Cambridge Environmental Assessments

WEBFRAM 4, Objective 2

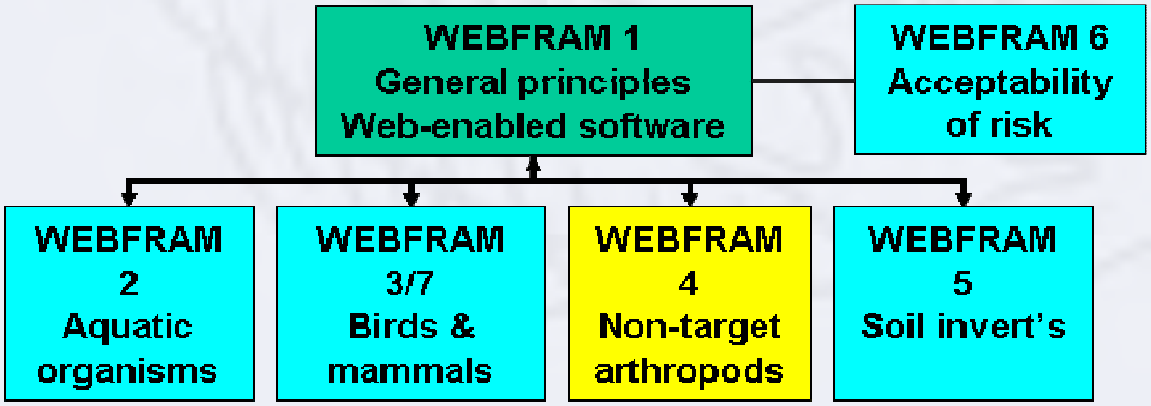
Variability and uncertainty in exposure estimates to above ground arthropods

Outline of presentation

- Scope and aims of the project, current status
- Methodology, exposure scenarios, examples of factors affecting exposure estimates
- Worked examples
- Limitations & research recommendations

WEBFRAM 4
project overview

- **Aim –** to add realism to current risk assessment procedures, characterise variability and uncertainty
- Deterministic & probabilistic approaches
- Factors influencing exposures: *application, vegetation, behavioural, ecological*
- Equations to describe relationships



Current status:

Draft submitted last week

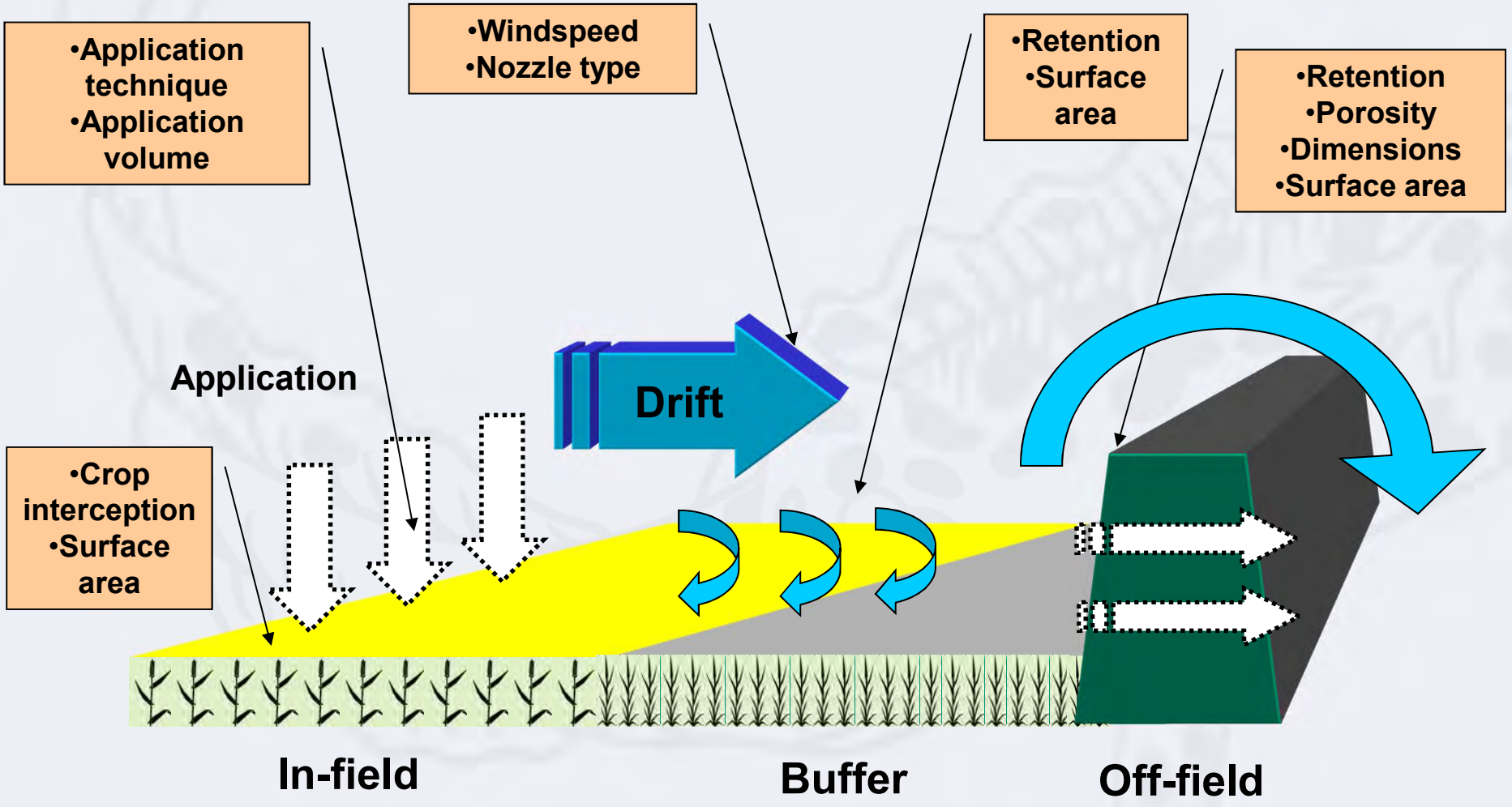
Methodology

- **Discussions at stakeholders meeting identified key influencing factors:**
  - Application factors, vegetation factors (in-field and off-field), ecological and behavioural factors
  - What are major sources of variability/uncertainty? (eg crop patchiness)
- **Prof. Paul Miller – application factors, drift cloud behaviour**
- **CEA – vegetation, interception, translation into exposure**
- ***Best available data, expert judgment, identified distributions of variables where possible***

Exposure scenarios

- **Three areas defined: in-field, buffer, off-field**
- **In-field - arable**
  - Scenarios account for application factors, crops & growth stages: cereals, OSR, 'beet, cabbage
- **In-field - orchard**
  - Apples, growth stages
- **Buffer strips & off-field areas**
  - Buffer strips (bare, grassed)
  - Off-crop vegetation (meadow, hedge)

WEBFRAM 4 arthropod exposure schematic



Factors affecting in-field exposure estimates

1. Application volume

- If > 300 L/ha, differential exposure to foliar strata (run-off)

$$\text{Exposure, } n_1 \,\&\, n_2 = \text{Exposure} \times 0.5$$

$$\text{Exposure } n_3 = \text{Exposure} + (0.5\, n_1 + 0.5\, n_2)$$

Where:

n_x = foliar strata;

Exposure = App rate x MAF

2. Crop architecture

- 4 crops, 5 growth stages
- Spray interception and foliar surface area characterised for each GS
- Based on FOCUS defaults & ADAS crop physiologist expert judgement

In-field exposure estimates

- **Similar to ESCORT 2: Application rate x MAF**
  - Also consider crop architecture, eg late cereals

$$E = \frac{\left(\frac{AR \times MAF}{Area}\right) \times Int}{FA}$$

$$E = \frac{\left(\frac{1000g\ ai/ha \times 1}{10000m^2}\right) \times 0.9}{4.5}$$

Exposure = 200 g ai/ha

Based on leaf area

…….Compare ESCORT 2: Exposure = 1000 g ai/ha

Soil exposure also easily derived – 100 g ai/ha

Factors affecting off-field exposure estimates

- **3-dimensional drift data**
- **Drift cloud behaviour** (formulation type, application volume, application pressure, nozzle type, boom height, tractor speed, wind speed)
- **Off-field vegetation architecture** (drift interception, surface area)

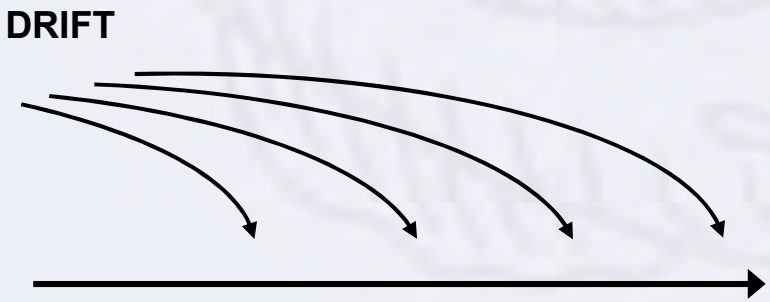
Off-field exposure: drift data

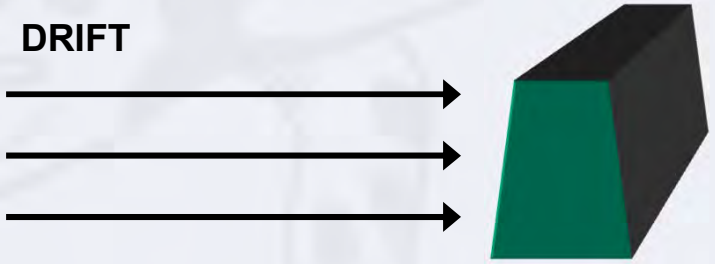
2-D 'fall-out'

Current (ESCORT 2) approach unrealistic – does not consider fraction of drift remaining in air

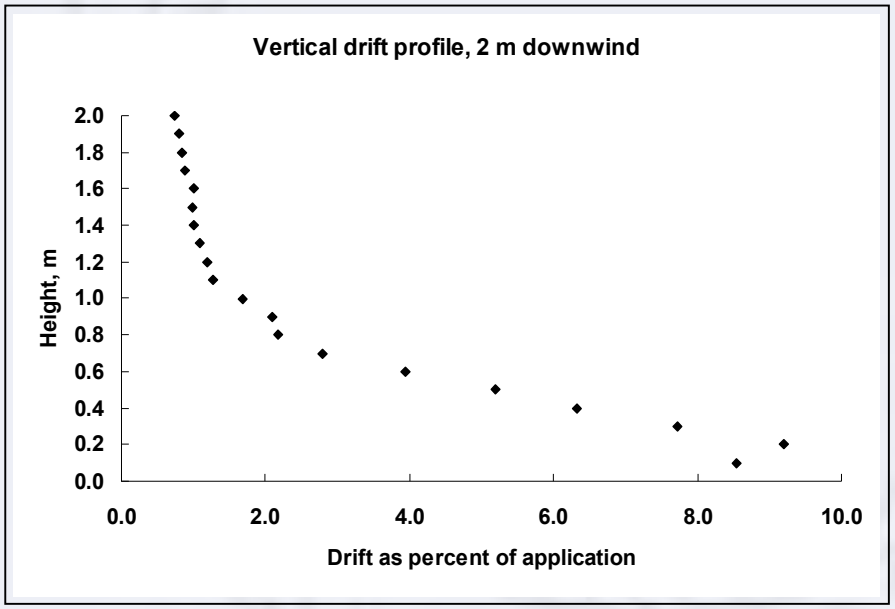
3-D cloud

Considers pesticide in air, potential interaction with off field vegetation (eg, hedge)



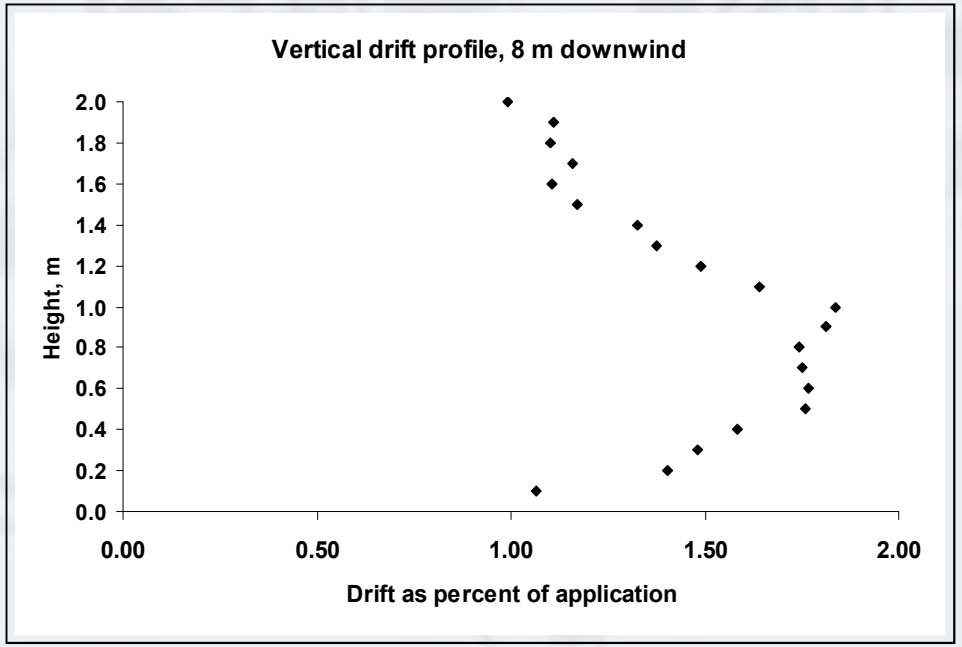


3 – dimensional drift data



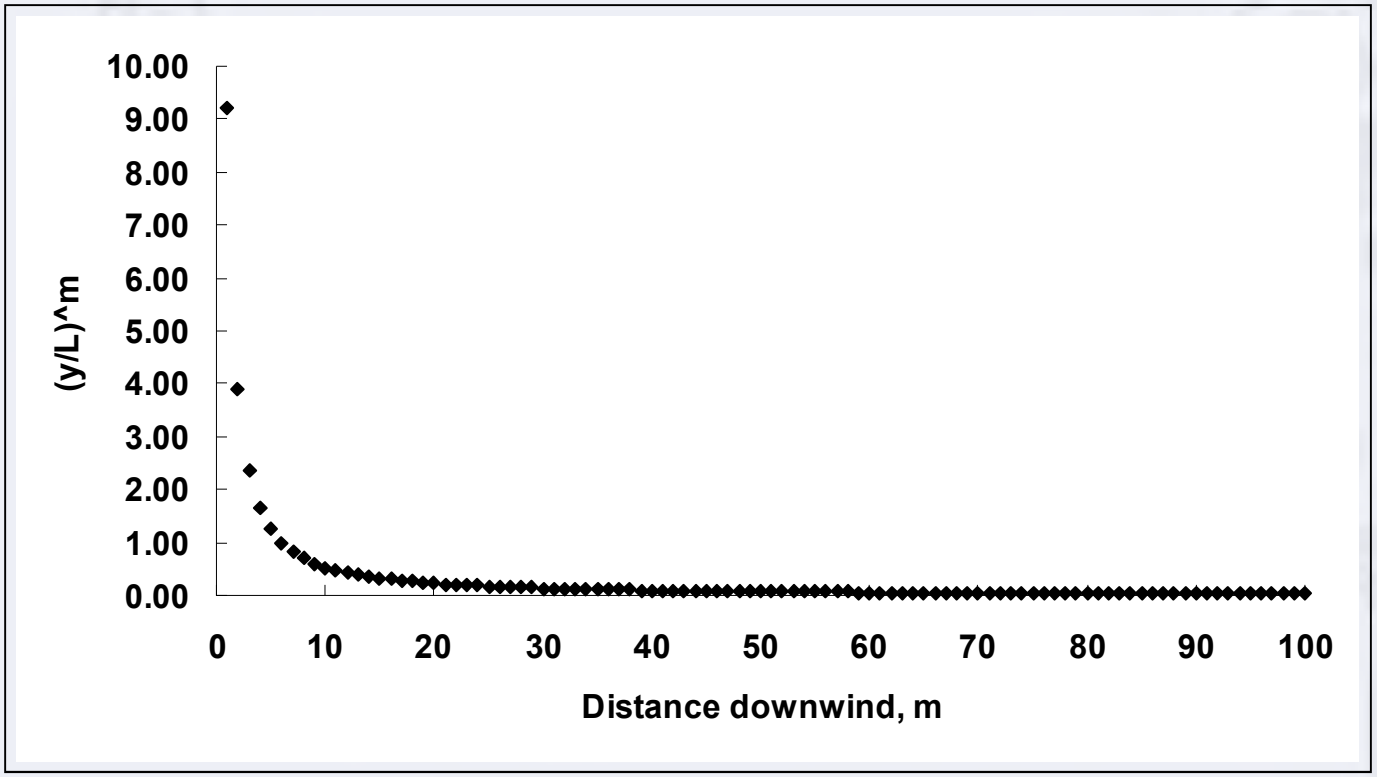
Vertical profile at 2 m downwind

Vertical profile at 8 m downwind



Drift extrapolation factor

Power law function used to extrapolate suitable drift data – used 2 m drift dataset (includes all vertical data points)



F/Fr = [y/L]^m

F = Drift flux

Fr = Reference flux

y = distance downwind

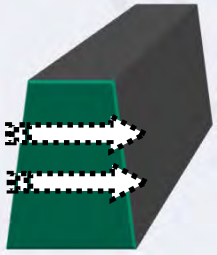
L & m = constants

Drift data is taken forward into off-field exposure scenarios…….

Off-field vegetation factors

- **Main factors are foliar interception & surface area**
- **Buffer strips: bare or grassed** – *interception and surface area fixed*
- **Off-field meadows:** *as per grassed buffer strips*
- **Hedges linked to growth stage of crop – 'early' or 'late'**

…..simple relationship: $$\text{Exposure} = \frac{\text{Drift} \times \text{Interception}}{\text{Foliar surface area}}$$



Exposure equations: buffer strips

- **Using drift data:** mean drift values over width of buffer (eg 6 m off-field) and height (here, 0.6 m)
- Incorporate interception & surface area
- Example 1000 g ai/ha application, mean drift value over 6 m = 220.66 g ai/ha

$$E = \frac{\left(220.66\text{g ai/ha} \times 1 \times 0.9\right)}{6.49}$$

Exposure = 30.6 g ai/ha *(based on leaf area)*

Exposure off-field: hedges

- **Using drift data:** for hedges, take mean vertical drift value (hedge height, eg 1.8 m) at distance downwind (here, 6 m)
- Incorporate interception & surface area
- Mean drift at 6 m to 1.8 m high = 21.017 g ai/ha total (includes all drift from 0.7-1.8 m and 10% 0.1-0.6 m)

$$E = \left(\frac{(21.017 \text{ g ai/ha} \times 1 \times 0.75)}{4.851} \right) \times 1.5$$

Exposure = 4.874 g ai/ha *(based on leaf area)*

Incorporating factors affecting drift cloud behaviour

- Equations allow end-user to change magnitude of parameters, examine effects on exposure estimates
- *Limitation: interactions between factors not characterised*
- Example: nozzle type (based on LERAP star rating 1-3)

$$D_{noz} = D_{ref} \text{ . (1-0.25 star)}$$

- Incorporated into off-field (hedge) equation:

$$E = \left(\frac{\left(21.017\text{g ai/ha} \times \left(1 - \left(0.25 \times 2\right)\right) \times 0.75\right)}{4.581} \right) \times 1.5$$

Exposure = 2.437 g ai/ha *(based on leaf area)*

Comparing off-field exposures with ESCORT 2

- **Off-field arable exposure under ESCORT 2:**

$$\text{Exposure} = 1000 \times 1 \times \left(\frac{0.0277}{10} \right) \times 5$$

Exposure = 13.850 g ai/ha, at 1 m (default for field crops)
Or,
2.850 g ai /ha at 5 m

….based on ground area

Exposures therefore largely similar for 'true' off-field areas between the two approaches. Buffer strip has higher exposure, but raises question: Are buffers intended to filter drift, or act as NTA refugia?

Departures from current assessment framework

- **In-field:**
  - Consideration of crop architecture, seasonality
- **Off-field:**
  - Two discrete off-field compartments
  - 3-D drift data
  - Drift cloud behaviour factors
  - Vegetation factors

Limitations

- **General – *lack of relevant data***
- **Orchard in-field & off-field scenarios**
  - Poorly characterised
- **Drift data**
  - An improvement but sufficient replication?
  - Only 2 m dataset used to derive all drift values
- **Ecological & behavioural considerations**
  - Beyond scope
  - Does industry have data?
  - Complex community reactions, region specific?

Research recommendations

- **Gather orchard specific exposure information**
  - Spray behaviour
  - Interception by crop
  - Drift behaviour
- **Further characterise off-field areas – all crop types**
  - Vegetation types? Interactions with drift? Habitat quality?
  - Proximity to cropped area? GIS analysis
  - Impacts of farm management? Grower survey
- **Arthropod community responses to pesticides**
  - Relate arthropod assemblages to off-field veg type/region
  - Effects of drift & repeat exposure?

Cambridge Environmental Assessments

Thank you