such approach (PHA 2008; Lloyd et al. 2010). International trade rules make allowance for such systems by providing broad guidance, including “ISPM 30 Establishment of areas of low pest prevalence for fruit flies” and “ISPM 35. Systems approach for pest risk management of fruit flies”. However, the finer details for system approaches to underpin international market access are still being refined (APPPC 2015).

1.3. The need for adaptive co-management

As implied earlier, pest control in agricultural systems traditionally involves a positivist technocratic mode of thinking, that is, reasoning is predominantly based on objective and absolute knowledge that is regarded as universal truths. Knowledge hierarchies exist that determine whose knowledge counts (Bickerstaff & Simmons 2004; Enticott & Wilkinson 2013). Communication with local grower and town communities often relies on top-down, generic information provision (Royce 2011). Although important, Enticott and Franklin (2009) warn that “expert” knowledge should not be privileged at the expense of local knowledge and learning processes rooted in the local socio-economic, cultural and political contexts. There is a need for a more constructivist approach, i.e. involving different knowledge systems to develop control strategies appropriate for the local context.

Adaptive co-management promises to overcome the constraints of reductionist approaches that gain...
understanding of systems by understanding the smaller composing elements. Instead, adaptive co-management deals with uncertainty and complexity in a more holistic way within a particular context through an emphasis on continual learning by drawing on different knowledge systems (Olsson et al. 2004; Berkes 2007a; Armitage, Marschke, et al. 2008; Plummer & Hashimoto 2011). Literature presents many facets associated with adaptive co-management, including acknowledgement that it is neither a precise science nor an “all-or-nothing” approach (Charles 2007). Plummer and Armitage (2007) undertook a Delphi study with 30 adaptive co-management experts and identified five key inter-related components:

- Social learning – on-going, mutual learning between diverse stakeholders across scales drawing on different knowledge systems (Schusler et al. 2003; Lebel et al. 2006; Luks & Siebenhüner 2007). It includes “learning-by-doing” that assists in identifying context-specific ways to address issues in socio-ecological systems (Janssen & Anderies 2007; Leys & Vanclay 2011).
- Communication – information flows between all partners and across scales, resulting in a shared understanding of issues, possible strategies (Plummer & Armitage 2007) and eventually working towards the same goals.
- Adaptive capacity – making adjustments in response to feedback, including the capability to design systems to withstand perturbations and adapt without losing key functionality (Folke et al. 2003; Armitage 2007).
- Shared decision-making – requires interactive participation of key stakeholders in setting priorities, formation of local institutions and other local decisions by building on multiple knowledge systems (Pretty 1995).
- Shared authority – power is shared between at least two stakeholder groups, usually but not always public and private groups (Plummer & Armitage 2007).

Adaptive co-management entails an iterative management process (Pahl–Wostl & Hare 2004; Leys & Vanclay 2011) where knowledge development processes are closely linked to on-ground decision-making and implementation processes (Luks & Siebenhüner 2007).

2. Data and research design

2.1. Research overview

The research questions addressed in this article are

- How can adaptive co-management thinking assist industry-driven FF AWM?
- How can the lessons learned from the industry-driven FF AWM case studies advance adaptive co-management theory, especially in relation to achieving market access?

The collective action and collaborative nature of AWM suggest that AWM lends itself well to adaptive co-management principles. However, there is a caveat as AWM is not an end in itself as there are other options to control QFly. In certain contexts, alternative approaches might be more appropriate, including farm-wide management or creating pest-free places of production. These options have limitations, and discussing them falls beyond this article’s scope. Moreover, collective action has several challenges, most notably free-riding and people opting out when others are not following recommended practice (Ostrom 2005). Collaboration is further challenged by heterogeneity and high numbers of resource users. Kruger (2016) investigates these challenges for AWM and they are not addressed in detail here.

2.2. Methods

This qualitative investigation is based on three case studies of where AWM is either implemented or attempted. There are few established industry-driven FF AWM programmes in Australia; hence, recent initiatives were included to better understand the challenges involved in starting these programmes. Case studies provide a key strategy for studying a phenomenon in its natural setting by including both the complexity and the influence of context (Punch 2005). This project assumed early on that regions will differ significantly, which impacts their ability to achieve collective action (Ostrom 2005). Hence, theoretical sampling of case studies was used (Eisenhardt & Graebner 2007) to achieve maximum variation of social and institutional profiles (Flyvbjerg 2006), including different demographic profiles, histories and supporting parties.

Table 1 contains an overview of the case studies. This article puts particular focus on Central Burnett as the critical case study, as it is seen as a model of industry-driven QFly management (Davidson & Davidson 2012; Hargreaves & Nimmo 2012; PHA 2008). Although some believe that replicating the development of the Central Burnett programme is impractical (Clarke et al. 2011), understanding how success came about is important, including identifying lessons learned. The Riverina – as it operates now – and Young–Harden are recently established programmes, and although it is too early to tell whether they are successful, they have traits that are helpful in this analysis.

The main data sources were 43 in-depth, semi-structured interviews with key informants and three focus groups with management groups across the three case studies, which occurred between September 2013 and March 2014. Where available, existing reports and management group meeting minutes were also investigated. Key informants were selected using purposive
Table 1. Overview of the case studies.

<table>
<thead>
<tr>
<th>Location and/or local government areas (LGAs)</th>
<th>Central Burnett</th>
<th>Riverina</th>
<th>Young–Harden</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of commercial growers (according to respondents)</td>
<td>Along the Burnett River within the North Burnett Region LGA 60 (mainly citrus)*</td>
<td>LGAs of Carrabool; Griffith; Leeton; Murrumbidgee; Narrandera Approx. 420* citrus growers; 372* grape growers; 55* prune growers 8133 ha* citrus; 7200 ha vegetables; 15,000 ha grapes (RDA 2014) 1365 ha walnuts; 885 ha prunes; 300 ha cherries; smaller plantings of other hosts (approx. 30,000 ha of horticulture) (Davidson &amp; Davidson 2012)</td>
<td>LGAs of Young and Harden Approx. 40* stonefruit growers (most grow cherries); 20* grape growers Estimated 650–700 ha* cherries; and up to 1000 ha* of wine grapes</td>
</tr>
<tr>
<td>Crops produced</td>
<td>2266 ha* citrus (mainly mandarins) 370 ha table grapes (Lloyd et al. 2010)</td>
<td>240 y/trap/day, but were reduced to 1 y/trap/day, but were reduced to 1 y/trap/day</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- *Numbers provided by local industries.
- Personal communication with Nathan Hancock, Citrus Australia Limited (12 February 2016).

...sampling (Morse et al. 2008), i.e. respondents were chosen based on their current connection with the regional QFly issue. A range of respondents were chosen to ensure a diversity of perspectives (Eisenhardt & Graebner 2007). They were identified based on their official roles and their insight in the local situation as proposed by stakeholders. They included local programme coordinators, key growers, on-farm consultants as well as representatives of programmes’ management groups, packhouses, local shire councils and local industry associations. Interview questions were broad and open-ended to allow for authentic accounts (Punch 2005). Respondents were asked about their experience with the programme, its progress and their perspectives on the local management group, communication processes used, how learning occurs and the contribution of different stakeholders. Interviews were audio-recorded and transcribed verbatim and then coded using the qualitative research analysis tool NVivo. A summary of the findings of each case study was sent to the particular case’s respondents to identify gaps or to add additional perspectives. This led to a few additional updates to the findings. Documented studies about the social aspects of FF AWM, in particular the Hawaii FF AWM programme (Mau et al. 2007), were also studied.

3. Findings

This section outlines each case study in light of aspects relevant to adaptive co-management. Table 1 provides a comparative overview of key traits of each case. Systems approach trials were initiated in both the Riverina and Young–Harden with the support of New South Wales Department of Primary Industries (NSW DPI) in 2015. As these developments occurred after the fieldwork, they are not covered in this paper.

3.1. Central Burnett (Queensland)

QFly management in Central Burnett shows spectacular results. Peak trap catches before AWM were up to 240 flies/trap/day, but were reduced to 1 fly/trap/day...
by 2010. Backyard fruit infestation levels in towns fell from 60.8% to 21.8% (Fay et al. 2011).

Current QFly management is the product of decades of refinement with incremental advances over time. A local private crop consultant became involved in the region in the late 1970s when integrated pest management was initiated to reduce dependence on chemical pest control. It led to the currently used QFly baiting and trapping practices. He was later joined by two other consultants, who initially worked for him but eventually became independent consultants, resulting in similar thinking about QFly control amongst them. Collectively, they have served around 90% of growers for over 20 years.

In the past, growers identified and co-funded QFly research projects through a local research and development levy-based body, the then Central Burnett Horticulture Committee, in conjunction with researchers from the then Queensland Department of Primary Industries (QDPI). The researchers drew on their knowledge gained from the earlier papaya fruit fly eradication in north Queensland. Research in the late 1990s proved that there was extremely low QFly infestation in commercial citrus during the winter season. This enabled a systems approach-based protocol (ICA-28) based on a “winter-window” underpinned by pre-harvest bait spraying and fruit inspection, which facilitated domestic market access to some Australian states (Lloyd et al. 2010).

When an AWM trial, co-funded between the then Horticulture Australia Limited and local growers, was introduced in 2003, local QFly behaviour was already well understood (Lloyd 2007). The Central Burnett Area-Wide Management Committee formed in 2002 and still comprises the three crop consultants, citrus and non-citrus grower representatives from grower groups, state government staff (although less involved than before), a local shire council representative and some other local stakeholders (Lloyd et al. 2010). Respondents emphasised that AWM continues because the management group drives it. Meeting minutes reflect regular activities to remind growers and town residents to support the programme.

Many research and implementation activities happened in growers’ orchards. Crop consultants and QDPI researchers assisted growers to fine-tune systems to suit individual operations. Earlier research showed that towns provided hotspots for QFly breeding. During the AWM trial, the project budget funded town treatments, lowering QFly pressure coming from towns. These successes contributed to 75% of growers agreeing to contribute financially to the programme’s continuation (Lloyd 2007). Town treatments are still funded with grower voluntary contributions.

Crop consultants are in regular contact with grower clients providing opportunity to discuss QFly-related issues. Consultants understand what is happening across the region in terms of current on-farm practices, growers’ opinions and the QFly situation. The AWM trial project team made additional efforts to strengthen communication and relationships with other local horticultural industries. Personal contact is complemented with other communications, including letters to growers, local newspaper articles, occasional radio talks and displays at community events (Lloyd 2007).

However, getting lucrative overseas markets to accept the AWM programme as a suitable phytosanitary measure has not been achieved. This is in part due to the on-going review of the QFly CoP (Fay et al. 2011). QFly-sensitive overseas markets require the region’s produce to undergo cold treatment.

### 3.2. Riverina, New South Wales

Citrus is the main industry pushing for QFly control in this extensive, multi-crop area as it hinders market access, especially for export navels. Since July 2013, NSW DPI handed on-ground QFly control to local industry. The region used to be a part of the Fruit Fly Exclusion Zone (FFEZ), a formal interstate trade zone co-funded and managed by state governments and industries (Dominiak et al. 2006). NSW DPI withdrew support after unprecedented QFly detections left the NSW FFEZ unviable (NSW DPI 2012). Moreover, a local industry body, Riverina Citrus, ceased in 2012 due to local tension about its management. It played a key role in QFly management, such as working closely with NSW DPI and local governments to manage QFly in towns. Local councils’ involvement in QFly management ceased when NSW DPI reduced its support. Respondents mentioned that town residents and growers now seem accustomed to others addressing QFly problems and lack ownership of the issue.

At present, NSW DPI support to industry includes assisting with market access applications, explaining market access regulations, offering technical information and checking a reduced trapping grid to monitor QFly levels.

Most citrus growers run low-input, part-time operations producing for the juice market. A smaller proportion is focused on lucrative, but QFly-sensitive, export markets and they are eager for the cold treatment requirement to become obsolete.

Against this backdrop, Riverina Biosecurity started in September 2012 as a new local group to oversee biosecurity issues across Riverina horticulture industries. Its current charter is to educate the local community and growers about QFly management. The ultimate aim is a grower self-funded bait spray programme across all Riverina horticulture at an estimated cost of AUS$3.75 million per year (Davidson & Davidson 2012).

The Riverina Biosecurity Executive Committee comprises of representatives from Citrus Australia,
Horticulture Australia Limited, Local Land Services, NSW DPI and three local grower association bodies. Citrus Australia provides assistance with interpreting market access protocol requirements and by lobbying government about QFly-related issues. Other horticulture industries show little interest in participating while QFly is of little economic significance.

A new part-time local QFly coordinator started engagement with key local stakeholders. A fruit fly expert was contracted to lead workshops for growers and town residents about QFly management. Some respondents felt that local knowledge is being overlooked, including the input from credible, local growers who are informally experimenting with QFly management.

3.3. Young–Harden, New South Wales

Cherry growers are the main group pushing for FF AWM as despite negligible QFly damage the pest hampers market access, including the need for cold treatment to several markets.

Between 2003 and 2006, the NSW DPI carried out QFly-related research in Young–Harden and identified potential for AWM. Progress in strengthening market access is hampered by a lack of a current QFly CoP to provide guidance about trapping methods acceptable to markets (Marte 2007). Several respondents were frustrated with the lack of information about what would satisfy prospective markets.

In October 2012, the Young and Harden shire councils and local growers formed the Fruit Fly Action Group to address QFly in response to restricted market access concerns. Most group members were chosen for their expertise, knowledge and involvement in other related networks. Local governments, in particular the Young Shire Council, play a key role in driving the group’s activities. Some group members have a good relationship with a NSW DPI QFly researcher, including formal and informal trials happening on growers’ land. On-ground progress is challenged by people with little incentive to address QFly, including various town residents, lifestyle and absentee landholders.

4. Discussion

This section is structured around the five key components of adaptive co-management (Plummer & Armitage 2007).

4.1. Social learning

AWM requires an in-depth understanding of the local QFly situation, including QFly biology within the crops involved, how and when the pest moves and what non-commercial plant hosts support it (Clarke et al. 2011). With limited state government assistance, greater onus rests on local stakeholders to carry out and fund activities that will deliver such knowledge.

The Central Burnett programme is underpinned by a thorough understanding of local QFly behaviour. Social learning occurred between crop consultants, QDPI researchers and some growers through collaborative sense-making drawing on different knowledge systems, including lessons learned elsewhere. The broader grower community shaped the local QFly-related research plans and learned by implementing some new technologies, i.e. male annihilation technique. This kind of participatory research is likely to spark discussion and learning, and often strengthens social capital (Pretty 1995). In the Riverina and Young–Harden, there are growers experimenting with QFly control measures suggesting that there is local interest in participating in learning activities. This could be drawn into more formal social learning processes, such as growers collaborating with a researcher.

In the successful Hawaii FF AWM programme, growers are seen as adult learners, that is, “autonomous, self-directed, relevance-oriented individuals who took responsibility for their learning and enjoyed cooperative learning environments” (Mau et al. 2007, p. 673). At the start, growers were required to sign agreements delineating their personal responsibilities to secure support. They were obliged to undertake hands-on learning by implementing prescribed on-farm fruit fly control techniques following an agreed schedule (Mau et al. 2007). Participatory implementation changes land managers from passive recipients of pest management advice to self-reliant, active practitioners of pest management (Pretty 1995).

Knowledge content is not the only motivator for adoption (Pretty 1995). How people perceive that knowledge has been generated and under which conditions also determine their willingness to adopt practices (Pretty 1995; Cote & Nightingale 2012). Local evidence of towns being hotspots for QFly and the success of interventions during the AWM trial convinced many Central Burnett growers to contribute financially to town treatments after the trial ceased (Lloyd 2007). A Riverina respondent said:

Whatever campaign or strategy they come up with…it has to be based on evidence from around here. [External expert] can come all he likes and say it works in [location elsewhere] and everyone goes ‘who cares?!’. It’s got to be a strategy developed here for here given the crops the growers grow here and everything else that goes on here. It will need a totally different strategy than anywhere else.

Social learning also requires attentiveness to process knowledge, such as how organisations, groups and individuals best interact and how learning processes can be optimised (Olsson et al. 2004). In the Hawaii FF AWM “word of mouth” between growers was an important pathway for adoption, and personal
communication was more effective than print materials (Vargas et al. 2008). Some Young—Harden growers pointed to the importance of encouraging local constructive conversations about QFly control and the value of learning from each other.

All three cases show the need for local stakeholders to have the opportunity to learn about the complexities and requirements around achieving market access to QFly-sensitive markets to shape their expectations.

However, social learning is not without challenges. Whilst it provides a key means for building local capacity, it offers little in addressing the motivations, such as self-interest, underlying people’s behaviour (Leeuwis 2000), when considerable proportions of the regional community have little incentive to control QFly. Individuals’ interest in social learning about a resource is strongly related to the personal risk posed and their dependence on the resource (Ruitenbeek & Cartier 2001). The reluctance of other industries to be represented on Riverina Biosecurity is a prime example. Hence, heterogeneity amongst potential participants might complicate social learning (Muro & Jeffrey 2008).

4.2. Communication

Central Burnett demonstrates that trust between different stakeholders to sustain effective communication is fundamental. Repeated meaningful interactions involving open communications foster trust relationships and facilitate a shared understanding (Lebel et al. 2006; Armitage, Plummer, et al. 2008). Both the quantity and quality of interactions are important (Measham et al. 2012). In particular, face-to-face interactions are known to foster a group identity, trust and a sense of shared purpose (Marshall 2004).

Central Burnett exhibits trust-based communication between crop consultants and their grower clients. During the trial, these trust relationships also extended to the state government researchers. In Hawaii, a shared vision and objective for fruit fly control was achieved through several “candid” discussions with key stakeholders (Mau et al. 2007). Young—Harden respondents consider the existing trust between Fruit Fly Action Group members as an asset that stems from previous non-QFly-related collaborations. In the Riverina, lack of trust developed for a range of reasons, including past tensions that led to the demise of Riverina Citrus, different on-farm objectives and various identities based on location or cultural background.

Effective communication requires both “within group” bonds and bridging “between groups” bonds (Coleman 1988; Bodin et al. 2006). Information needs to circulate within groups, e.g. horizontally within certain local commodity groups, local town communities and local government staff, as well as between vertically aligned groups, such as between government departments and industry bodies. Locally effective communication facilitates shared understanding and collective action to address the issue. Vertically, it relates to information flow with different groups providing support, e.g. for market access and for locals to stay abreast of QFly control developments.

Information brokers are required to link and facilitate effective information flow between groups. These individuals typically understand the “inner life” of different groups and the continual change that happens in them (Bodin et al. 2006). The data suggest that brokers are more prevalent towards the local level, such as Central Burnett crop consultants or Young—Harden Fruit Fly Action Group members who are involved in other industry-related groups. Information brokers between local industries and the market access negotiation arena, especially for international export, are lacking. In the Riverina, Citrus Australia plays this role to some extent. All three case studies had limited access to individuals with in-depth insight into international market access processes and many were frustrated with a lack of downward information flow from Australian Government officials who have insight into how to maximise trade opportunities.

We should be getting a lot more information from DAFF [the then Australian Department of Agriculture, Fisheries and Forestry] saying this is the sort of problems we encounter when we do negotiations… DAFF should be more proactive and coming to us and saying here are the issues we had with [certain country], here are some of the gaps we need industry to work on…such information will give us more clout when they go back and start talking trade. (Young—Harden Focus Group participant)

Likewise, feedback loops to decision-makers are often lacking about the inefficiencies caused by their decisions and lessons learned on the ground (Allan & Curtis 2005; Berkes 2007b; Folke 2007). For the case studies, this includes the impacts and costs associated with government staff turnover and the associated social memory loss; a lack of guidance about acceptable QFly control procedures for market access and complying with impractical on-farm market access requirements that are the outcome of government-to-government market access negotiations. Young—Harden respondents pointed out that meeting with government staff increases mutual understanding of the barriers and opportunities that each party faces.

4.3. Adaptive capacity

Adaptive capacity is a corollary of sustained social learning and effective communication between stakeholder groups horizontally and vertically (Armitage 2007). The Hawaii programme demonstrates that monitoring and evaluation activities throughout the programme’s lifetime, starting from programme
planning, support social learning and are crucial to ensuring that the programme remains on track. This relates to both the pest control and social components of the programme (Mau et al. 2007). Central Burnett shows that the involvement of locals, who have a long-term commitment to the industry and having readily, continued access to QFly control expertise, supports adaptive capacity. Local social learning processes together with minimal change to the management group membership result in a high level of social memory about what works and does not work in the local context (Olssson et al. 2004; Folke et al. 2005; Bodin et al. 2006). The management group meeting minutes reveal that when change is introduced to adapt, such as altering town treatments to adjust to lower grower contributions, results are closely monitored to ensure that the system does not lose functionality. It emphasises the importance of context-specific, local knowledge about QFly behaviour and control to be able to adjust to perturbations. Effective leadership is required to drive such adaptation processes (Folke et al. 2005), as is exemplified by the Central Burnett management group.

4.4. Shared decision-making

The planning of the Central Burnett AWM programme and the research leading up to it were done collaboratively between the state government researchers, crop consultants and local growers involving meetings and other forms of personal contact.

Effective social learning and negotiation are unlikely to happen if it is not embedded in well-managed processes (Leeuwis 2000). Process knowledge and skill are required for shared decision-making, as power relations can skew decisions and ultimately outcomes (Muro & Jeffrey 2008; Leys & Vanclay 2011). Deliberative processes can fail if not well facilitated (Garmendia & Stagl 2010).

This implies that members of local management groups need to be selected not only based on which organisation they represent, but also on skills, influence and personality traits. In Hawaii, management group members were selected based on whether they can commit to a shared vision, had good two-way communication skills, were flexible, had an aptitude for consensus-building and would sustain mutual trust between members (Mau et al. 2007).

Deciding on priorities in the management process invariably requires making trade-offs (Andries et al. 2004). In Young–Harden, the involvement of others who have been involved in QFly management and AWM elsewhere, as well as in market access processes, is valuable in providing guidance in prioritising activities. However, when decisions involve trade-offs between local social and pest management objectives, such as the level of QFly control and how to deal with risk contributors with little incentive to control QFly, decisions need to be negotiated locally to be rooted in the local socio-economic, cultural and political context. External “experts” should not determine these decisions (Lebel et al. 2006).

Shared decision-making also implies that growers need to feel represented on the management group to garner their support for decisions. This is more challenging in areas with fragmented grower communities, such as the Riverina, and will require additional investment in engagement and relationship-building.

4.5. Shared authority

In the biosecurity and trade context, a large power differential exists between horticulture industries and government agencies, which stems from the roles and responsibilities governments have under international and national biosecurity and market access institutions.

Adaptive co-management theory emphasises the importance of power-sharing and identifies policy and regulatory frameworks as key barriers (Plummer & Armitage 2007). In the complex market access context, there is tension between “bottom-up” and “top-down” approaches. “Top-down” or “command-and-control” dimensions are known to undermine both social learning (Gunderson & Holling 2002) and locally tailored management approaches (Prager & Vanclay 2010).

In the domestic context, there is evidence of “top-down” and “bottom-up” approaches. Examples of ICAs representing “top-down” approaches include ICA-56 Emergency Pre-harvest Baiting and Inspection Protocol for Pest Free Areas as well as others dealing with post-harvest treatments. More “bottom-up” approaches are reflected in those ICAs that have been developed involving growers, researchers (often from state governments) and funded by the national research and development body with levy funds co-matched by the Australian Government. Examples include Central Burnett’s ICA-28 and ICA-34 Pre-harvest Field Control and Inspection of Strawberries (South East Queensland produce only). Challenges include difficulty in getting all states to accept all ICAs (NFFS Implementation Committee 2009), the use of levy funds is controversial (ACIL Allen Consulting 2014) and these protocols are costly and time-consuming to develop (Clarke et al. 2011). These are some of the reasons driving harmonised protocols that can be widely applied.

Moreover, grower respondents emphasised that market access negotiation is an area where they have limited control. Sometimes, markets are lost due to changing rules in importing countries. For example, Young–Harden lost the Taiwan market at the end of 2005 after this country upgraded its quarantine requirements, despite no QFly ever detected in traded produce for over 20 years (Marte 2007). Several
respondents mentioned that some market requirements are illogical, costly and impractical. Gaining market access is also tied up in political processes, despite the WTO’s intention to have it purely science-based (Maye et al. 2012). Changing market access rules can be lengthy, expensive processes. For example, making protocols more workable on-farm could take many years when generating data are required to prove that alternative methods can sufficiently manage QFly risk.

Hence, if achieving access to particular markets is the sole objective of an AWM programme, the market access process can frustrate sustained support for all programme components. This suggests that the main focus of AWM programmes ought from the outset be to protect the local industry from current and potential increases in QFly pressure, regardless of what markets require. Market access requirements need to be seen as added components to these programmes.

Moreover, FF AWM programmes need some centralism mostly contained in the management groups for coordination and to support adaptive capacity (Bodin et al. 2006). Hendrichs et al. (2007) point out that AWM programmes often cannot function without “top-down” elements, such as regulation to secure support from risk contributors. However, these programmes can also not function without the positive support from growers and town communities and effective engagement is fundamental to complement and shape “top-down” approaches (Hendrichs et al. 2007; Vreysen et al. 2007).

Strong representation of different local groups, shared decision-making — including quality negotiation and facilitation processes — and a clear understanding of what is negotiable and what is not, are cardinal in developing well-supported AWM programmes. Representation on AWM management groups needs to allow for the views of different groups affected by the AWM programme to be considered during decision-making (Jennings & Moore 2000).

5. Conclusion

Fundamentally, adaptive co-management calls for a shift in focus from implementation only to implementation based on continual learning involving various knowledge systems (Allan & Curtis 2003; Janssen & Anderies 2007). Important here is that these activities not only increase participants’ knowledge but also build local momentum and ownership of QFly issues and, thus, create the much needed shared vision and collective knowledge base about local QFly issues. This is likely to contribute to support for such programmes, but will not guarantee support from all risk contributors.

Social learning can start with a small group of interested growers and other local stakeholders, such as crop consultants or local government staff, in conjunction with external QFly experts. The group sets learning priorities and decides how the group will function.

Adaptive co-management is only workable if it is nested in an enabling environment (Ostrom 2005). This on-ground perspective presented here suggests a number of ways in which government and industry bodies can encourage local industries to engage in such processes:

- Encourage social memory and sustained situational thinking (Plummer & Hashimoto 2011) by minimising staff turnover of officers interacting with growers.
- Give preference for research projects involving participatory approaches with growers.
- Insist on best practice engagement components in on-ground programmes, including prioritising funding for these components. In particular, make monitoring and evaluation of stakeholder engagement a requirement, such as the programme logic approach (Mau et al. 2007; Kruger 2012).
- Invest in making experts available to guide grower groups in learning processes, including continual sense-making for the local context.
- Develop and offer training packages to growers and other local stakeholders for capacity building, including basic skills in research, monitoring and evaluation and group facilitation.
- Prioritise two-way information flow between growers and government decision-makers. In particular, invest in information brokers across on-ground, state and national levels.
- Invest in people that can guide local industries through the market access process.
- Nurture a workplace culture where maintaining trust and strong relationships with grower groups is prioritised.
- Revising and releasing an updated QFly CoP and other forms of guidance is a matter of priority.

Ways forward for growers and growers groups:

- Create forums for interested growers to meet regularly, interact, learn collaboratively and take collective decisions (Muro & Jeffrey 2008). Encourage representation across groups.
- Engage others in the region that could make a contribution, e.g. packhouses, local government, chemical suppliers and gardening groups.
- Engage with experts in on-ground fruit fly management and market access.
- Find existing information, including engaging those with knowledge of the region’s QFly history and retrieving past trapping data from state government where available. Learn from other regions.
Adaptive co-management offers neither “quick fixes” nor cheap solutions to local QFly issues. Significant transaction costs can be expected at the start for capacity-building, but over the long run, this approach leads to more sustainable, locally owned systems (Pretty 1995) that stand the best chance to continually adapt to QFly-related challenges. It offers a solid foundation for additional market access requirements.

For adaptive co-management theory, this work illustrates that the influence of the market and the biosecurity institutional context presents top-down elements. Different markets lead to different on-farm objectives for QFly control, which can complicate finding a shared vision for regional QFly control. However, this is best dealt with by locals remaining focused on minimising local QFly pressure, despite market objectives and demands.

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