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Regulating Ag Innovation without Killing it

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Pennycress --as harvestable cover crop

Winter cover crop

Oilseed harvested in spring

No-till soybeans planted after harvest

Target 30 million acres

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Pennycress domestication & “canola moment”

- Lower seed fiber
- Lower glucosinolates
- Lower erucid acid

- Increase yield
- Earlier maturity
- Reduced shattering

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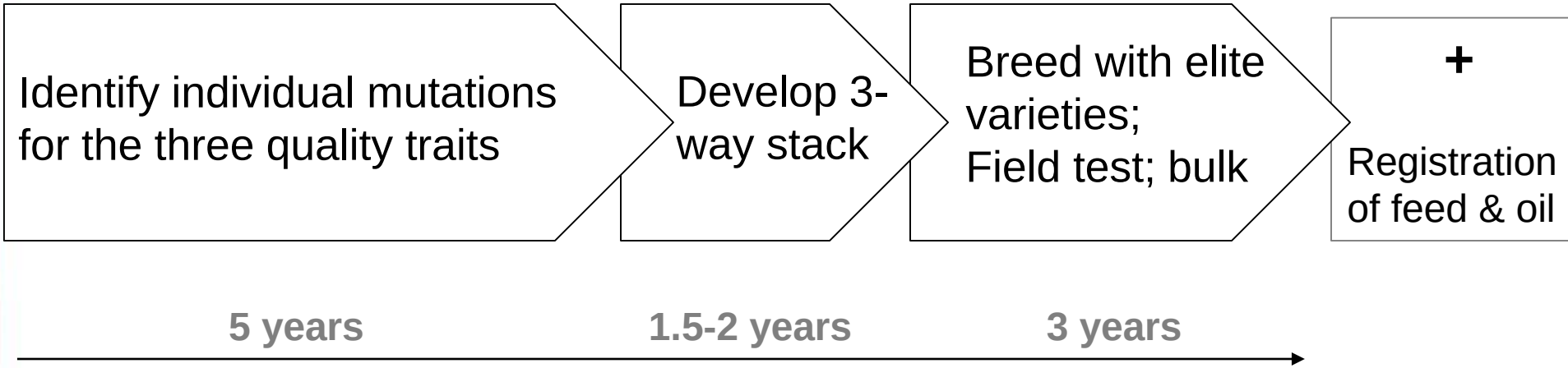
Potential development path

Conventional Breeding?



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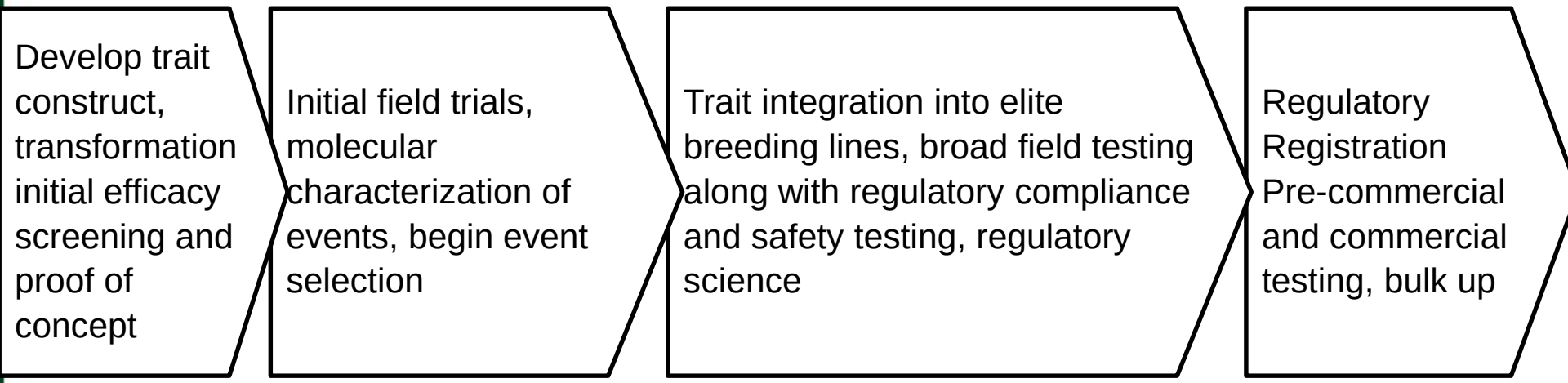
Potential development path

Genetic Engineering?



±10 years

+ registration of feed and oil

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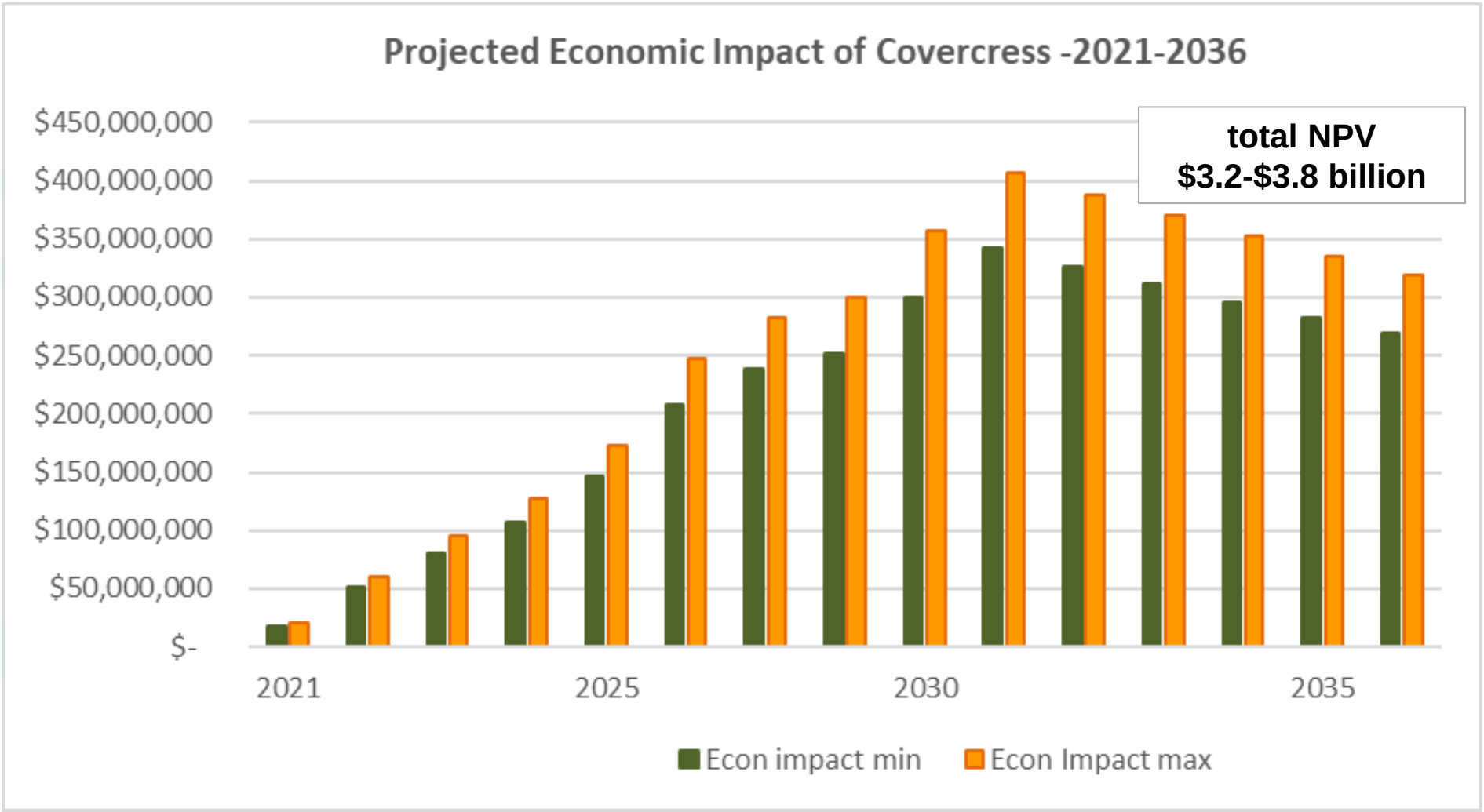
The economics of editing:

CoverCress
The cover crop that pays.

	DISCOVERY Gene/Trait Identification	PHASE I Proof Of Concept	PHASE II Early Development	PHASE III Advanced Development	PHASE IV Pre-launch
	2013-14: First wild accessions	**Identify desired traits, design editing cassete**	**Perform edits, early field trials**	**Extensive field trials**	**2020: Preparing for product launch**
	Sample plants gathered from the wild. Collaboration with universities & USDA breeding programs	Three traits: --Seed coat --Low glucosinolates --Low erucic acid	Mulitplex editing allowed modification of all traits at one time. Development of transformation	AIR Breeding edited varieties with elite varieties	Field work continues. Seed bulk up Meal esting and
	Arabidopsis, canola, etc.	Parallel breeding for agronomics	Parallel breeding for agronomics	Parallel breeding for agronomics	
	Funding Rounds:	**2015: $2.5 M Series A**	**2017: $2.4 M Venture Capital**	**2018: $2.0 M Venture Capital**	**Total: $6.9 M**

6-7 years development & less than $7 million in spending

Potential economic impact of innovation



Author calculations

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The impact of regulation

Emerging Regulatory Environment for Genome Editing

	Type of Edit			
possible via conventional breeding?	yes	yes	yes	no
nucleic acid template?	no	short	long	yes
"Foreign" DNA	no	no	no	yes
Selected Countries	SDN-1	SDN-2	SDN-3 cisgenic	SDN-3 transgenic
Argentina	Not GE	Not GE	Likely not GE	GE
Brazil	Not GE	Likely not GE	Likely not GE	GE
US	Not GE	Depends	Depends	Depends
Australia	Not GE	GE	GE	GE
Japan (Environment)	Not GE	Not GE	Not GE	GE
Japan (Health)	Not GE	Not GE	GE	GE
EU	GE	GE	GE	GE

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The costs of regulation

- Bureaucratic cost
- Compliance cost
- Opportunity costs

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The case for **efficient regulation**

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Emerging regulatory environment & impact

Emerging Regulatory Environment for Genome Editing

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Brazil	Not GE	Likely not GE	Likely not GE	GE
US	Not GE	Depends	Depends	Depends
Australia	Not GE	GE	GE	GE
Japan (Environment)	Not GE	Not GE	Not GE	GE
Japan (Health)	Not GE	Not GE	GE	GE
EU	GE	GE	GE	GE

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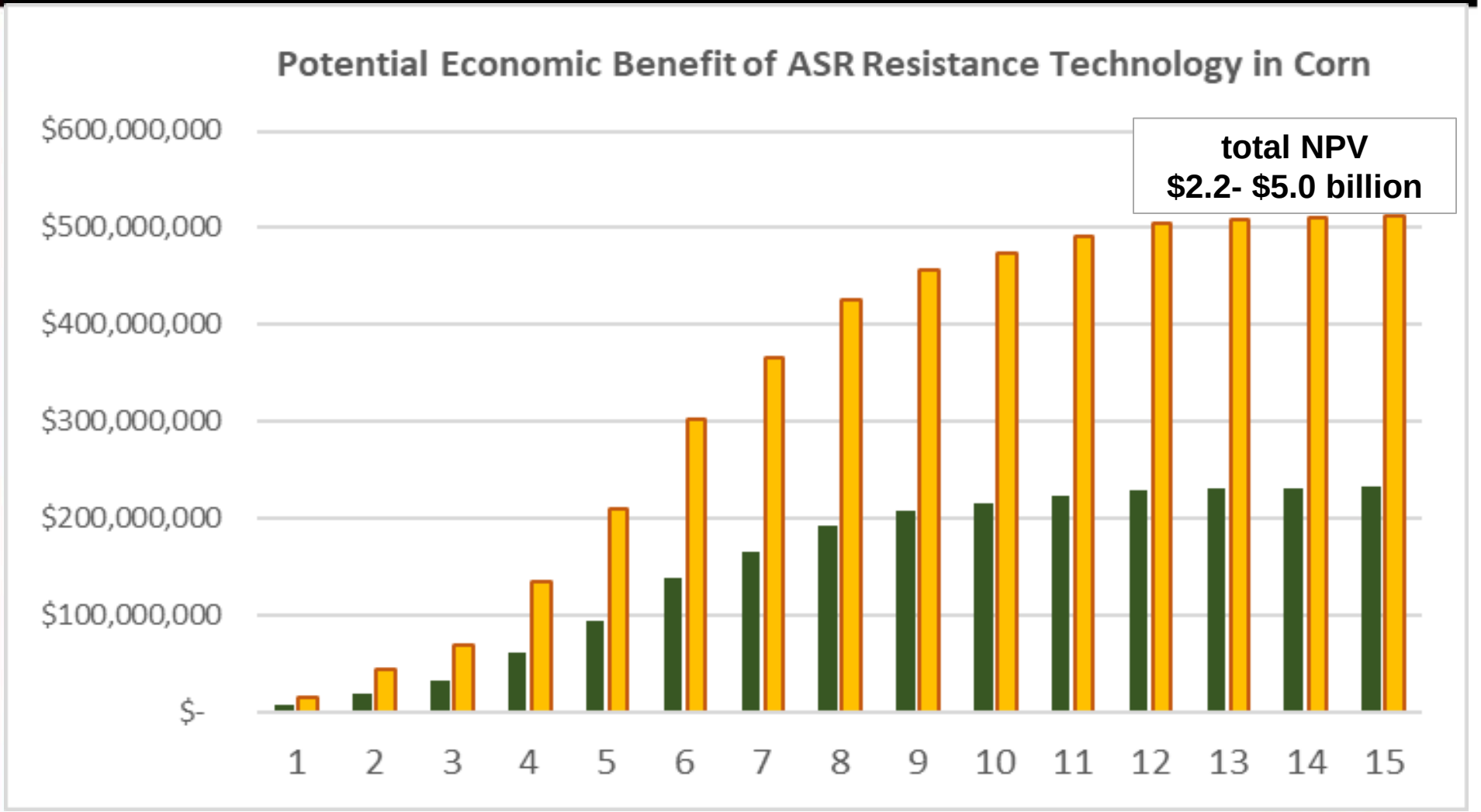
Impact of regulation on other genome editing innovation



Author calculations

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Concluding comments

- Agricultural innovation creates significant economic benefits for society
- Excessive, uncertain, complex regulations can undercut innovation and limit the potential benefits
- Foregone economic benefits are often the largest part of regulatory costs
- To maximize the benefits of agricultural innovation, regulations must be risk-proportional & efficient

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