PRiME

Pesticide Risk Mitigation Engine

Arizona Applications

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Pesticide risk mitigation engine: PRiME

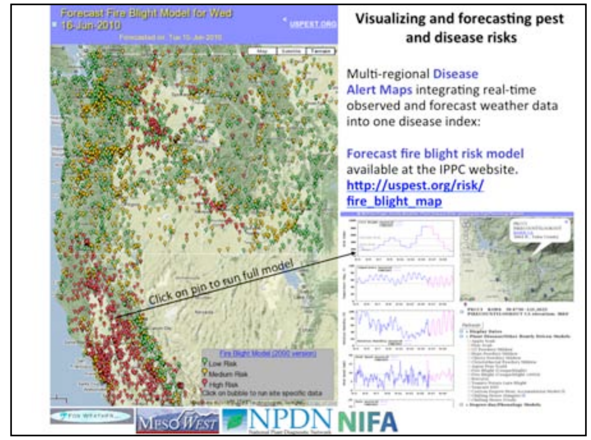
PRiME outreach to farmers

Key features

- Field-specific pesticide risk indexes
- Human health, aquatic & terrestrial environment
- Mitigation options tuned to high risk outcomes
- Supports management decisions
- **HELPS MAINTAIN DIVERSE CHEMISTRIES IN MARKETPLACE**

Complements existing education program e.g. response to IPM/water quality extension, 6mo. LaGrande, OR

Activity	%
PRE-SEASON	
Seeking information to reduce off-target losses	73
Consider sensitive sites before application	75
Installed buffers	33
Considering buffers	33
DURING SEASON	
Use of on-line weather forecasting	61
Sprayer adjustments to reduce drift	87
Seeking NRCS cost share for IPM practices	65

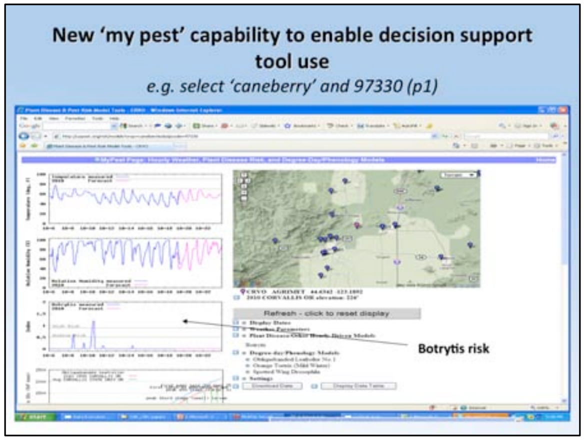


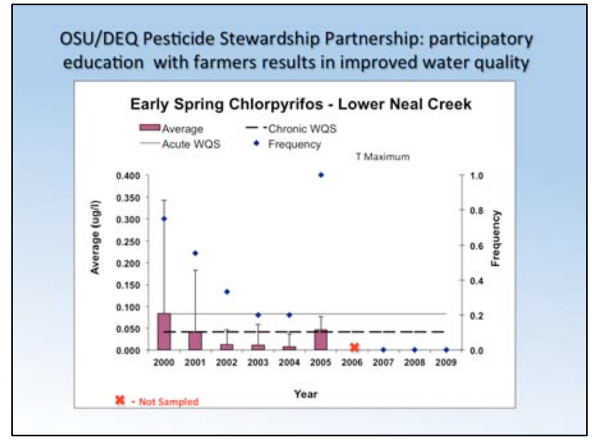
This is an example product of the http://uspest.org/wea current online system providing decision support for pest and disease management that can be replicated for numerous insects, weeds, and plant disease risk models. Shown here is the standard Cougarblight (WSU) fire blight model that is used throughout much of the country in apples and pears. The model shows tomorrows predicted risk level for infection by fire blight, Erwinia amylovora, a bacterium that overwinters in cankers on infected pear or apple trees. This map is automatically updated daily using both real time weather data and forecasts for thousands of weather stations in the Western US. A non-forecast version of this map is available and online for the full 48 state continental US. A multi-state view allows for plant biosecurity-level "disease risk alerts", which can be focused upon single states or growing regions as needed. Clicking on a pin runs the model for that particular weather station, providing more detail and longer-range results needed for on-the-ground IPM decision making. This integration represents an improvement from previous risk alert maps and is a step towards the objective of terrain-sensitive disease risk mapping that is gridded over area-wide growing regions at 800m – plus resolution.

AFRI Plant Biosecurity project: 2010-85605-20544, "Automated mesoscale pest risk forecast maps for agricultural production and potential plant biosecurity threats", Oregon State University, lead institution.

"I grant permission to USDA/NIFA to use this information for communicating about this project." -

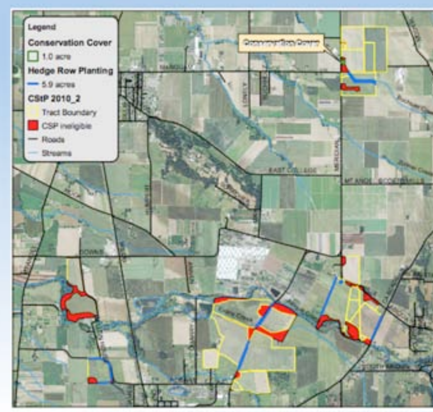
Leonard Coop, PI





Lower Neal Creek (Hood Watershed) Chlorpyrifos results since 2000 – shows the generally (but not linear) decreasing trends over time. The 2005 uptick was quickly reversed, but I should note we saw the same increase in the Mill Creek (The Dalles) watershed in 2005 after 3 yrs of declines ….so, it could have been a year with high pest concerns (Jeff may recall).

Watershed scale IPM planning,
e.g. Pudding watershed, fall 2010 (hops, winegrape, corn)



Over 1,000 acres being provided with habitat and resources for natural enemies since fall workshops

Initial exploration of risk assessment tools to evaluate the benefits of B.t. cotton in Australia

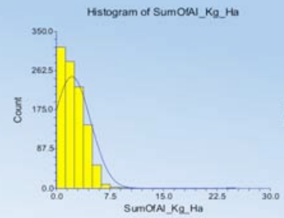
Use of *Environmental Impact Quotient* to compare pesticide health & environmental risks in conventional and transgenic cotton

Mass application rates and spray frequencies in *B.t.* and traditional cotton

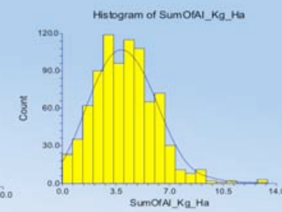
	Traditional cotton (853 fields)			*B.t.* cotton (1032 fields)		
	Mean	S.E.	Range	Mean	S.E.	Range
AI (kg/ha)	**4.10**	0.01	0-13.4	**2.38**	0.06	0-25.1
Formulated pesticide (kg/ha)	**15.57**	0.26	0-78.4	**8.58**	0.19	0-55.0

	Traditional cotton (853 fields)			*B.t.* cotton (1032 fields)		
	Mean	S.E.	Range	Mean	S.E.	Range
Number sprays/crop	**11.04**	0.12	1-27	**6.62**	0.11	1-17

Average Pesticide Use/Grower (Kg/ha)



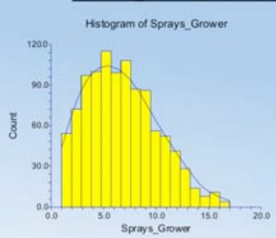
Bt-Cotton



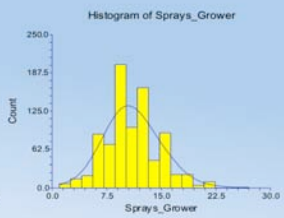
Traditional Cotton

Most commodities world-wide are treated with <1 Kg/Ha/year

Average Number of Sprays/Grower



Bt-Cotton



Traditional Cotton

A method to measure pesticide environmental impact

Rating system used to develop environmental impact quotient (EIQ Kovach et al., 1992) (1, least toxic, 5, most harmful)

- **Mode of action**: non-systemic (1), all herbicides (1), systemic (3)
- **Acute dermal LD50 for rabbits/rats (mg/kg)**: >2000 (1), 200-2000 (3), <1-200 (5)
- **Long-term health effects**: little or none (1), possible (3), definite (5)
- **Plant surface residue half-life**: 1-2 weeks (1), 2-4 weeks (3), >4 weeks (5)
- **Soil residue half life**: <30 d (1), 30-100 d (3), >100 d (5)
- **Toxicity to fish (96h LC50)**: >10 ppm (1), 1-10 ppm (3), <1 ppm (5)
- **Toxicity to birds (8-day LC50)**: >1000ppm (1), 100-1000 ppm (3), 1-100 ppm (5)
- **Toxicity to bees**: rel. non-toxic (1), mod. toxic (3), highly toxic (5)
- **Toxicity to beneficials**: low impact (1), moderate impact (3) severe impact (5)
- **Groundwater and run-off potential**: small (1), medium (3), large (5)

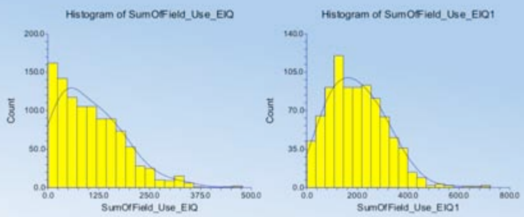
Calculating the EIQ

- **EIQ** = *[C[(DT*5)+(DT*P)]+[C*((S+P)/2*SY)+(L)]+[(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]]/3*
- *DT= dermal toxicity, C= chronic toxicity, SY=systemicity, F= fish toxicity, L=leaching potential, R= surface loss potential, D=bird toxicity, S= soil half life, Z=bee toxicity, B=beneficial arthropod toxicity, P=plant surface half life*
- **EIQ (field use rating)**= *EIQ *%AI*rate*

Environmental impact quotient, based on Kovach *et al.* (1992)

Quotient	Traditional cotton (853 fields)			*Bt* cotton (1032 fields)		
	Mean	*S.E.*	*Range*	*Mean*	*S.E.*	*Range*
Field EIQ	**199.2**	3.87	0-723.7	**106.2**	2.51	0-478.2
Farm worker	**191.0**	3.87	0-747.0	**101.3**	2.44	0-438.1
Consumer	**29.5**	0.58	0-112.1	**15.8**	0.37	0-69.3
Ecological	**377.1**	7.31	0-1374.3	**201.6**	4.81	0-1124.5
Aquatic/fish	**92.2**	1.90	0-329.4	**45.0**	1.22	0-322.7
Bird	**108.6**	2.40	0-475.6	**57.4**	1.54	0-312.1
Bee	**62.3**	1.21	0-219.2	**35.4**	0.84	0-333.6
Predator	**114.1**	2.10	0-385.0	**63.6**	1.46	0-368.5
Ground water	**8.0**	0.15	0-27.3	**4.28**	0.01	0-23.5
Terrestrial	**284.9**	5.46	0-1045.0	**156.6**	3.64	0-801.8
Picker	**32.1**	0.65	0-128.3	**18.5**	0.46	0-100.0
Applicator	**137.9**	2.90	0-564.9	**71.7**	1.81	0-343.0

Field Use EIQ



Bt-Cotton **Traditional Cotton**

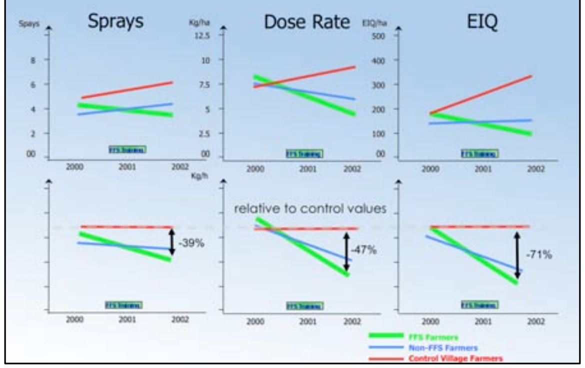
Interesting, but is the EIQ scientifically based, and can statements of benefits be supported?

Review of the EIQ

http://www.vegetableipmasia.org/docs/Workshop/Report_of_the_International_EIQ_meeting.pdf

FFS Impact on Insecticide Use

Pakistan Impact Assessment Study – 190 farmers



EIQ Review

- **Technical issues**
  - Serious flaws in initial concepts, structure, relevance, scope for interpretation/calibration
- **Practical/operational issues**
  - Data challenges (user information, chemical data, database completeness and accuracy)
- **Applications**
  - Impact assessment> training> pesticide selection
- Scope for development of a science-based risk assessment and mitigation tool that addresses these limitations

PRiME
Pesticide Risk Mitigation Engine

- Provides producers with an opportunity to look at site-specific risks for their farm and manage appropriately to minimize those risks, especially in sensitive areas.
- If riskier pesticide uses are appropriately mitigated on a site specific basis they can continue to be part of an overall IPM strategy that balances efficacy, economics, and environmental risk.

Risk indicators included in PRiME

- Terrestrial Environment
  - Birds – acute
  - Birds – chronic
  - Small mammal acute
  - Earthworm acute
  - Pollinator acute
- Aquatic Environment
  - Crustacea – acute
  - Algae – acute
  - Fish – chronic
- Human safety
  - Farm-worker – dermal
  - Bystander – inhalation
  - Consumer – food residues
  - VOC production (California)
- In various planning stages
  - IPM/bio-control
  - Resistance management
  - Ground-water leaching

- Detailed 'white paper' available for each index
- This presentation will not provide a full description but give examples of important and novel features NOT typically found in other systems.

Some of the pesticide indicators reviewed/analysed

- AARI and ATRI
- APPLES (Environment Canada)
- BRI
- Danish Hasse Diagram
- Danish Load Index
- Dutch Yardstick
- EcoRR
- EIQ
- EPRIP
- ERIP
- ERS
- ESCORT_2
- FA
- IPEST
- Norwegian indicator
- PEAS & MATF (Cons. Union)
- PEI relative ranking (Dunn)
- p-EMA
- PERI
- PESTDECIDE
- POCER
- SCRAM
- Stemilt growers
- SYNOPS
- SyPEP
- U. California HPPRS
- WWF

How does PRiME improve on these:

1) PRiME is a risk-based – not a hazard-based indicator

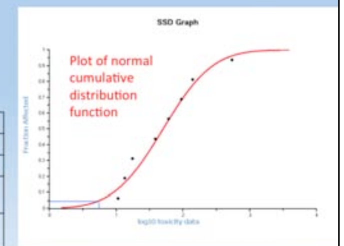
- **hazard:** inherent property of an agent or situation capable of having adverse effects on something. Hence, the substance, agent, source of energy, or situation having that property
- **risk**: the probability of adverse effects caused under specified circumstances by an agent in an organism, a population, or an ecological system

2) PRiME uses available toxicity data fully and addresses inter-species differences in toxicological susceptibility

- No binning of toxicity data (e.g. 1-10; 10-100 etc...) – this leads to early loss of information
- Broad acceptance of toxicity data – more flexibility on test protocols and inability to access source data
- ... But: Strategy for identifying outliers/potential errors
- Different but unbiased strategies for pesticides with large and small databases
- Guiding principle: Use of Species Sensitivity Distributions (SSDs)

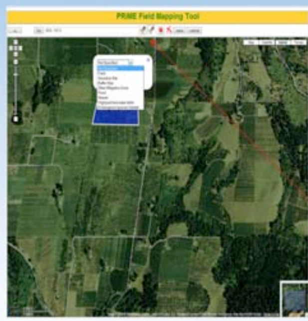
Example of HC_5 determination (Hazardous concentration at the 5% tail of the SSD)

Species	Toxicity (ppb)
Chanos chanos	38.7
Gambusia affinis	543
Gasterosteus aculeatus	10.7
Lepomis cyanellus	60.4
Lepomis macrochirus	17.5
Oncorhynchus mykiss	13.5
Pimephales promelas	140
Tilapia nilotica	94.3



LL HC5	0.719174472
HC5	5.099081571
UL HC5	14.06414958

3) PRiME Includes local conditions to produce an individualised risk score.



e.g. Field Mapping

Users map and name their block using Google Earth.

PRiME automatically retrieves site-specific soils data from NRCS.

In addition to mapping cropping areas, users map sensitive areas, mitigation zones and/or areas at high risk for runoff.

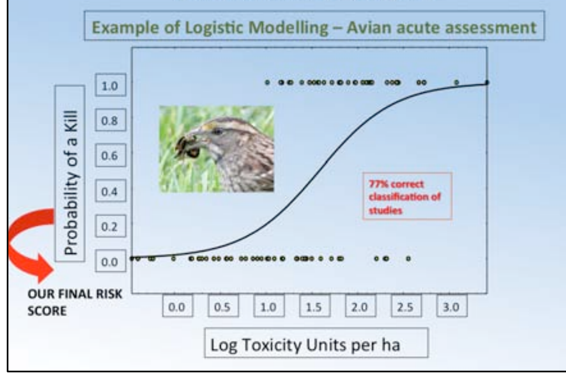
4) PRiME adjusts each risk score separately for differing application methodology

Equipment choice and application methodology converted to:
Use Pattern Adjustment Factors
to adjust risk – expert opinion

e.g. Avian UPAFs for spray applications

Pre-Plant or Pre-Emergence			Post-Emergence			Aerial application
Surface or unspecified	Incorporated	Tarped	Ground Foliar Applied	Surface soil-applied between rows	Incorporated soil-applied between rows	
0.5	0.1	0	1	0.5	0.1	1

5a) Where possible, PRiME calibrates estimated risk scores against documented field impacts.



Explain principle of logistic regression.

5b) Where it is not possible to calibrate against actual field impacts, PRiME adopts a solution closer to regulatory assessments ...

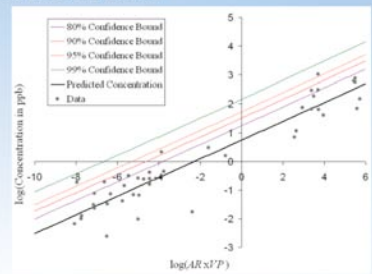
E.g. Risk to human health

- **US EPA's Reference Concentration (RfC) or Human Equivalent Concentration (HEC) or California DPR's Screening Levels used to calculate a Reference Exposure Level (REL) for a 1-year-old**

$$\text{REL}\ (\mu g/m^3) = \frac{\text{RfD (mg/kg-day)} \times \text{BW(kg)} \times 10^3\ \mu g/mg}{\text{BR (m}^3\text{/day)}} \times 100\%$$

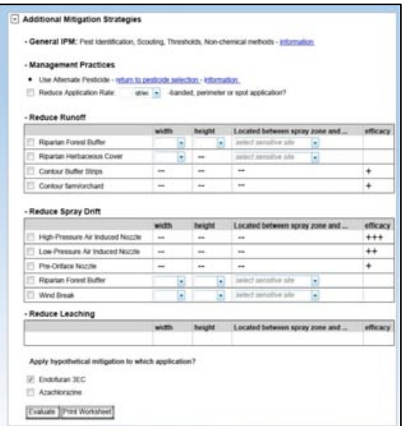
... But exposure models use all available empirical sources

e.g. Regression of California air monitoring data against Application Rate and Vapour Pressure



6) PRiME incorporates possible mitigation measures and assesses their ability to reduce actual risk to the environment and human health.

How: PRiME recalculates risk comparing the effects of hypothetical mitigation.


Additional Mitigation Strategies

- General IPM: Pest Identification, Scouting, Thresholds, Non-chemical methods - information

- Management Practices

- Use Alternate Pesticide - return to pesticide selection - information.
- Reduce Application Rate -banded, perimeter or spot application?

- Reduce Runoff

	width	height	Located between spray zone and ...	efficacy
Riparian Forest Buffer			select sensitive site	
Riparian Herbaceous Cover		--	select sensitive site	
Contour Buffer Strips	--	--	--	+
Contour farm/orchard	--	--	--	+

- Reduce Spray Drift

	width	height	Located between spray zone and ...	efficacy
High-Pressure Air Induced Nozzle	--	--	--	+++
Low-Pressure Air Induced Nozzle	--	--	--	++
Pre-Orifice Nozzle	--	--	--	+
Riparian Forest Buffer			select sensitive site	
Wind Break			select sensitive site	

- Reduce Leaching

	width	height	Located between spray zone and ...	efficacy

Apply hypothetical mitigation to which application?

- [x] Endofuran 3EC
- [ ] Azachlorazine

Evaluate | Print Worksheet

PRiME – Other Features

- Comprehensive and defensible set of indices using best available and up to date science.
- Online and user friendly (even if complex calculations in background)
- High level of data protection for users.
- Based on field-level application impacts – with possibility of aggregation
- Sustainable financial plan to ensure continued functionality and up-to-date databases.
- Quality of Service (e.g. short response time)

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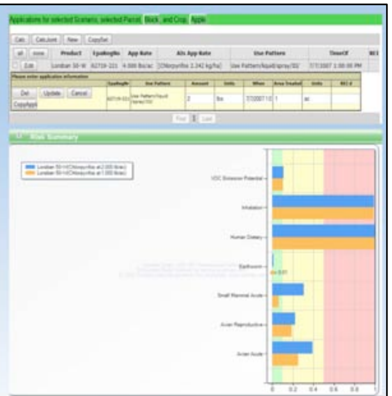
Simple graphical output:

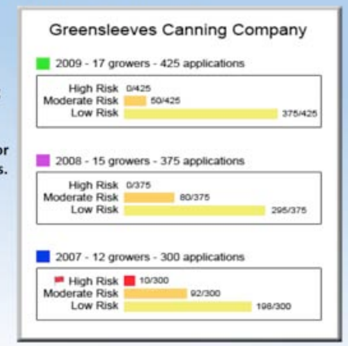
E.g. Risk summary for Lorsban 50W (chlorpyrifos) applied at 4 lbs. per acre vs. 2 lbs. per acre.



Aggregation strategies that do not 'average away' high risk situations.

E.g. PRiME could* display a summary showing the total number of applications falling into each risk category in a given year, allowing program managers to report progress or compare program participants.

***Still under discussion**



Sum of nspray	Column Labels				
Row Labels	**1995**	**1996**	**2005**	**2010**	**Grand Total**
Acephate	28	14	30		72
Acetamiprid			21	2	23
Amitraz		9			9
Azinphos-methyl	1				1
Bifenthrin		1	2	6	9
Chlorpyrifos	13	25	20	3	61
Cyfluthrin	13	10	11	1	35
Cyhalothrin, lambda	3	1	1		5
Cypermethrin, zeta			3		3
Dicofol			2		2
Dimethoate		2			2
Disulfoton	13	24	25	7	69
Endosulfan			5		5
Esfenvalerate			2	1	3
Etoxazole	19	5	8		32
Fenpropathrin	4	2			6
Imidacloprid			2		2
Indoxacarb, S-isomer	8	4	2		14
Methamidophos		2			2
Methidathion	4	5	1		10
Methomyl		1	4		5
Naled	1				1
Oxamyl	1	2	10		13
Oxydemeton-methyl		2			2
Phorate				3	3
Profenofos	3	1			4
Pyriproxyfen		7	6	5	18
Grand Total	**111**	**117**	**155**	**28**	**411**

With help from Arizona IPM program

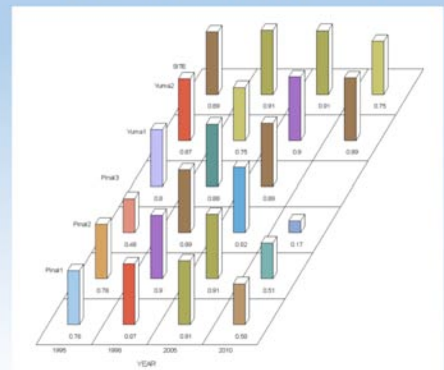
Initial selection of a small number of blocks representing historical trends

Pesticide, rate and timing recorded

Some treatments were to parts of larger blocks: later analysis will account for this

This analysis: 'realistic worst case'

Cumulative Means over all Risk Indices



Average of mnScore Index	1995	1996	2005	2010
Aquatic Algae	0.08	0.17	0.29	0.08
Aquatic Invertebrates	0.98	0.99	1.00	0.78
Avian Acute	0.88	0.94	1.00	0.52
Avian Reproductive	0.83	0.88	0.97	0.51
Earthworm	0.49	0.99	1.00	0.79
Fish Chronic	1.00	1.00	1.00	0.75
Inhalation	1.00	0.97	1.00	0.50
Small Mammal Acute	0.86	0.98	1.00	0.70
Grand Total	**0.76**	**0.87**	**0.91**	**0.58**

Initial assessment

- Risks greatly reduced in recent years
- A combination of *B.t.* cotton, IPM program, IRM and new chemistries
- Some sites now exhibit low risk: could be the majority
- More variation than in the past
- Can support science-based measurements that argue for chemistries and labels to be retained, to contribute to IRM
- Scope for a more complete assessment that takes into account, chemistry, number and area of applications