

Assessing Risk Through a Pesticide Impact Ranking Index PIRI

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Summary

- Purpose of PIRI
- Scope of PIRI
- Structure of PIRI
- Groundwater
- Surface Water Pathways (Erosion, Run off, Spray drift)
- Input data required
- Validation of PIRI
- Problems, Lessons Learned
- PIRI Around the World
- Main PIRI window
- Examples of PIRI windows
- Conclusions
- Acknowledgements



Purpose of PIRI

- Assess contamination potential of pesticides
 - A systematic means of improving the understanding of risk to surface and groundwater
- A (semi)quantitative basis for comparing risks



Scope of PIRI

- Ranks pesticides for their relative potential to contaminate water
 - Compares potential of pesticide contamination from different landuses within or among catchments
 - Considers migration potential to ground and surface water, but not dilution or breakdown in waterbody



Structure of PIRI

- $\text{Detriment} = \text{Value} \times \text{Toxic load} \times \text{Transport}$
 - Value (=score) of water body (Human health, Ecological etc)
 - Toxic load (amount applied \times toxicity)
 - Transport
 - Groundwater
 - Surface water (Erosion, Run off, Drift)



Groundwater

- Attenuation factor approach (Rao *et al.* 1985) = loss through degradation
- Considers
 - Retardation factor (moisture content, sorption to organic matter (K_{OC}), Organic carbon content (f_{OC}))
 - Residence time in soil profile (Recharge rate, water content, depth of soil profile, depth to groundwater, retardation factor)
 - Half life
- Preferential flow not considered



Surface Water Pathways (Erosion)

- Obtain estimate of soil loss
- Moderated by buffer zones
- Considers K_{OC} , half life, f_{OC}
- Very important for pesticides with high K_{OC}
- Requires logistic curve to give realistic estimates over the range of K_{OC}



Surface Water Pathways (Run off)

- Similar approach to OECD
- Considers
 - K_{OC} , half life, rainfall+irrigation, f_{OC}
 - Soil conditions and slope factors
 - Run off fraction
- Moderated by buffer zone
- Important pathway for low K_{OC} pesticides
- Need elapsed time to runoff event after application
 - Require work on this variable



Surface Water (Spray drift)

- Droplet size dominates
- Use tables of fraction of pesticide concentration at various distances downwind of target (currently Raupach model, but can be adapted to Ganzelmeier)
- Perform numerical integration to quantify amount received by waterbody



Input data required

- In-built data base
 - Pesticide fate data - K_{OC} , half life, LC50
- Actual, modelled or default
 - Pesticide use - Dosages, frequency, active ingredient, area, fraction farm used
 - Soil data - slope, depth, f_{OC} , cover, texture, loss
 - Rainfall/irrigation, recharge rate
 - Droplet size
 - Buffer zone width



Validation of PIRI - Case Study 1

(✓=found, ×=not detected, otherwise not tested)

Very High	High	Medium	Low	Very Low
Paraquat	Endosulfan ✓	Chlorpyrifos ✓	Phorate	2,4-D
	Trifluralin ×	Profenofos ✓	Dicofol ×	Aldicarb
	Pendimethalin ✓	Metalochlor ✓		Omethoate ×
	Diuron ✓	Prometryn ✓		Thiodicarb
	Deltamethrin ×	Fluometuron ✓		Dimethoate ×
	Oxyfluorfen ×	Parathion methyl ✓		
	Glyphosate			Amitraz ×

<i>Contingency Table</i>	<i>PIRI classified</i>	<i>PIRI not classified</i>	<i>Total</i>
<i>Detected</i>	9 (✓)	0	9
<i>Not Detected</i>	3 (×)	4 (×)	7
<i>Total</i>	12	4	16

Fisher's Exact probability: 1.92%



Validation of PIRI - Case Study 2

(✓=found, ×=not detected, otherwise not tested)

High	Medium	Low	Very Low
Benzofenap	Atrazine ✓	Maldison ✓	Bensulfuron methyl
Diuron ✓	Bromacil ✓	Cypermethrin ×	Clethodim
Endosulfan ✓	Chlorpyrifos ✓	Dicamba	Methomyl ×
Metolachlor ✓	Diazinon ✓	Propanil ×	Monocrotophos ×
Thiobencarb ✓	Molinate ✓	Methidathion ×	Primicarb
Trifluralin × (detected once)	MCPA ✓	Terbufos ×	
	Lambda cyhalothrin ×	Thiodicarb	

<i>Contingency Table</i>	<i>PIRI classified</i>	<i>PIRI not classified</i>	<i>Total</i>
<i>Detected</i>	10 (✓)	1 (✓)	11
<i>Not Detected</i>	2 (×)	6 (×)	8
<i>Total</i>	12	7	19

Fisher's Exact probability: 0.63%



Problems, Lessons Learned

- Lack of local data
 - Actual pesticide use
 - Soil loss estimates
 - Local variability
- Spray drift estimates very complex
 - poor prediction even when all parameters known
 - wind direction not known in advance
- Preferential flow cannot be modelled readily
- Wind erosion & transport of dust not modelled



PIRI Around the World

Australia: Adelaide Hills, Murray Irrig. Area, Griffith, Narrabri, Ord R., Toowoomba

Bangladesh

Burkina Faso

Chile

Costa Rica

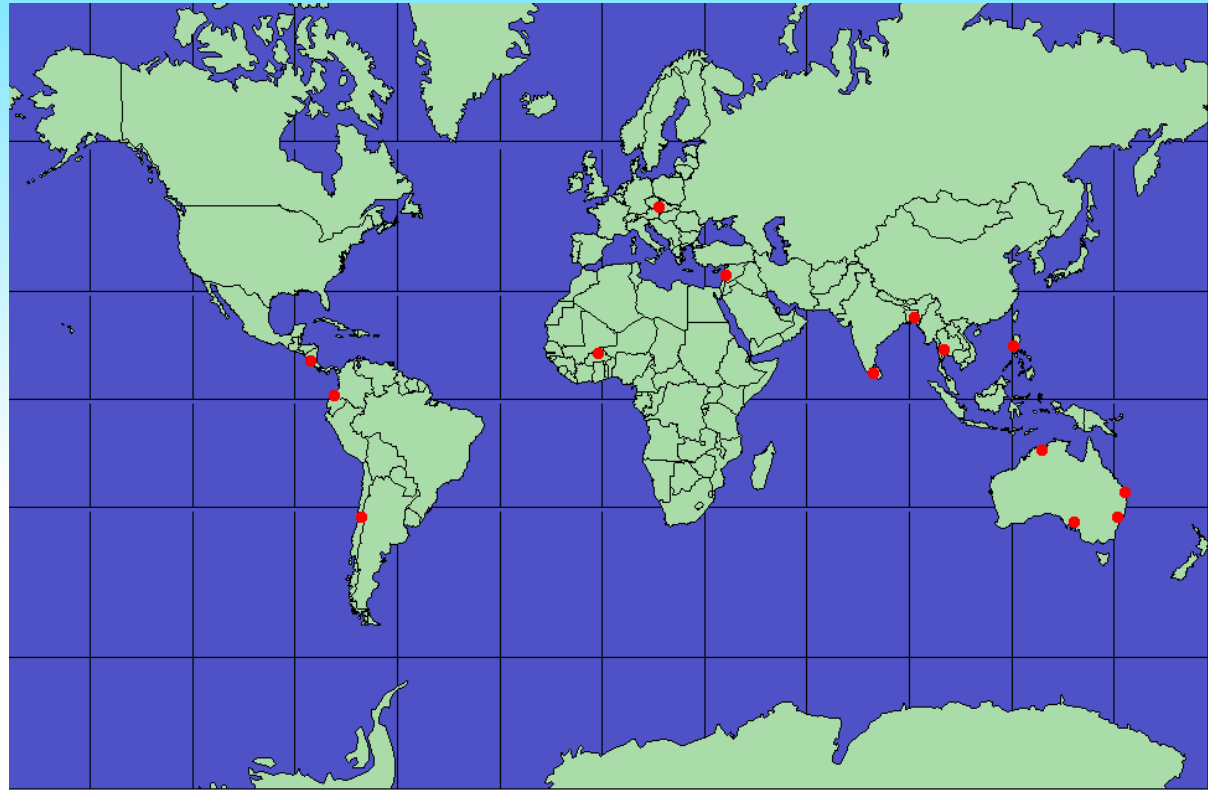
Ecuador

Philippines

Sri Lanka

Syria

Thailand



International Water Management Institute (IWMI), Colombo, for some catchments.

International Atomic Energy Agency (IAEA), Vienna, has sent trainees to Adelaide.

CSIRO
Aust. Centre for Int. Agric. Res. (ACIAR), Canberra, involved in using PIRI in Santa Cruz area

PIRI Pesticide Impact Ranking Index: Unknown

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PIRI Land Use information: Unknown

Land use

- apples
- banana
- citrus
- cotton

Select from the drop down list

Select impact options



- Surface Water, toxicity impact
- Ground Water, toxicity impact
- Surface Water, mobility impact
- Ground Water, mobility impact


Current data: D...
pesticide information: pestinfo.dft;
catchment information: catchment.det



User input for information on a crop – in this case citrus

PIRI Pesticide Impact Ranking Index: citrus



PIRI Land Use information: citrus

Land use	citrus	▼
Soil type of land use	Clay Loam	▼
Start month for period of interest (inclusive)	October	▼
End month for period of interest (inclusive)	March	▼
Toxicity, target species	LC50, Rainbow Trout	▼
Field cover	Covered Ground	▼
Usual moisture condition of soil during period of interest	Wet	▼
Soil organic matter (%)	1	
Total rainfall during period of interest (mm)	49.1	
Total irrigation during period of interest (mm)	100	
Recharge rate during period of interest (mm)	<input checked="" type="radio"/> estimate <input type="radio"/> actual 55.37	
Average minimum air temperature during period of interest (degrees C)	9.9	
Average maximum air temperature during period of interest (degrees C)	21.9	
Depth to water table (metres)		
Diameter of nearest water body (metres)	10	
Distance from edge of crop to water body (metres)	0.001	
Slope of land to water body (degrees)	<input checked="" type="radio"/> degrees <input type="radio"/> % 5	
Width of buffer zone (metres)	0	
Estimated average soil loss (tonnes/ha) during period of interest	5	
Minimum number of days from application of pesticide to first rainfall/irrigation	1	

NOTE: Recharge rate information is updated automatically with changes to soiltype, rainfall and irrigation unless set by user

For Soil type of land use, please select a value from the drop down list




Update Land Use Information	Select pesticides
Abort process	Select impact options

Current data: Directory C:/; Land use: citrus.dat; pesticide information: pestinfo.dft; application information: landuse.inf; catchment information: catchment.det



User selection of pesticides to be used on the citrus crop

PIRI Pesticide Impact Ranking Index: citrus

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PIRI Pesticides

Pesticide	6 Selected Pesticides
diuron	2,4-D amine
endosulfan	chlorpyrifos
ethefon	dimethoate
ethoprophos	endosulfan
fenamiphos	paraquat
fenbutatin oxide	fenamiphos
fenoxycarb	
fluaizifop-p-butyl	
glufosinate ammonium salt	
glyphosate	
haloxyfop	
iprodione	

These pesticides will be used for impact comparison



Update Land Use Information	Select pesticides	Update application & spray type parameters
Abort process	Select impact options	Clear Selected pesticides

Current data: Directory C:/; Land use: citrus.dat; pesticide information: pestinfo.dft; application information: landuse.inf; catchment information: catchment.det



User input for the application of pesticides to the citrus crop

P PIRI Pesticide Impact Ranking Index: citrus





File

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Tools

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PIRI Application information: citrus

Pesticide	Product application rate kg or L/ha	Fraction active ingredient	Frequency of use (x/period of interest)	Percent area treated	Spray type	Classification
2,4-D amine	1.1	0.25	1	100	Herbicide ▼	Aerially sprayed 320+-20 microns ▼
chlorpyrifos	1	0.5	1	100	Insecticide ▼	Aerially sprayed, droplet size 80+-20 microns ▼
dimethoate	2.1	0.3	1	100	Insecticide ▼	Aerially sprayed, droplet size 80+-20 microns ▼
endosulfan	4	0.3	1	100	Insecticide ▼	Aerially sprayed, droplet size 80+-20 microns ▼
paraquat	2.8	0.135	2	100	Herbicide ▼	Aerially sprayed 320+-20 microns ▼
fenamiphos	20	0.1	1	100	Insecticide ▼	Aerially sprayed, droplet size 80+-20 microns ▼

Please select a value from the drop down list

Update Land Use Information

Select pesticides

Update application & spray type parameters

Calculate pesticide risk

Abort process

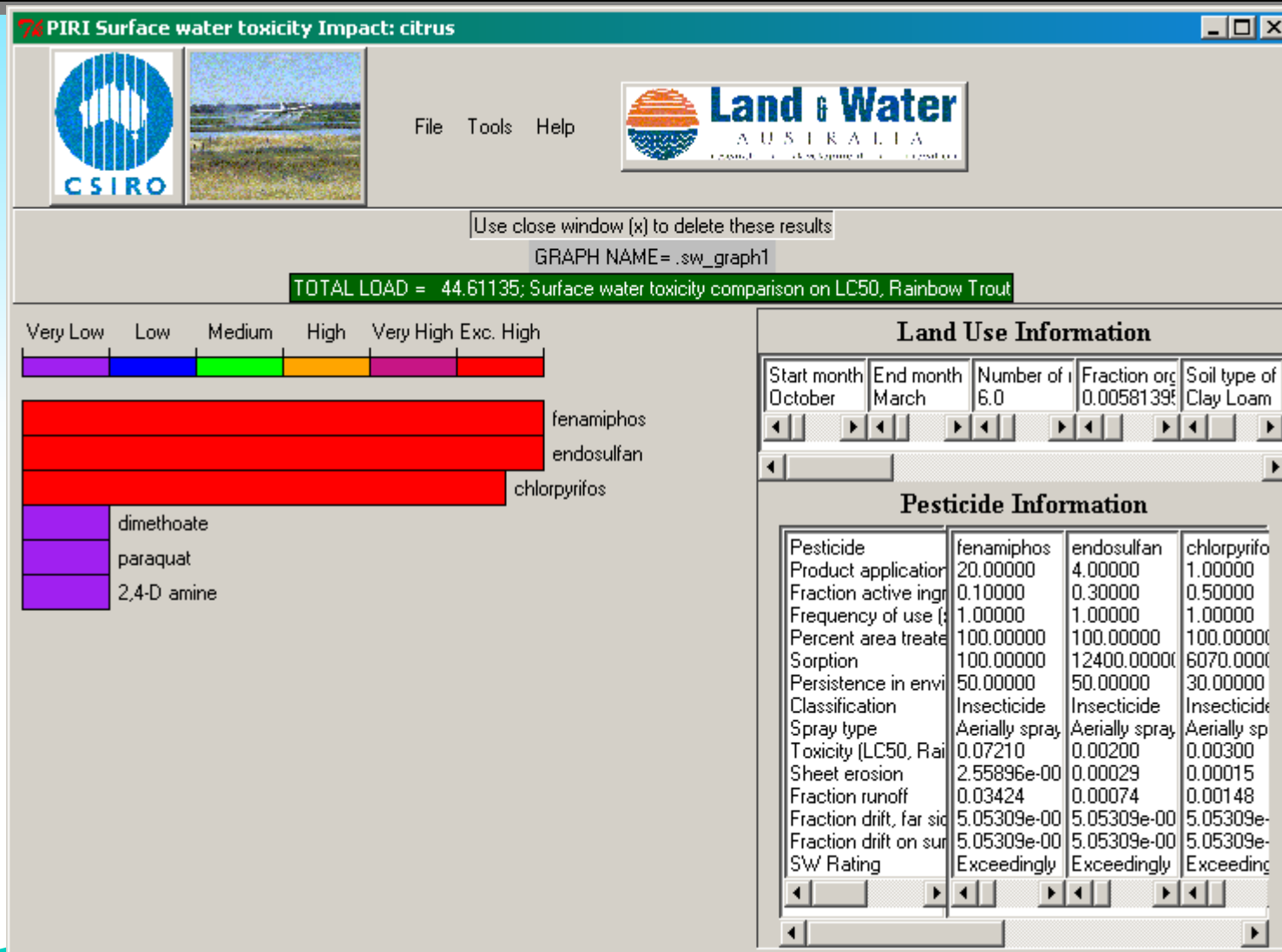
Select impact options

Current data: Directory C:/; Land use: citrus.dat; pesticide information: pestinfo.dft; application information: landuse.inf; catchment information: catchment.det




Expected risk to the surface water in the catchment area in which the citrus crop is located for the selected pesticides


- The tables can be copied to Microsoft Excel using the Tools menu




User input to enable a comparison of the total impact on the ground and surface water of the selected pesticides to be used on the citrus crop in 'First Catchment'

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PIRI Catchment information: citrus

Surface Water Value	Drinking Water	▼
Ground Water Value	Water of near drinking quality	▼
Industry	citrus	
Identifier	First Catchment	
Area of Crop (00ha = 1 sq km)	40	

For Surface Water Value, please select a value from the drop down list

Update Land Use Information

Select pesticides

Update application & spray type parameters

Calculate pesticide risk

Update catchment parameters

Calculate catchment risk

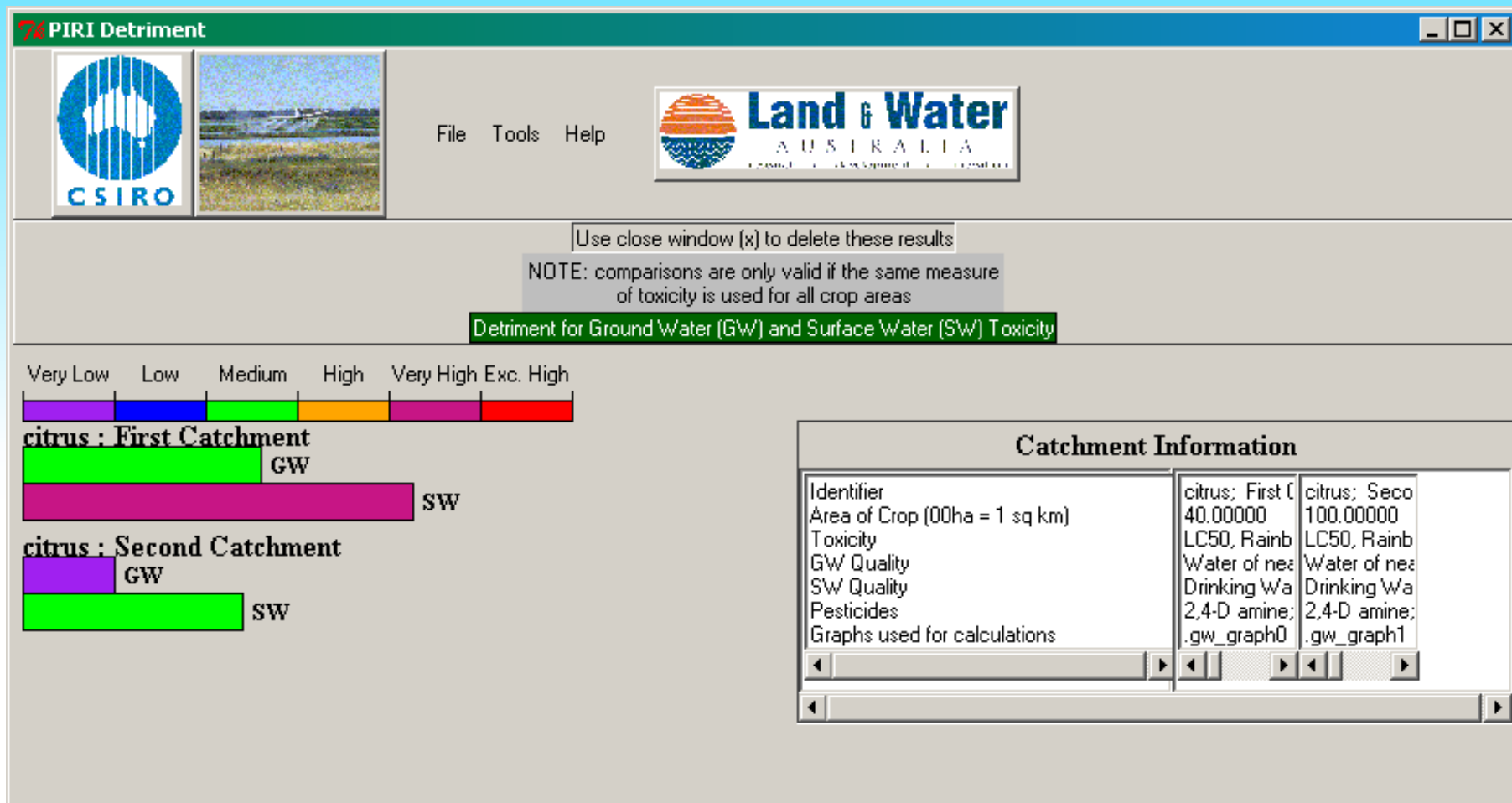
Abort process

Select impact options

Current data: Directory C:/; Land use: citrus.dat; pesticide information: pestinfo.dft; application information: landuse.inf; catchment information: catchment.det



Comparing the total impact on the ground and surface water of the pesticides to be used on the citrus crop in 'First Catchment' and 'Second Catchment'



Conclusions

- PIRI provides comparisons of
 - relative pollution potential (RPP) of pesticides in GW or SW
 - relative impact of different land uses in a catchment area or at a regional scale
- Ranks pesticides for their RPP to contaminate
 - SW transport pathways: drift, direct-runoff & atmospheric
 - GW transport pathways: depend on pesticide's K_{OC} , persistence in environment & loss through degradation
- Has an 84% success rate for predictions



Acknowledgements

- CRC for Soil and Land Management
- Land & Water Australia (formerly LWRRDC)
- CSIRO Land and Water
- CSIRO Mathematical & Information Sciences
- ACIAR and the International Atomic Energy Agency

