Simplified **cause-and-effect flowchart**

(From Patla and Keinath 2005)

Inhabit a

- Wetlan
- Riparia
- Meado
- Rangel
- Forests

Numerou

- Roads
- ✓ Livesto
- Campi
- Reserv
- Stocke
- Water
- Skidde
- Fire Suppression
- Loss of Large Woody Mat.

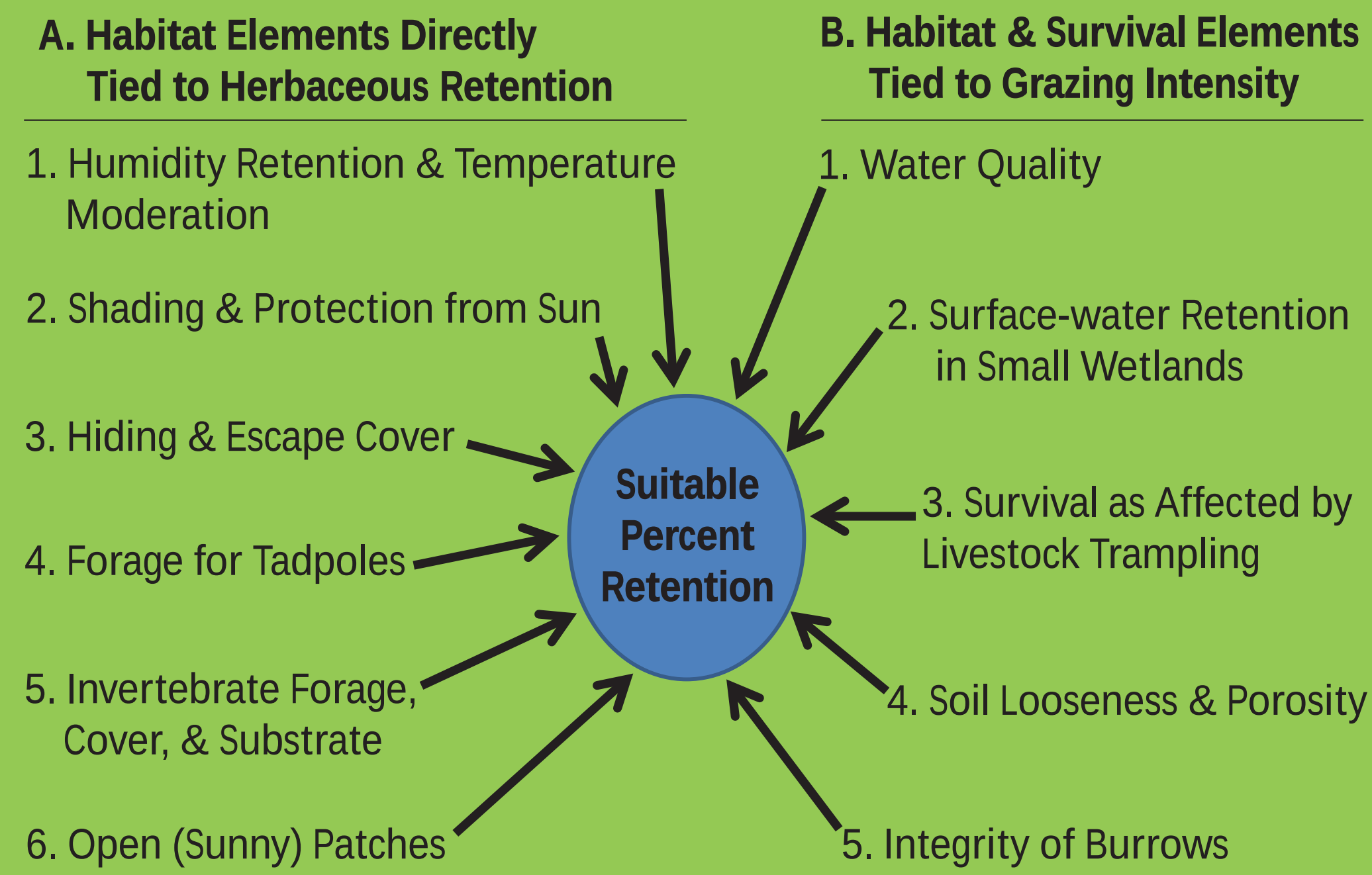
IV. Scientific Basis for 70% Threshold

11 Factors Considered in Process of Determining Retention Level

Why were the 11 Factors Examined in Detail?

- Livestock grazing use affects amphibians in many different ways.
- There are no amphibian–livestock studies that identify thresholds for livestock grazing.
- Many amphibian–livestock studies examined individual factors.
- A large volume of info. from a wide range of disciplines addresses individual aspects of frog & toad ecology affected by livestock.

Factors Considered in Determining Suitable Retention Level



A.1 — Humidity Retention & Temperature Moderation

Moist / Humid Habitat & Micro-sites are ***A Must***

- Wetland habitat
- ✓ Sedge and Grass Canopy Cover
- ✓ Litter
- Willow Canopy Cover
- Logs
- Burrows

A.1 — Humidity Retention & Temperature Moderation

- Frogs & toads seek out and require moist to wet habitat & microsites.

  (Dumas 1964, Schwarzkopf & Alford 1996, Sjogren and Ray 1996, Engle 2001, Patla & Keinath 2005, Rittenhouse et al. 2008, Bull 2009, Burton et al. 2009)

- Moderated temperatures are also important to frogs & toads.

  (Dumas 1964, Sjogren and Ray 1996, Engle 2001, Semlitsch et al. 2008/2009)

- In herbaceous plant communities → herb. veg. is central to retaining near-ground humidity and moderating temperature.

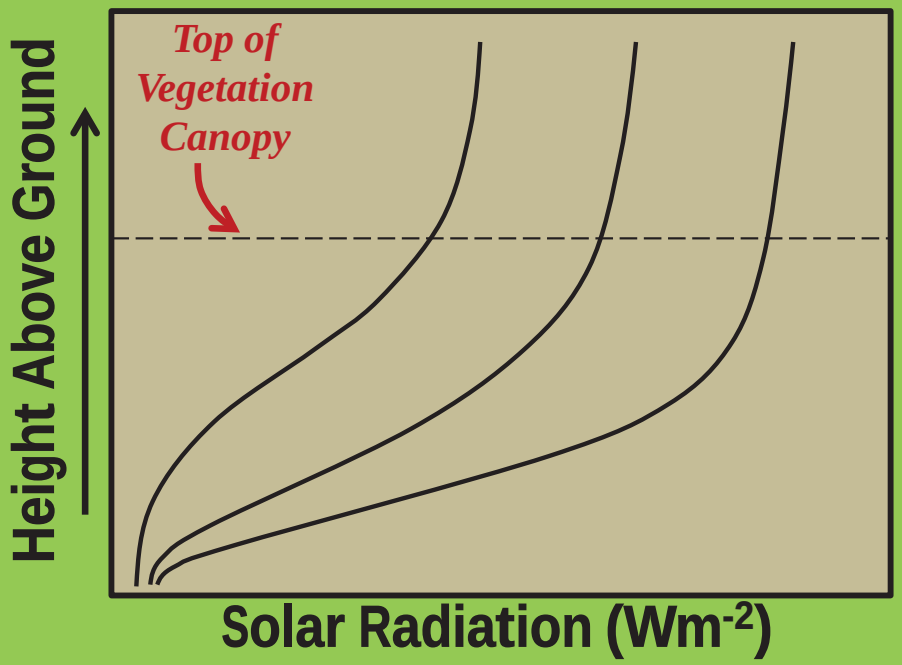
  (*Marlatt 1961, Thom 1971, Cionco 1972, Goudriaan 1977, Oke 1978, Baldocchi et al. 1983*)

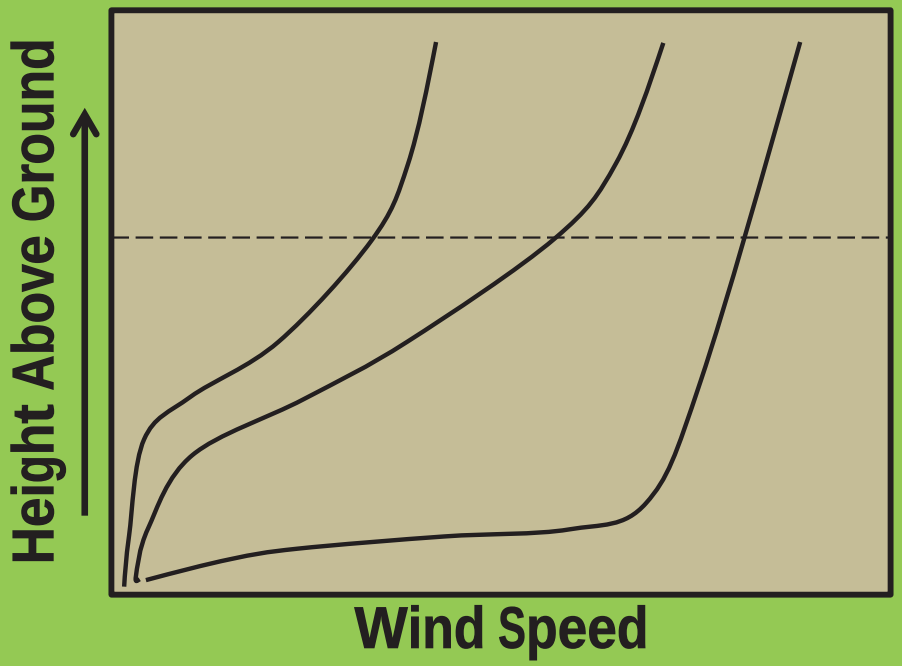
- Relative humidity of 65% at about 80 °F is lethal to adult spotted frogs in about two hours. (*Dumas 1964*)

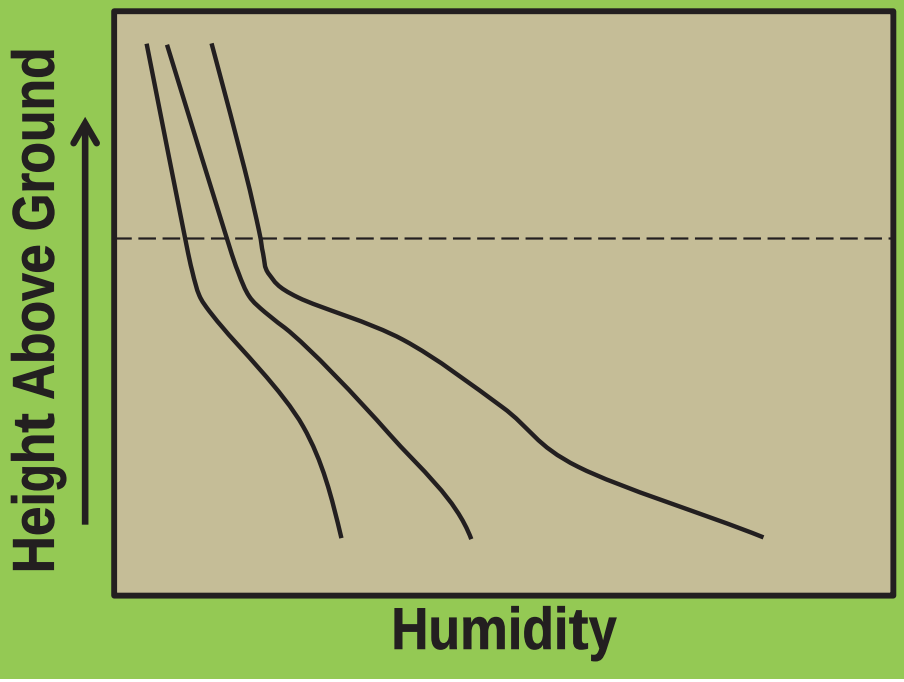
- While toads do not desiccate as easily as frogs, moist habitat and microsites are important to boreal toads

  (Thorson 1955, Schmid 1965, Duellman and Trueb 1986, Schwarzkopf & Alford 1996, Keinath and McGee 2005, Rittenhouse et al. 2008, Bull 2009)

A.1 — Humidity Retention & Temperature Moderation





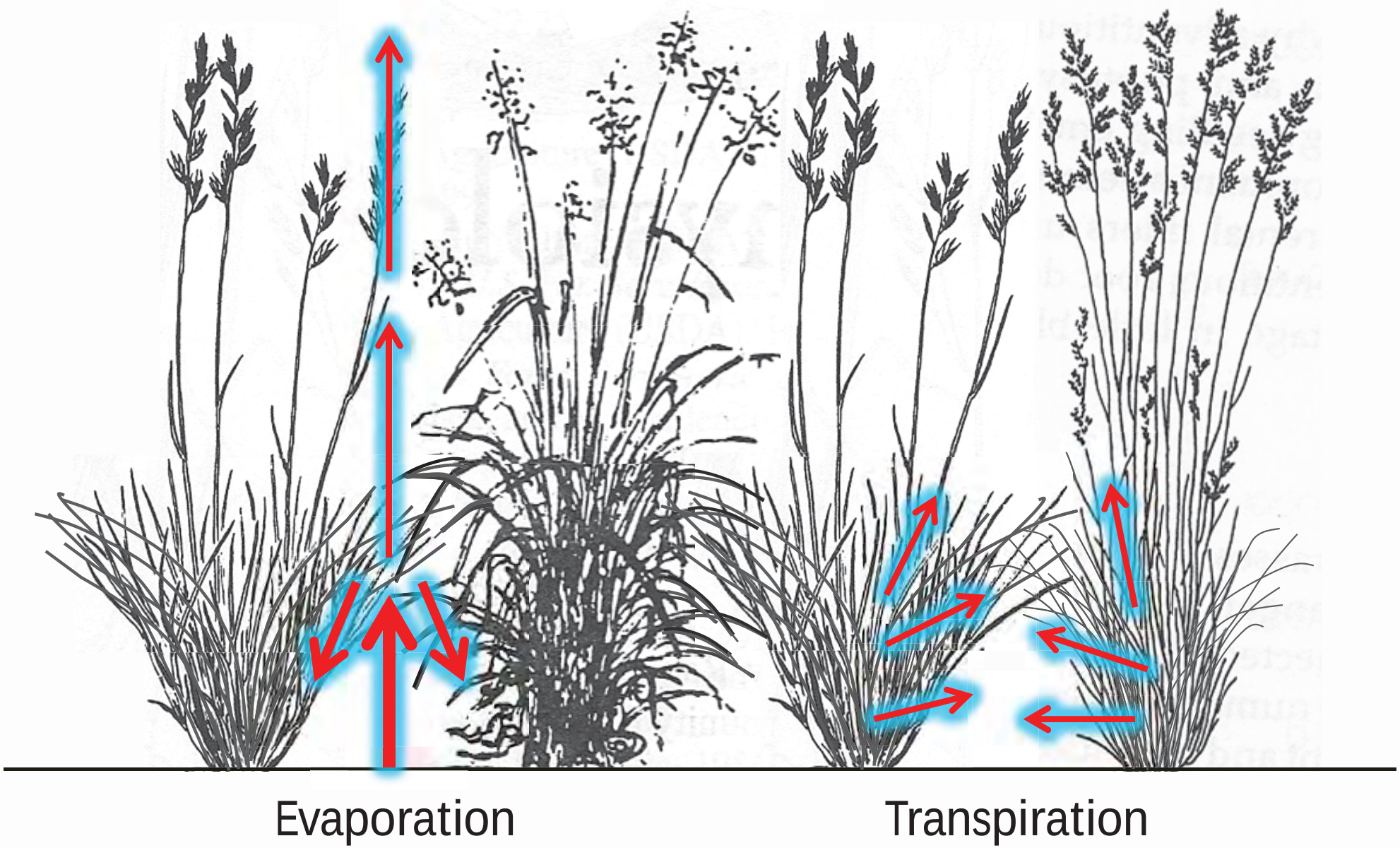


These results are for agricultural crops.

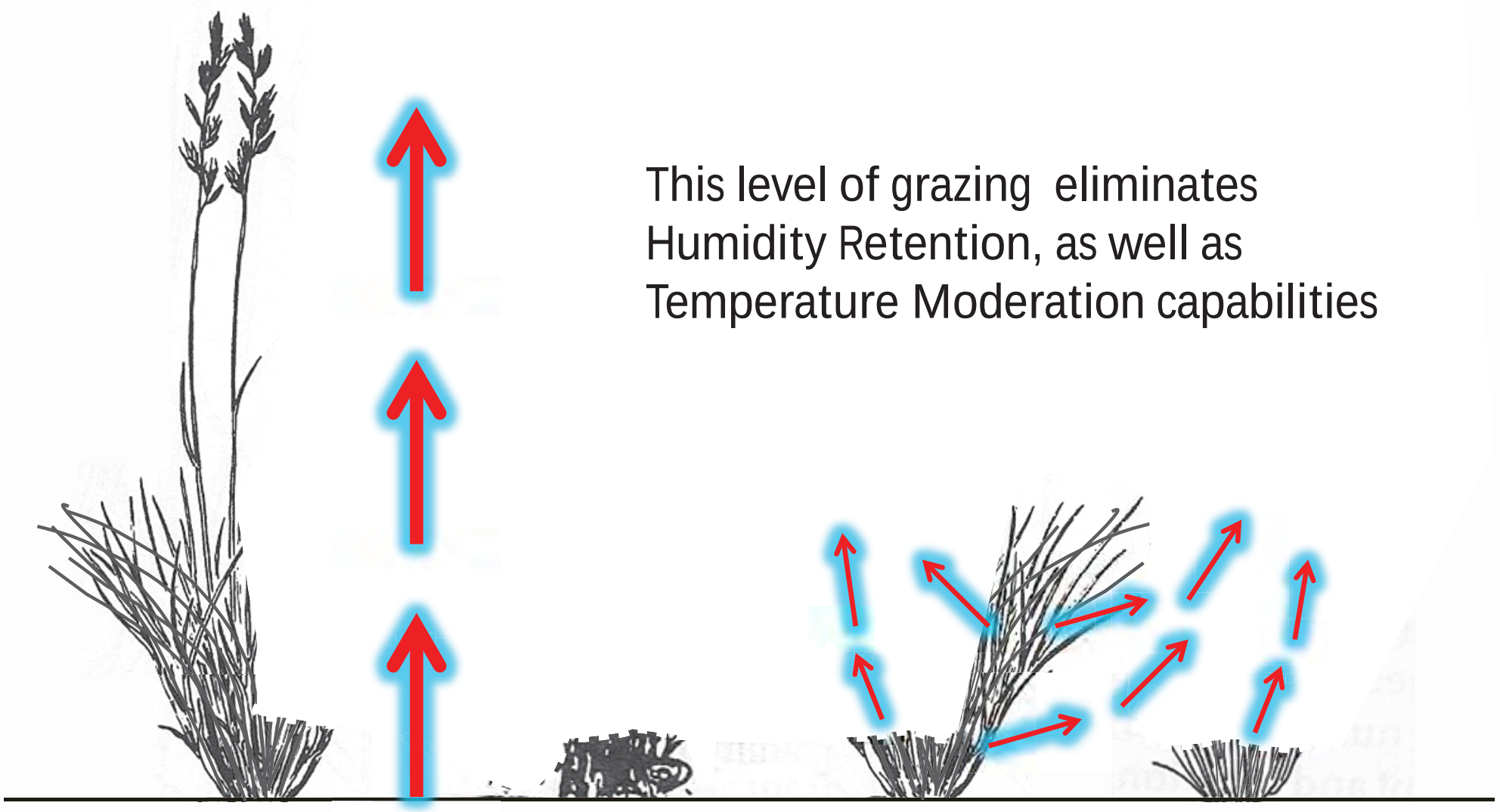
Native meadow veg. is more dense, so differences are greater.

Marlatt (1961), Thom (1971), Cionco (1972), Goudriaan (1977), Oke (1978), Baldocchi et al. (1983)

Canopy Cover Effects on Humidity



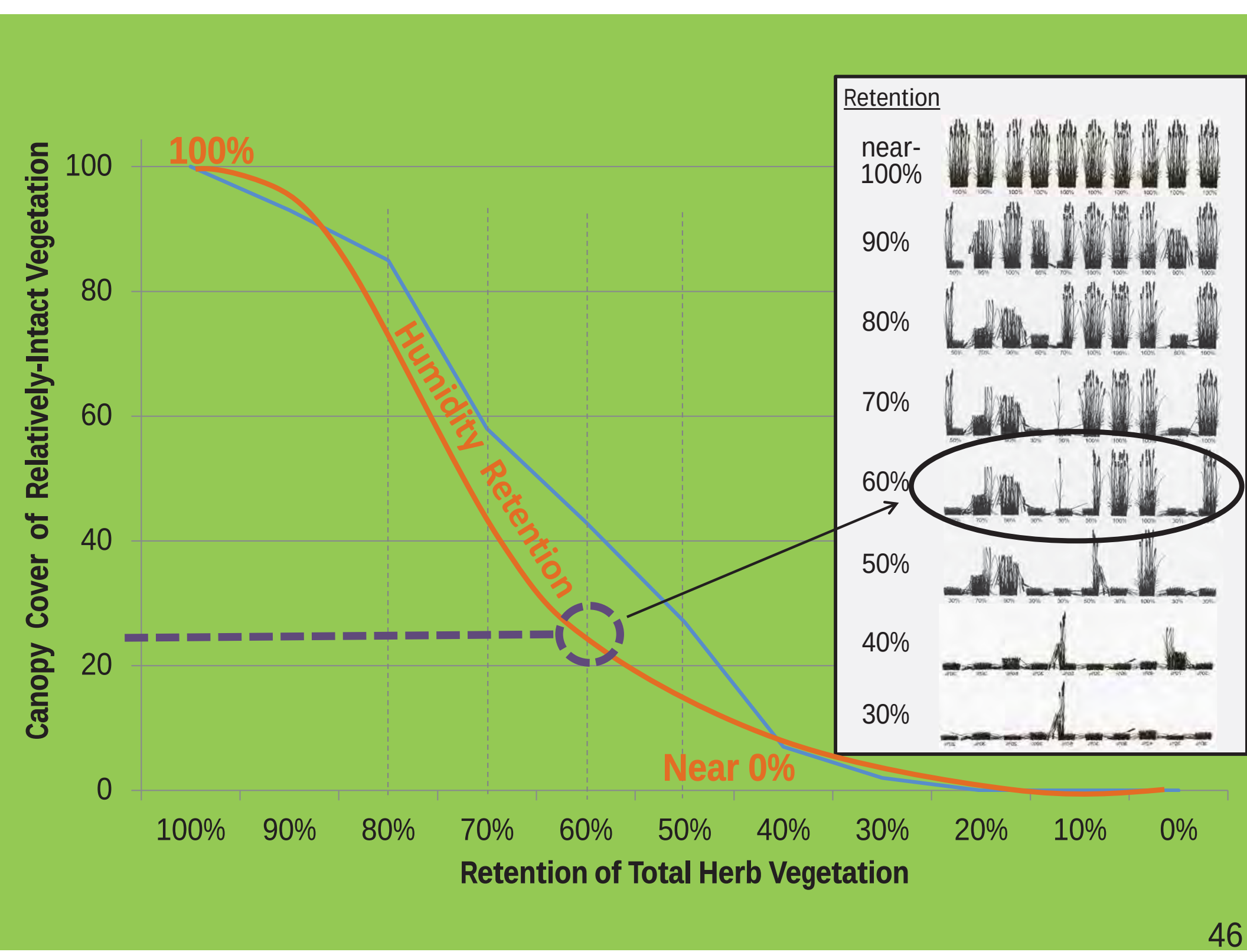
Canopy Cover Effects on Humidity



This level of grazing eliminates Humidity Retention, as well as Temperature Moderation capabilities

Evaporation

Transpiration


Canopy Cover of Relatively-Intact Vegetation
100
80
60
40
20
0
100%
Humidity Retention
Near 0%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Retention of Total Herb Vegetation
Retention
near-100%
90%
80%
70%
60%
50%
40%
30%

Humidity Retention

Percent Canopy Cover of Relatively-Intact Veg.

100% 80% 60% 40% 20% 0%

100%

85-100%

70-85%

Well Supported by Science

50-65%

35-50%

20-35%

≤15%

≤5%

Not Supported by Science

Retention

near-100%

90%

80%

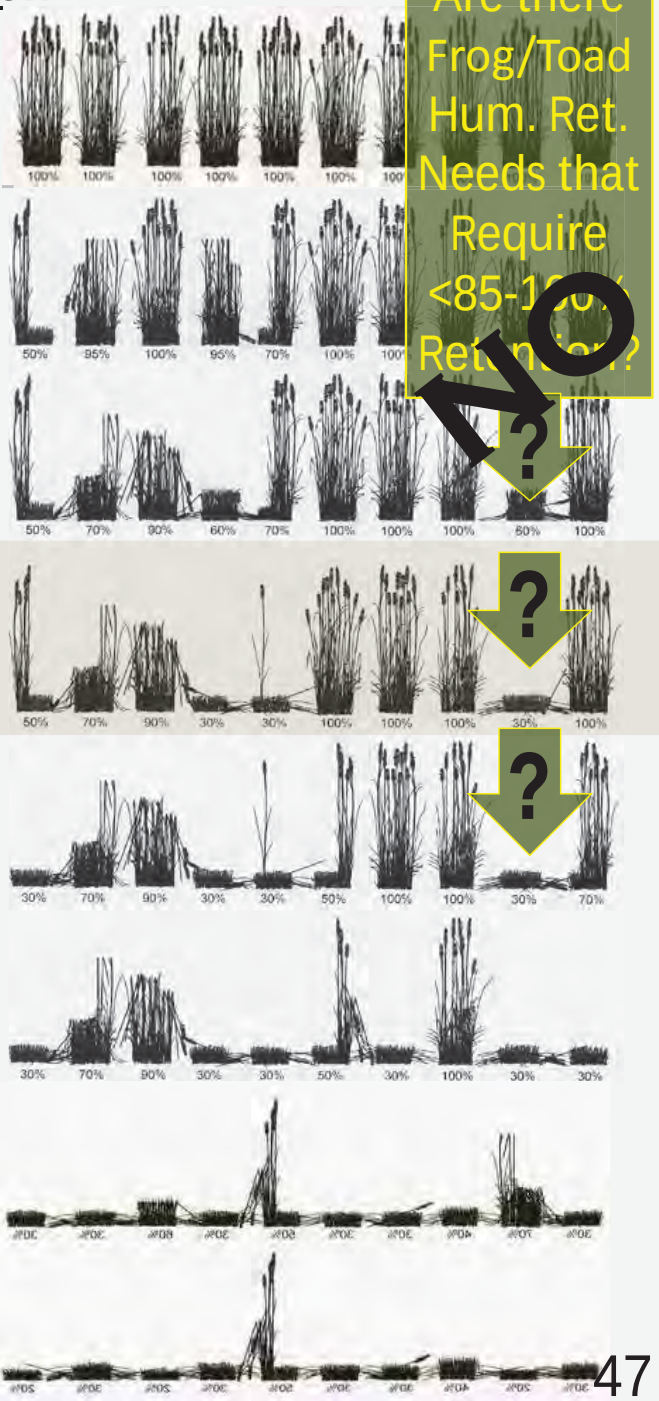
70%

60%

50%

40%

30%



Are there Frog/Toad Hum. Ret. Needs that Require <85-1[illegible] Retention?

NO

A.2 — Shade & Protection from the Sun

- Related to humidity retention and temperature moderation, but this element involves direct exposure to sun.

- Shade and protection from the sun is important to frogs & toads.

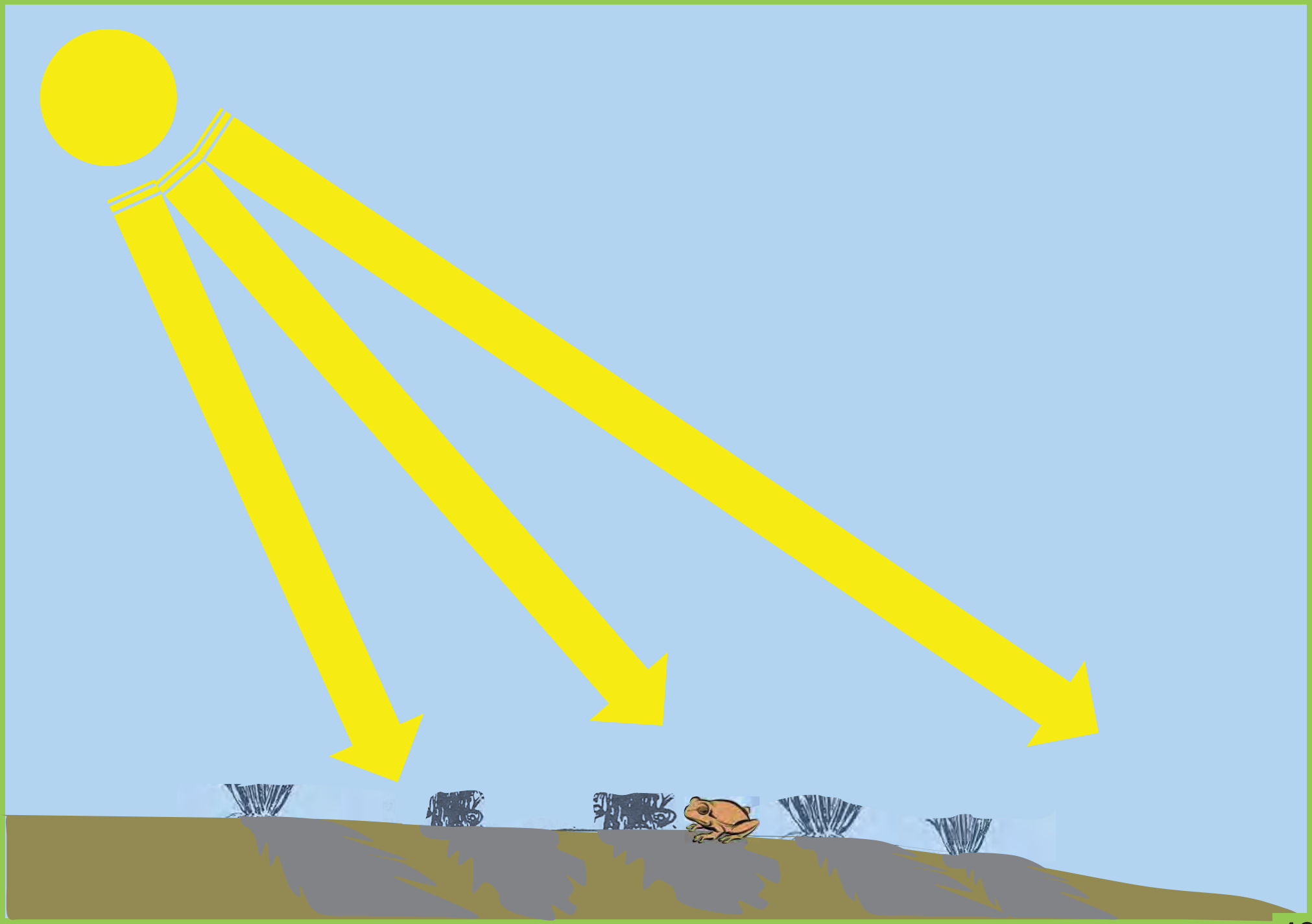
  (Schwarzkopf & Alford 1996 , Engle 2001, Bartelt et al. 2004, Semlitsch et al. 2008, Semlitsch et al. 2009)

- Access to sunlit ground and sunlit shallow water also important.

  → addressed in “6. Open (Sunny) Patches”


Herbaceous Veg. Contributes to:
• Protection from Sunlight
• Litter in Future Years

A.2 — Shade & Protection from the Sun



Shade & Sun Protection

Percent Canopy Cover of Relatively-Intact Veg.

100% 80% 60% 40% 20% 0%

100%

85-100%

70-85%

Large Amount of Shade Provided

50-65%

35-50%

Moderate Amount of Shade Provided

20-35%

≤15%

≤5%

Negligible or No Shade Provided

This Assumes Starting Canopy Cover near 100%

Retention

near-100%

90%

80%

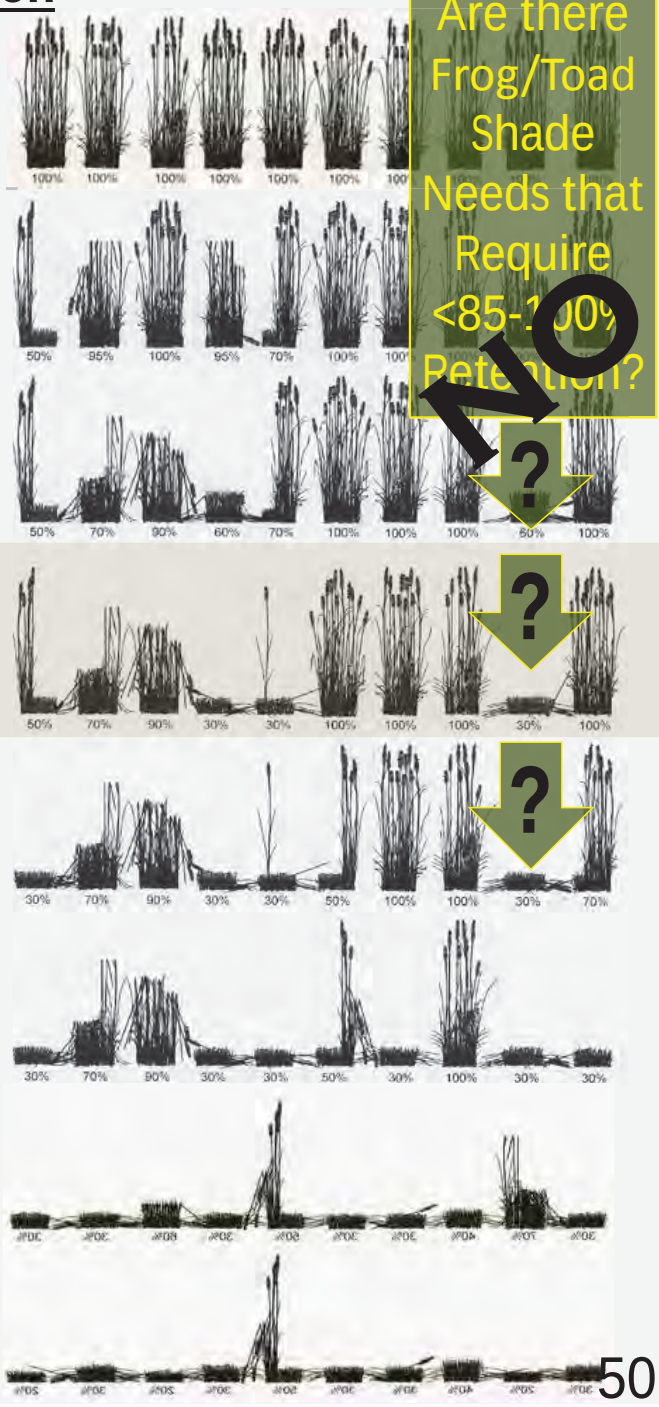
70%

60%

50%

40%

30%



Are there Frog/Toad Shade Needs that Require <85-100% Retention?

NO

?

A.3 — Hiding & Escape Cover

- Hiding & escape cover is important to tadpoles in wetlands.

  (Warkentin 1992, Healey 1998, Jansen and Healey 2002, Schmutzer et al. 2008)

- Hiding & escape cover is important to metamorphs on shorelines.

  (Jansen and Healey 2002, Bartelt et al. 2004, Burton et al. 2009)

- Hiding & escape cover is important to adults, juveniles, & metamorphs in aquatic and terrestrial habitats.

  (Healey 1998, Jansen and Healey 2002, Bull 2006, Shovlain et al. 2006, Bull 2009)

- Predators of boreal toads include:

coyotes	badgers	gray jays	sp. sandpipers	garter snakes
foxes	ravens	robins	mallards	salamanders
raccoons	magpies	killdeer	r-tailed hawks	

(12 references in *Wind and Dubois 2002, Keinath and McGee 2005, Muths 2005, Bull 2009)*

Fundamental Principle of W

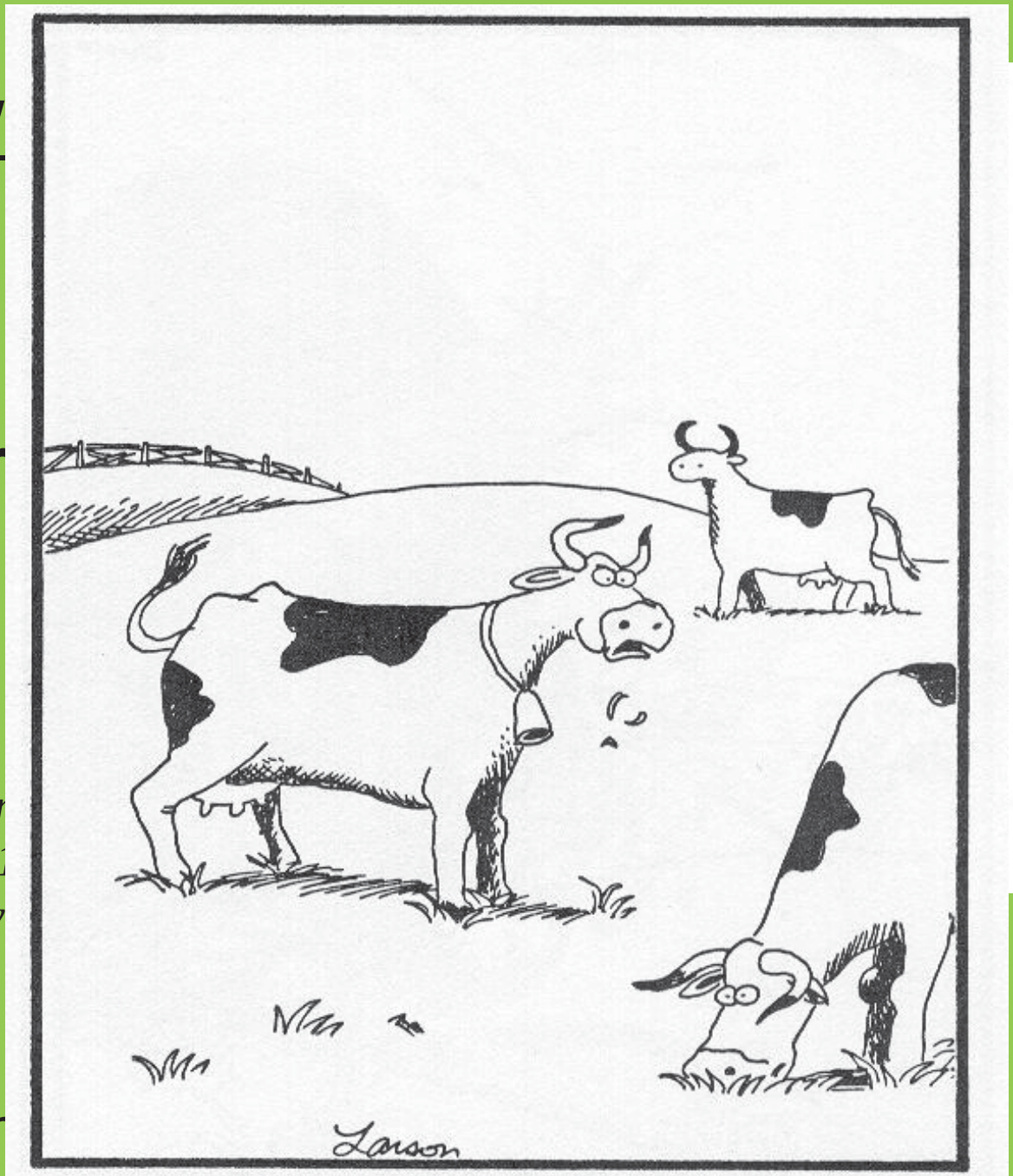
As Hiding Cover
(Herbaceous Veg.)

Pr

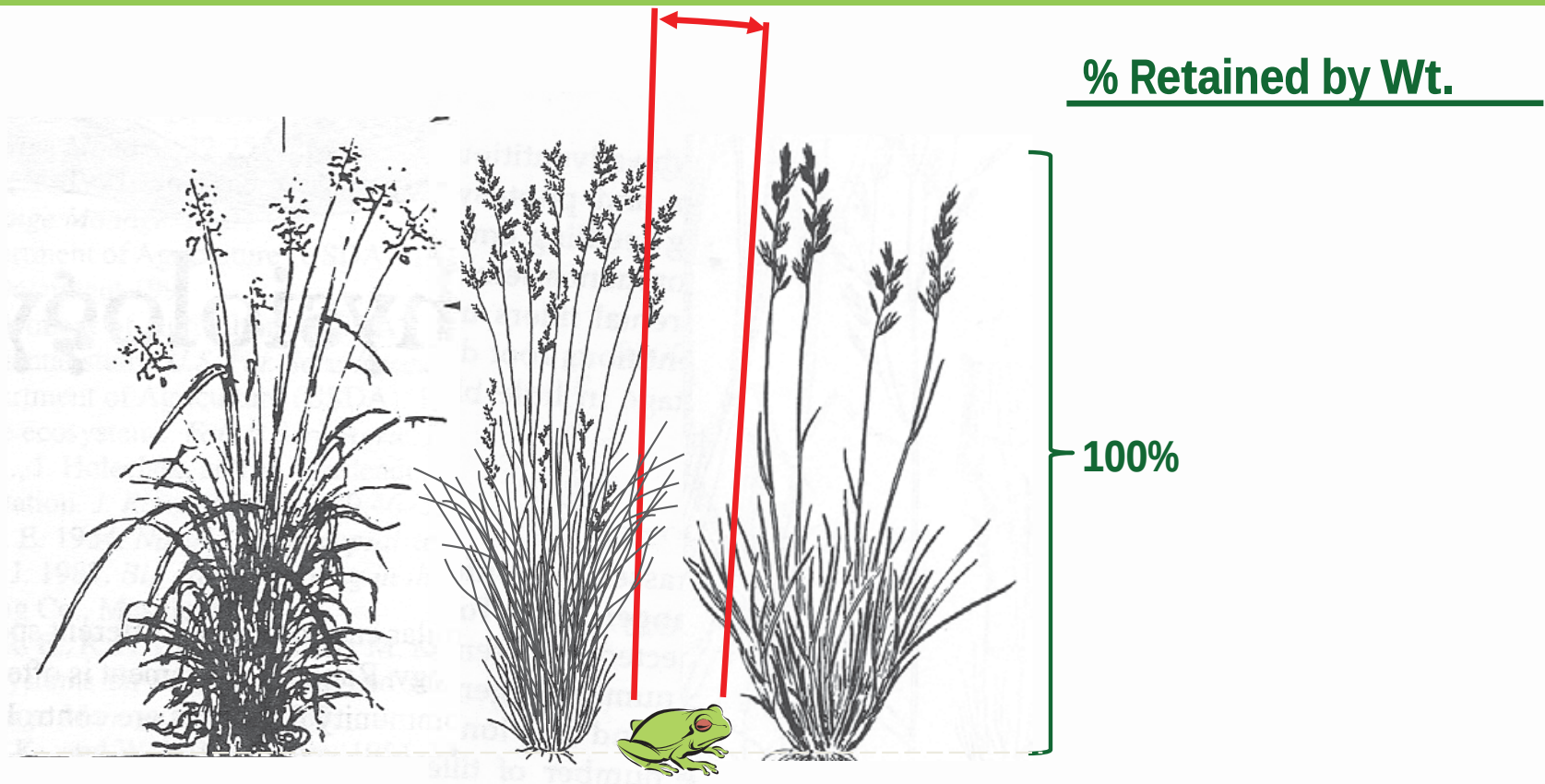
(Leopold 1933, Braun et al. 1978, Dasman
1984, Peek 1986, Beintema and Müskens 1
1992, Olson 1992, Fagerstone and Ramey
1996, Choate 2007)

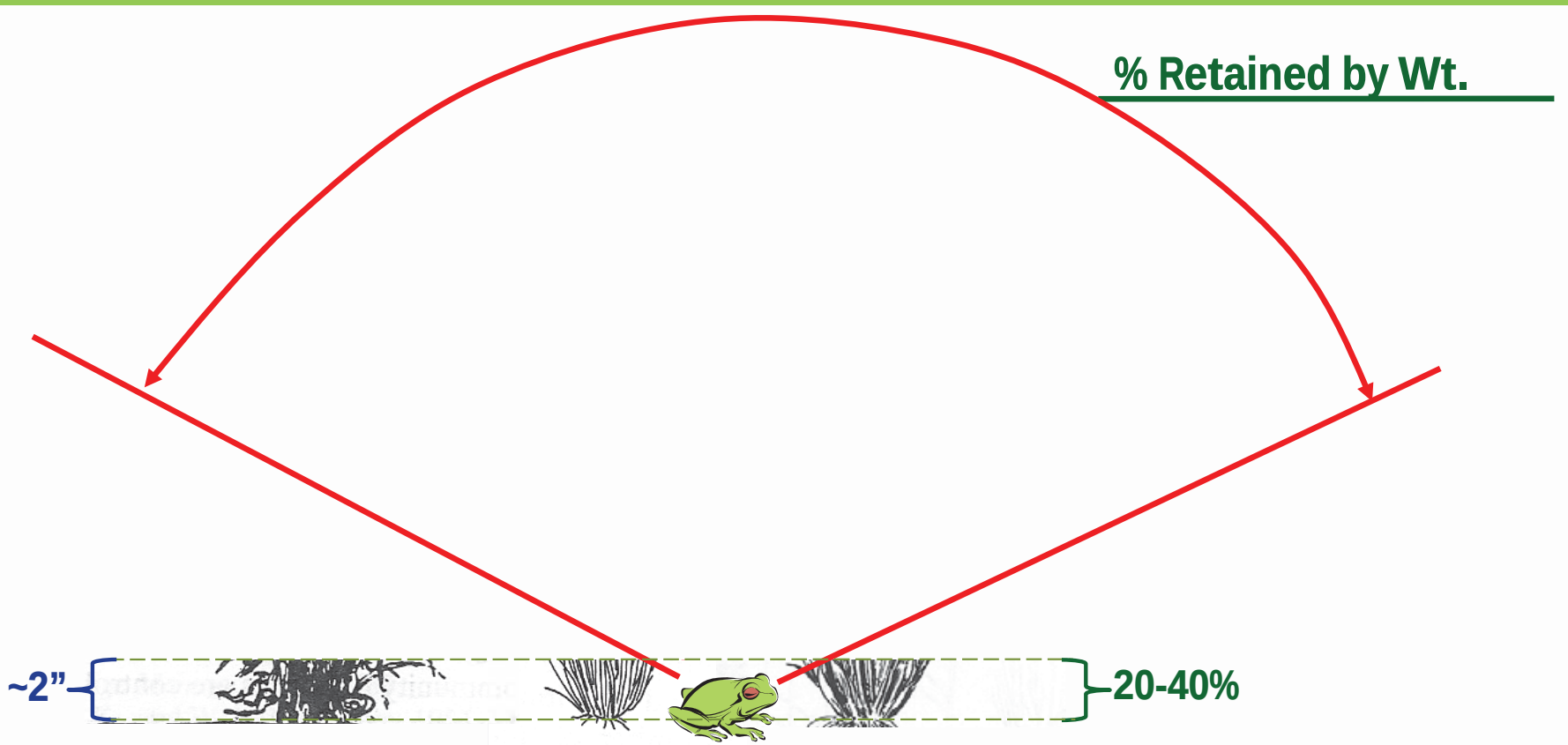
In herb. plant communities → h

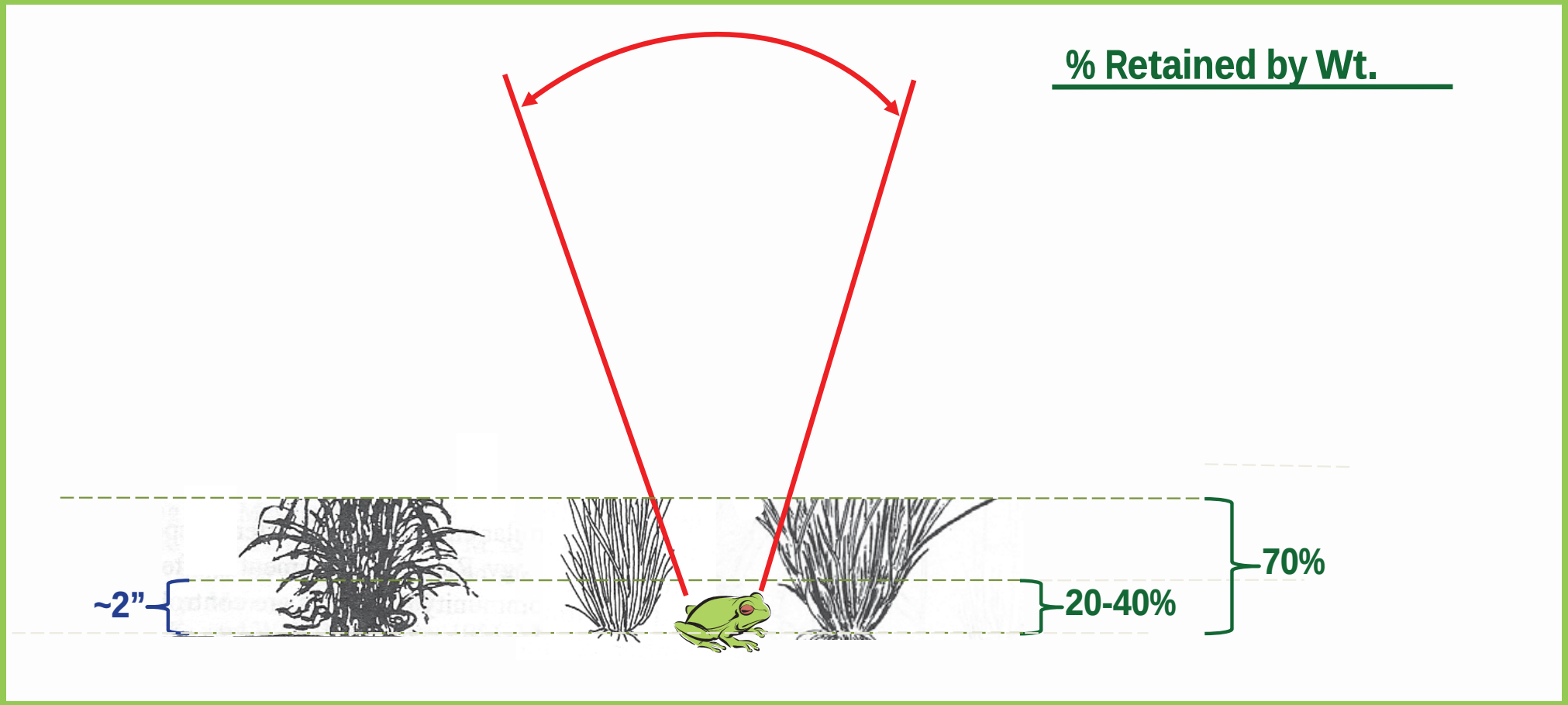
(Robel 1970, Birney et al. 1976, Pee
Dwire et al. 2004, Patla and Keinath



"Hey, wait a minute! This is grass! We've been eating grass!"


% Retained by Wt.
100%


% Retained by Wt.
~2”
20-40%


% Retained by Wt.
~2”
20-40%
70%

Studies on Livestock Grazing & Amphibians

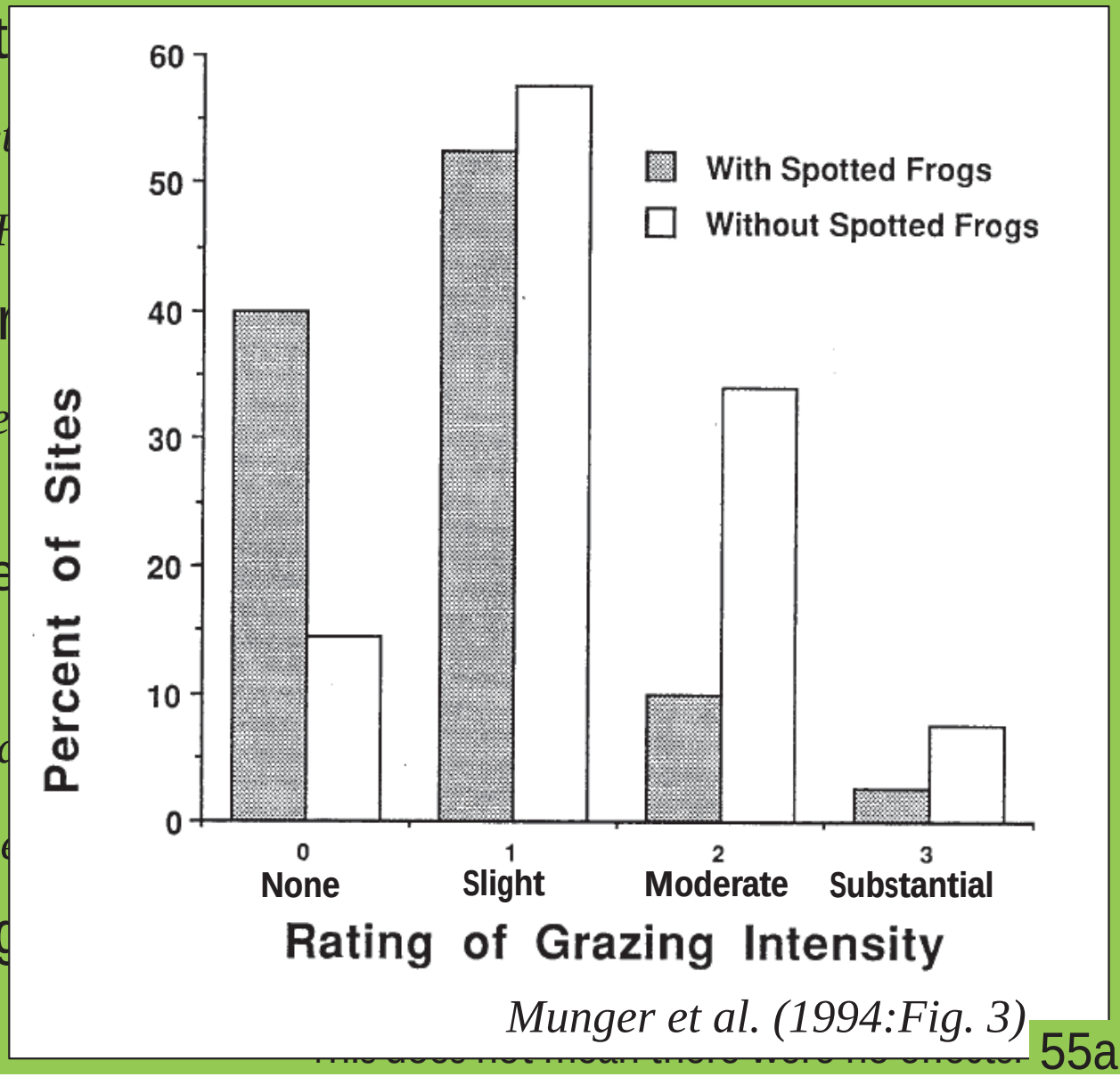
(Studies did not Specifically Assess Effects on Hiding Cover)

No effects on adult and tadpole occurrence, abundance, and/or survival were detected* where retent

- **~75-85%** *(Roche et*
- **~80%** *(Bull & F*
- **High levels** (i.e., light gr
- **~50-60%** *(Adams e*

Adult and tadpole occurrence where retention averaged:

- **~80%** *(Munger et c*
- **~70-85%** *(Schmutzer e*
- **Low levels** (i.e., heavy g



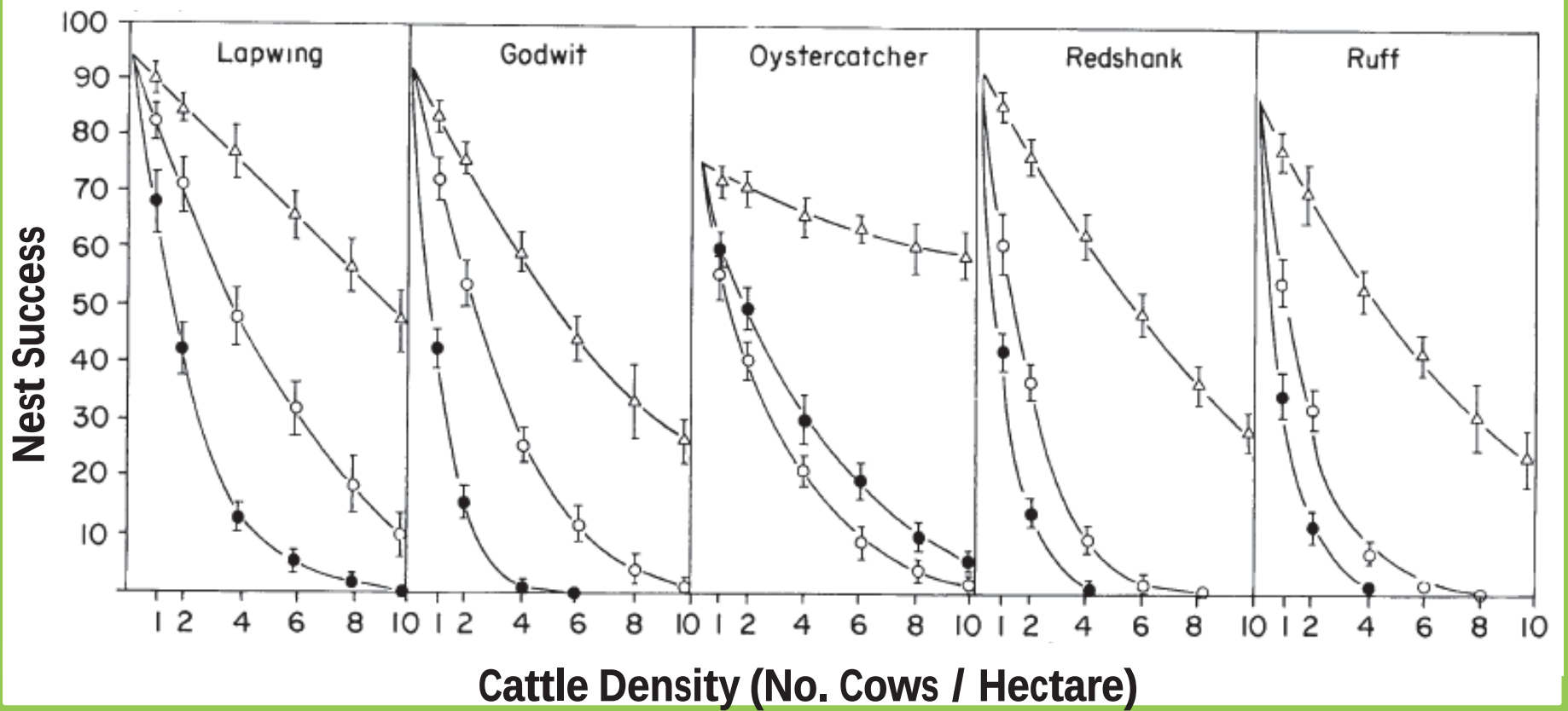
Munger et al. (1994:Fig. 3)

Annual production in
Yosemite toad study area:
1,000 – 3,500 pounds/acre
>2,000 pounds/ac. in 80% of meadows

Retention where toads occurred:
75-90% or more

Waterbirds

Beintema and Müskens (1987)

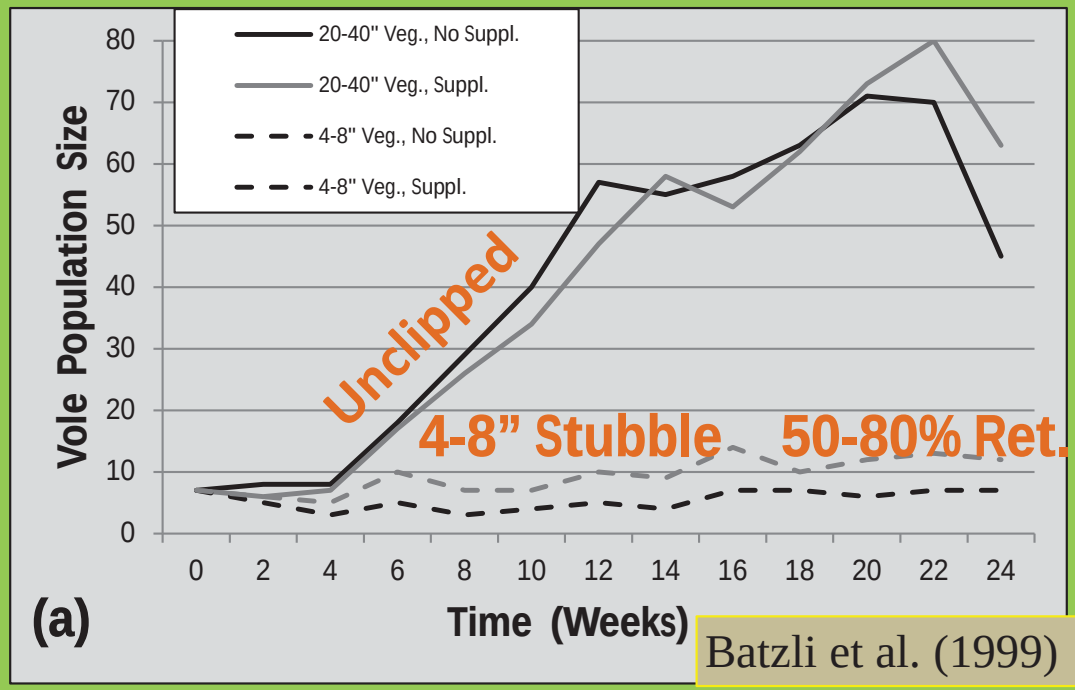


- About 18,000 nests in meadows were tracked during 1974 – 1983.
- Major declines in nest success was driven by reductions in cover and increased trampling.

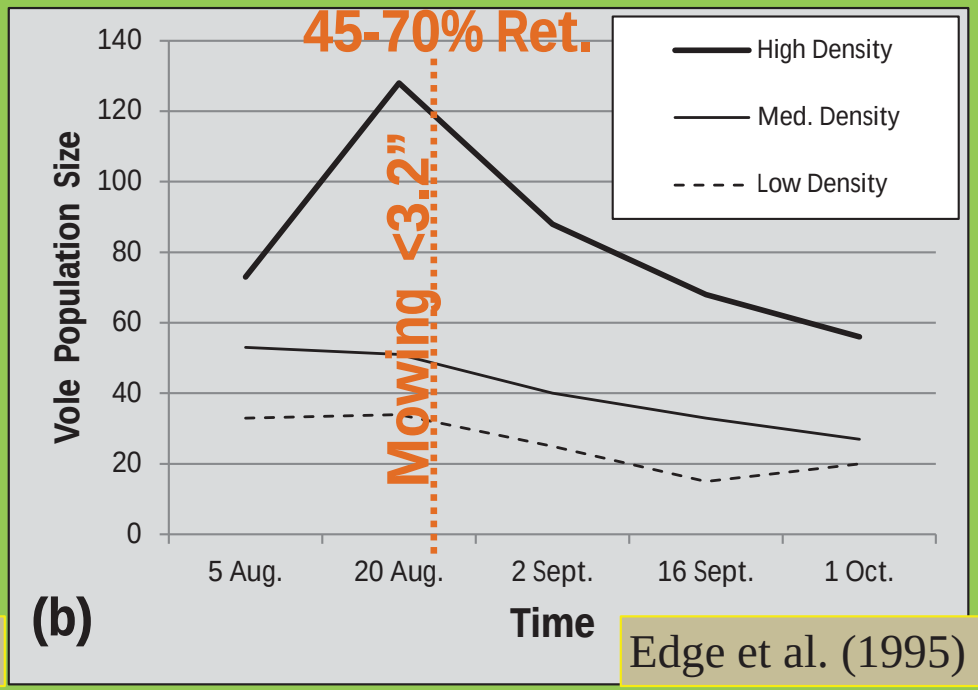
- *Kirsch (1969), Braun et al. (1978), & Gilbert et al. (1996)* reviewed >50 studies on effects of livestock grazing on waterfowl:

  → anything above light grazing generally is detrimental (predation).

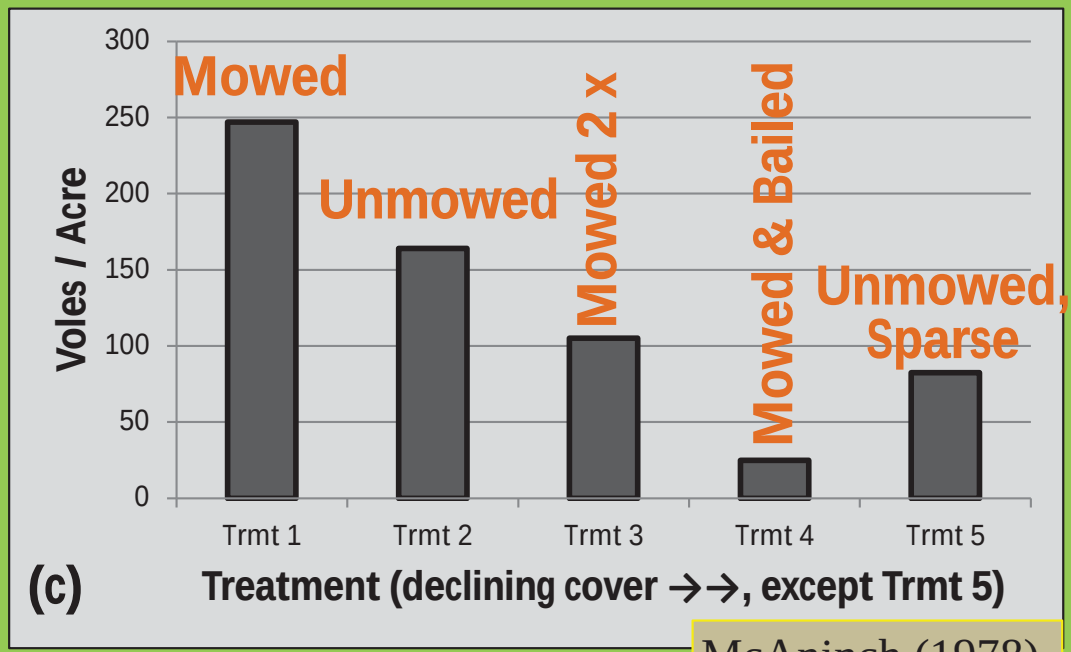
Voles



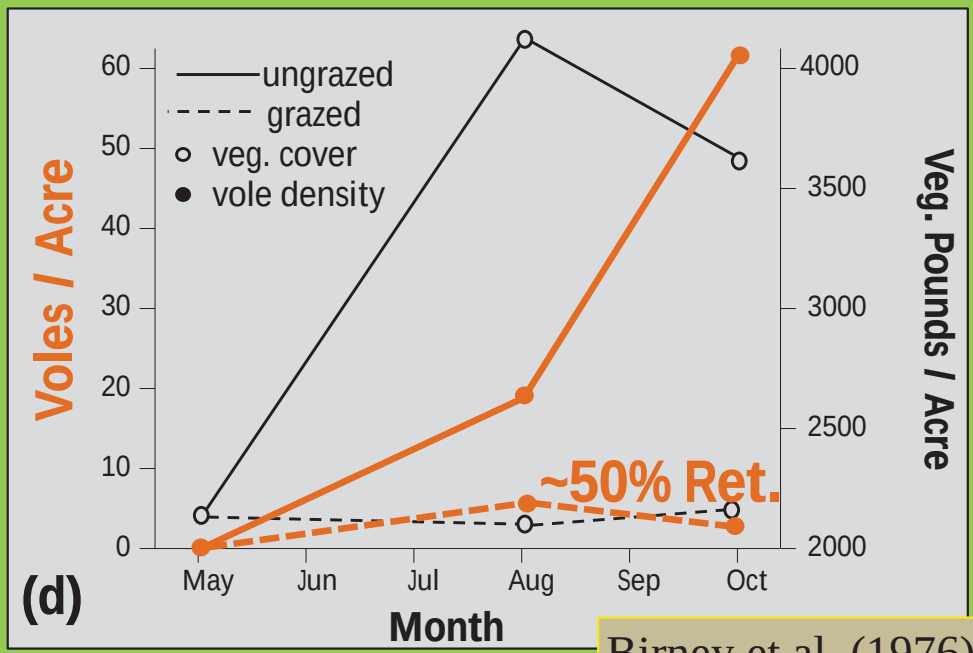
Batzli et al. (1999)



Edge et al. (1995)



McAninch (1978)



Birney et al. (1976)

A Few Variables

Weight of Vegetation Above about 2 Inches

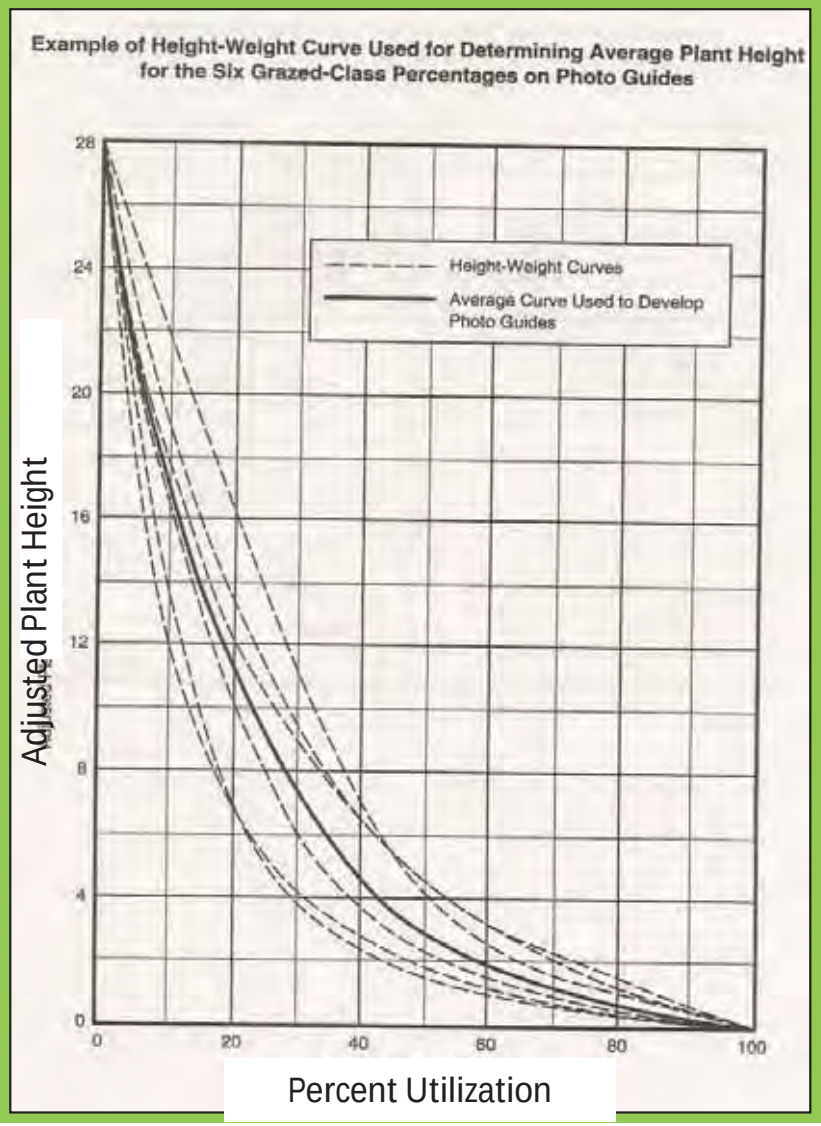
Weight of Herb Veg. Above 2 inches
(*for a Plant Community*)

2-inch height

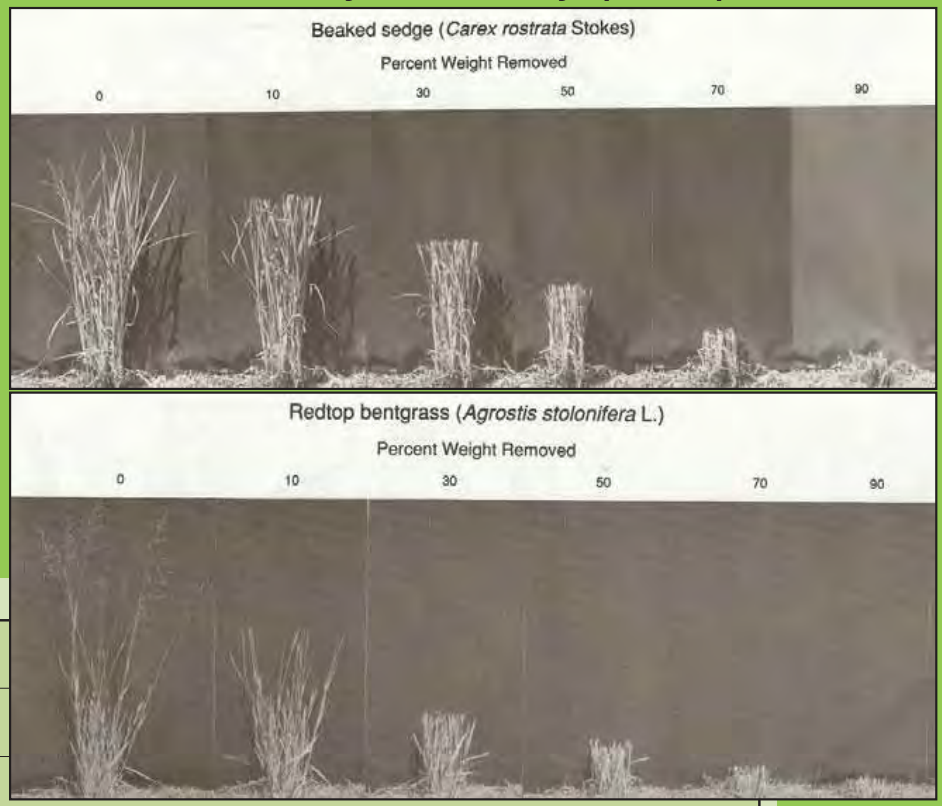
Height – Weight Ratios

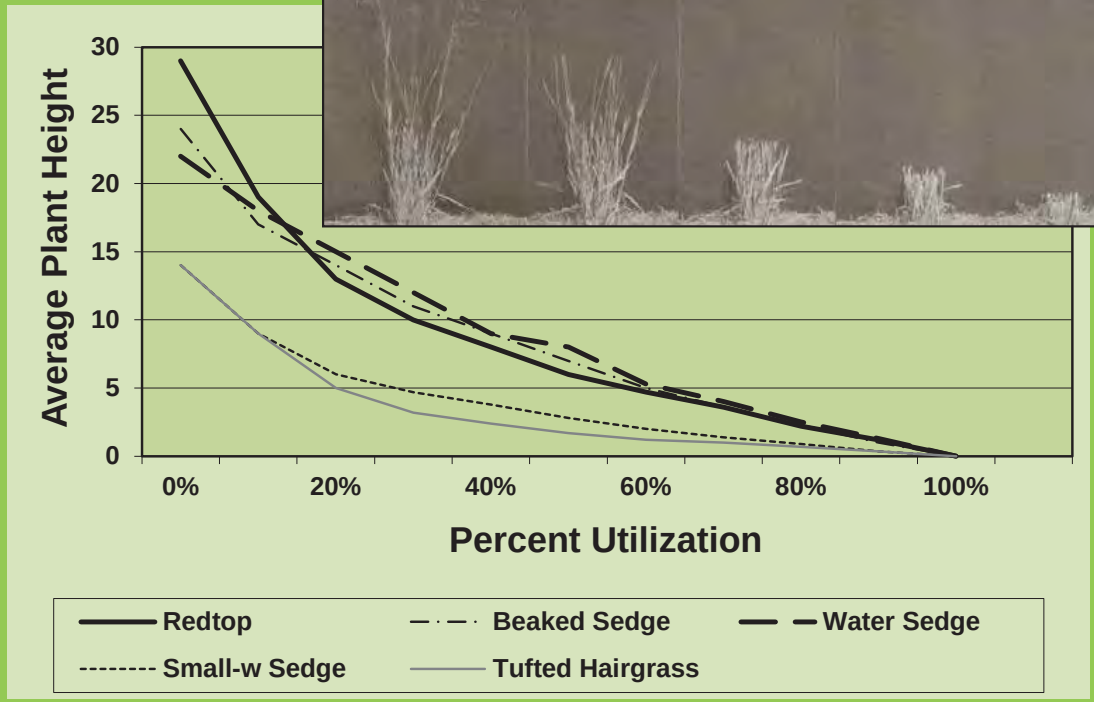
BLM et al. (1999)

Utilization Studies and Residual Measurements



Kinney and Clary (1994)





A Few Variables

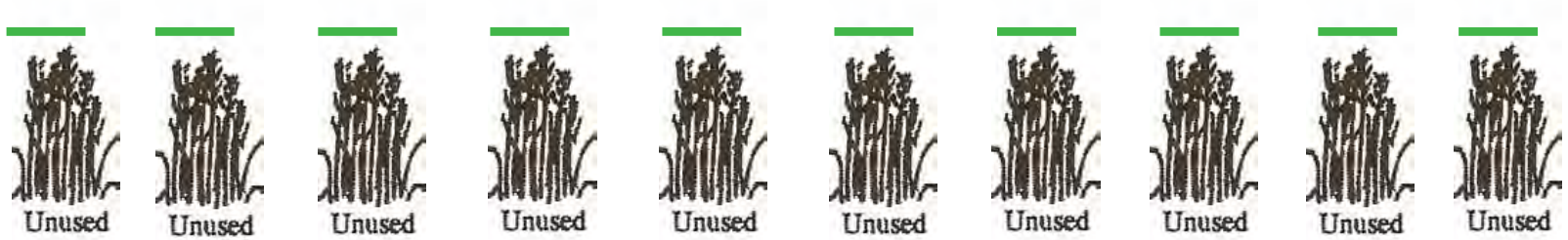
Weight of Vegetation Above about 2 Inches

Weight of Herb Veg. Above 2 inches
(*for a Plant Community*)

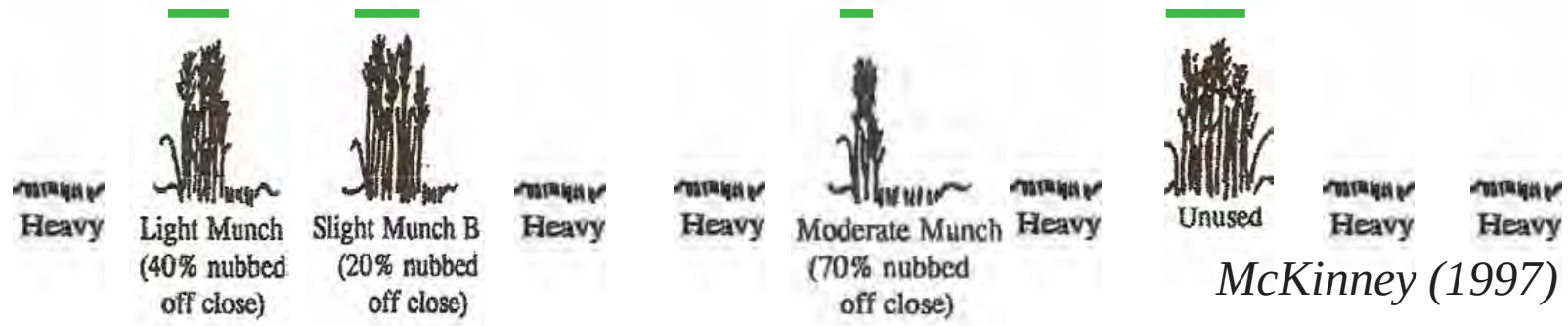
2-inch height

A Few Variables

Canopy Cover of Relatively-Intact Vegetation



50% Canopy Cover (with 100% Retention)



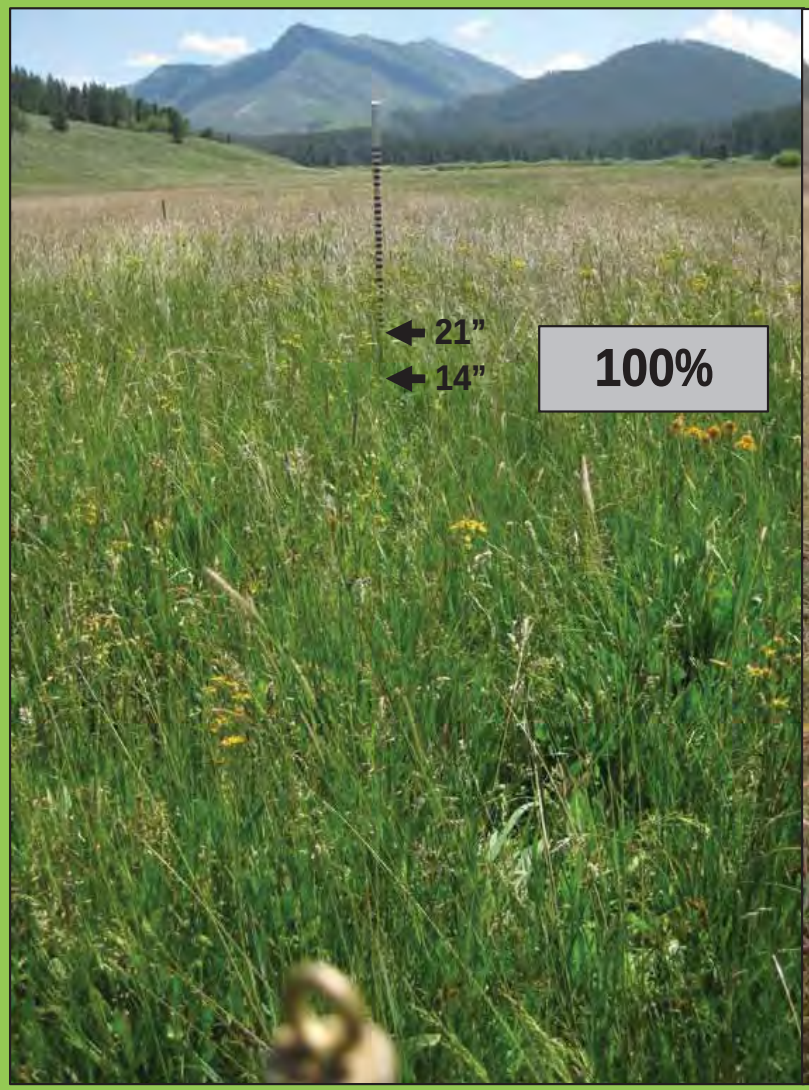
McKinney (1997)

15% Canopy Results from 50% Retention

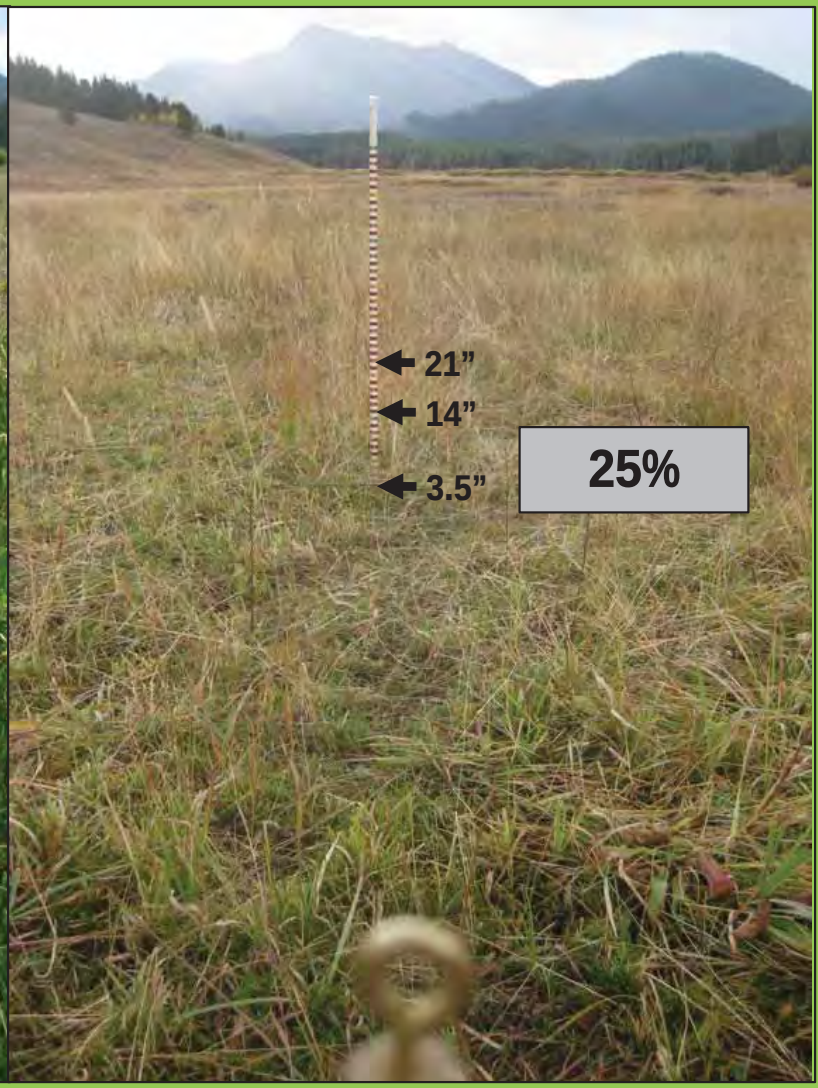
A Few Variables

Robel Pole Readings → indicator of hiding cover

Data was also collected on total herb weight

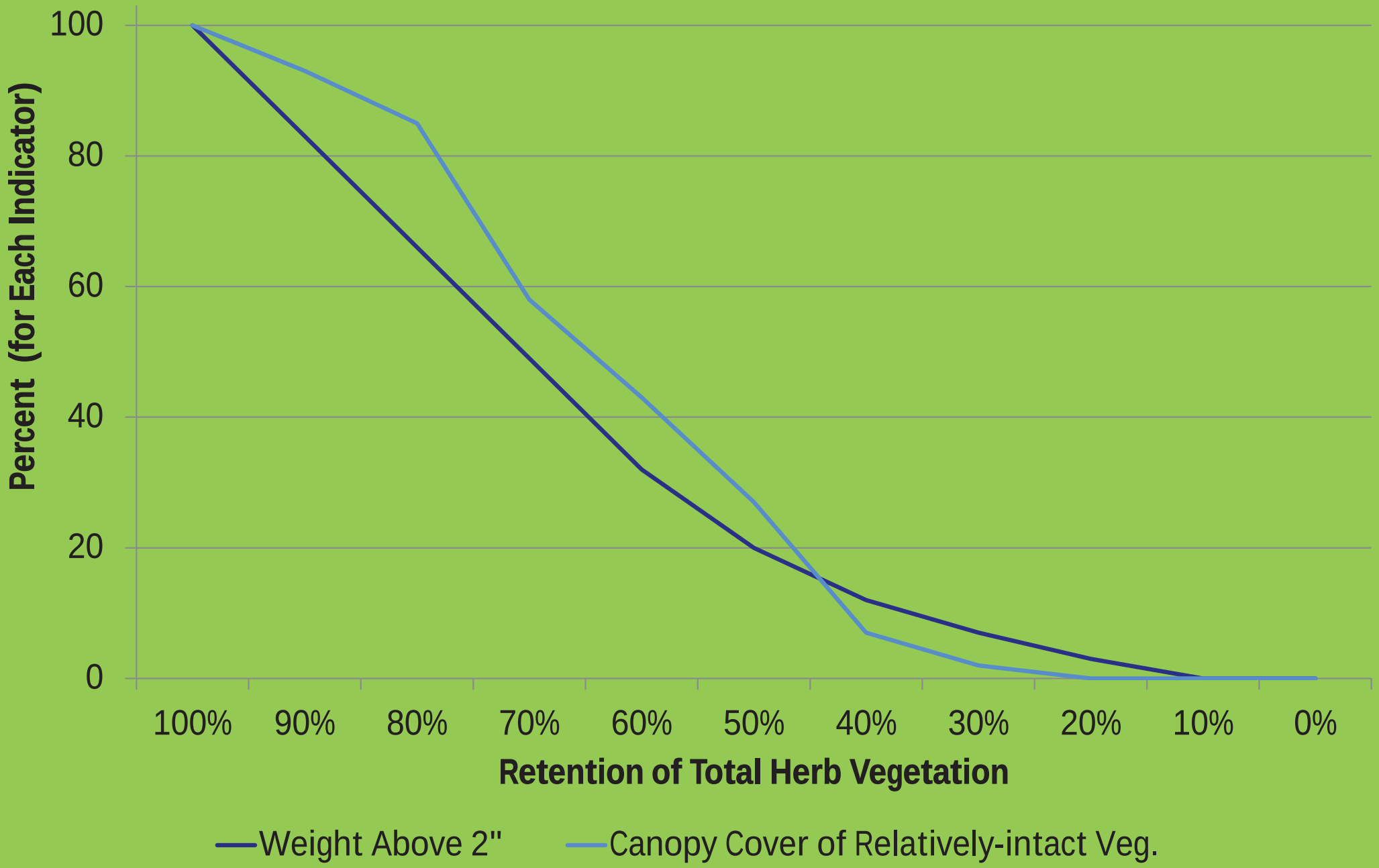


From 4 meters

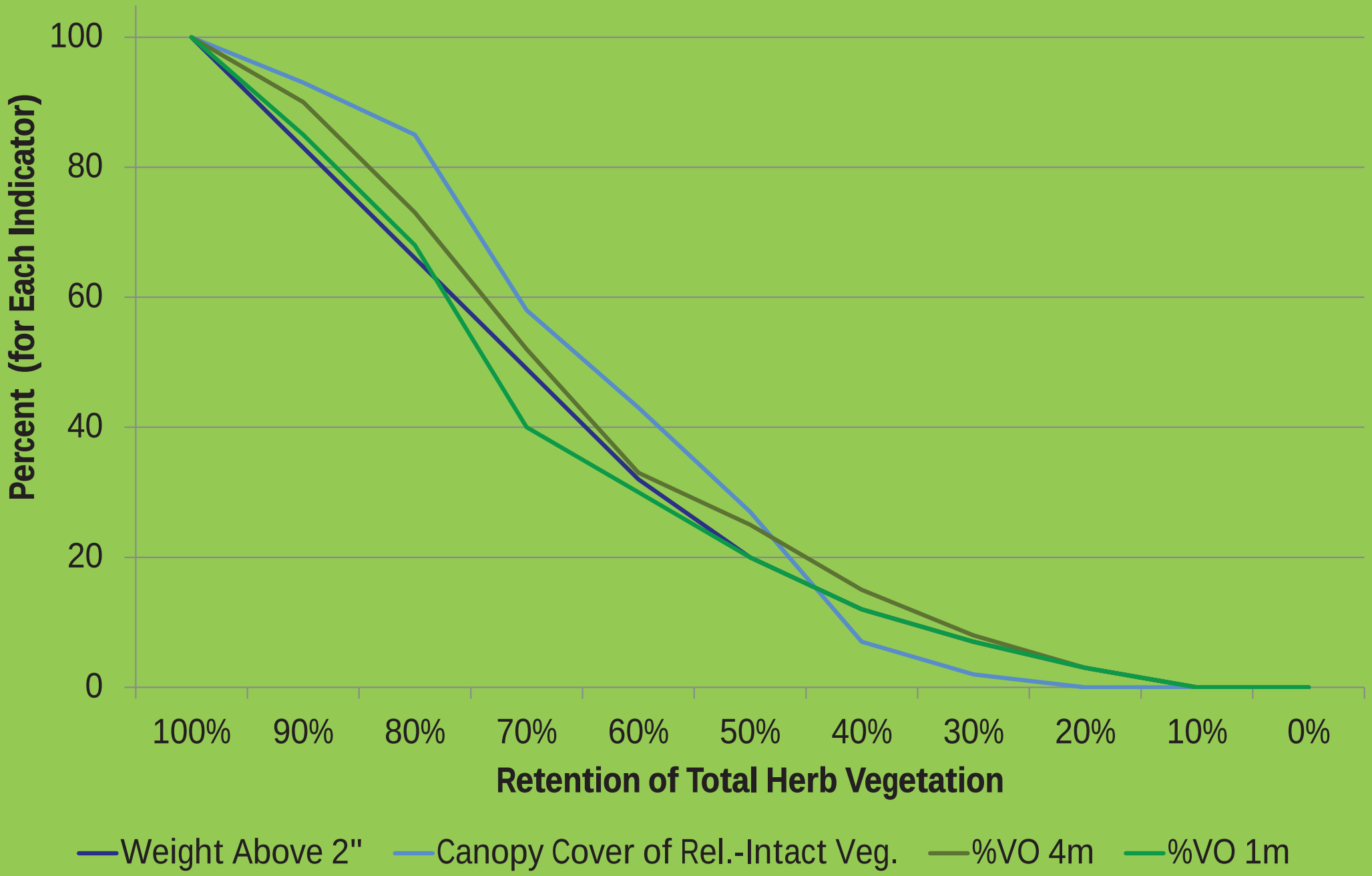


From 4 meters

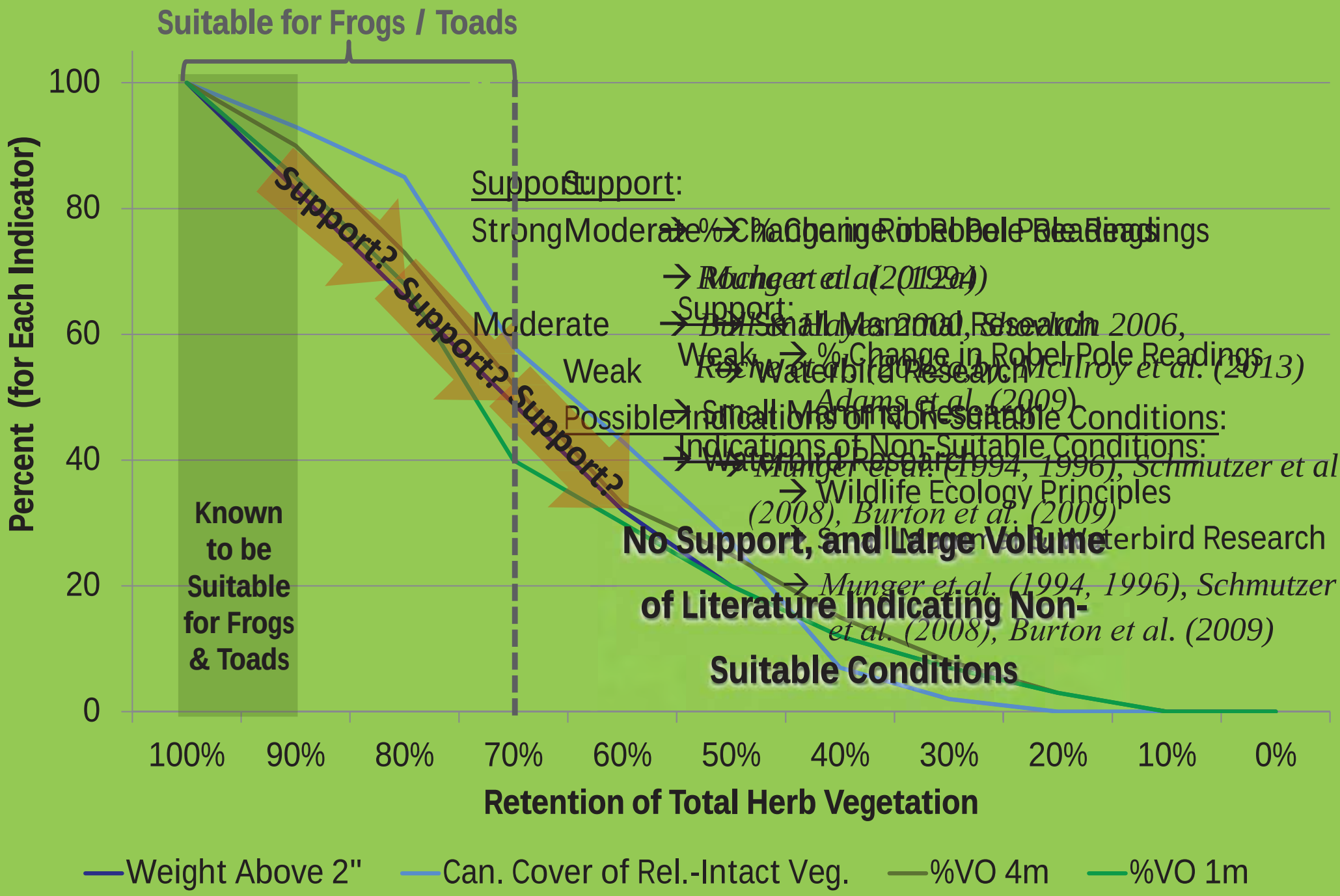
Relationship between Herbaceous Retention and Visual Obstruction



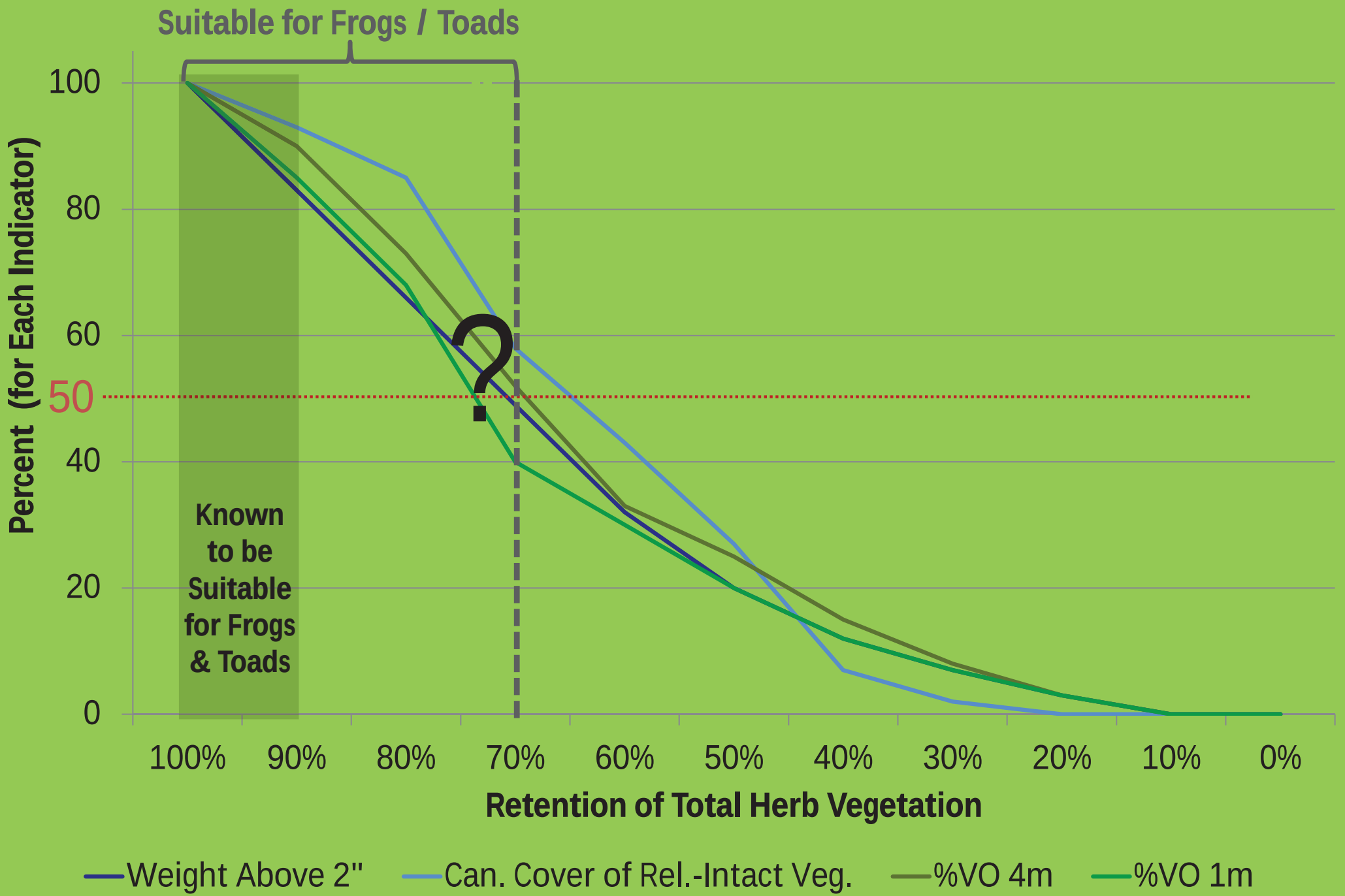
Relationship between Herbaceous Retention and Visual Obstruction



Relationship between Herbaceous Retention and Visual Obstruction



Relationship between Herbaceous Retention and Visual Obstruction



65d

Hiding & Escape Cover

Percent of Robel Pole Readings Retained

100% 80% 60% 40% 20% 0%

100%

70-100%

60-85%

Substantial Hiding Cover Provided

>50%

35-70%

<50%

25-50%

10-40%

Negligible or No Hiding Cover Provided

0-30%

0-20%

Retention

near-100%

90%

80%

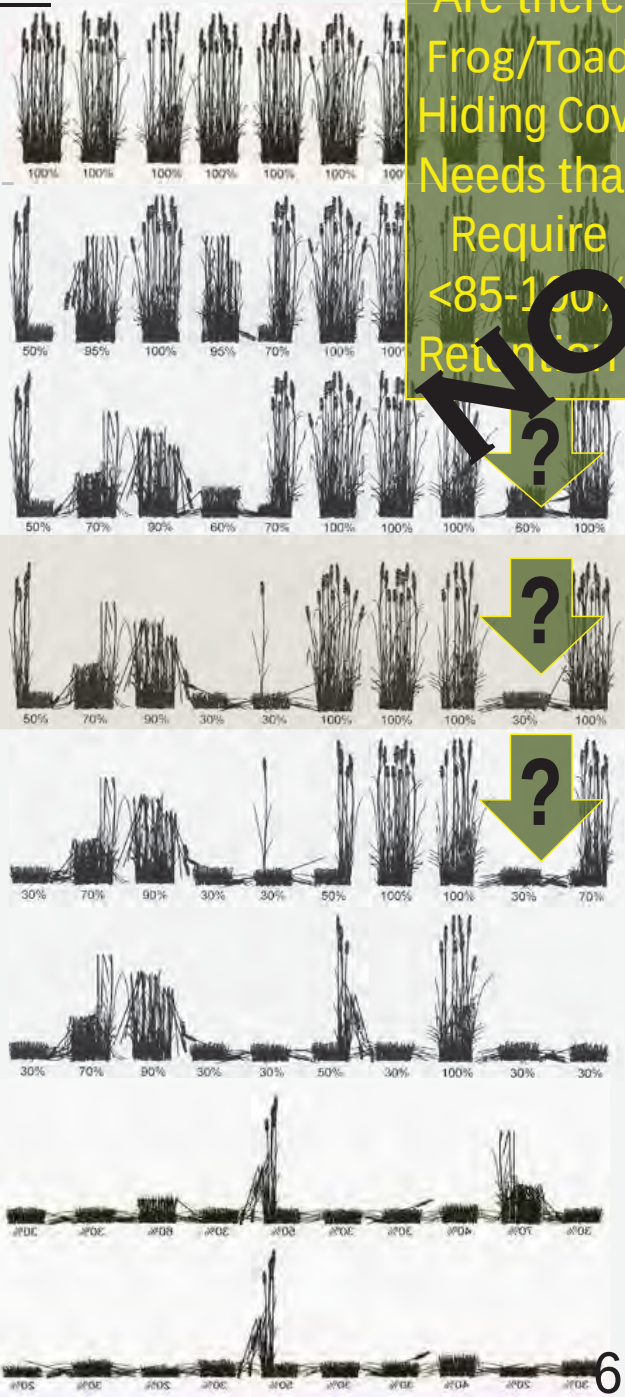
70%

60%

50%

40%

30%



Are there Frog/Toad Hiding Cov. Needs that Require <85-100% Retention?

NO

A.4 — Forage for Tadpoles

- Herb vegetation (including detritus) is important for tadpole forage.

  (Warkentin 1992, Jansen and Healey 2002, Schmutzer et al. 2008)

Studies on Livestock Grazing & Amphibians

(Studies Did not Specifically Assess Effects on Tadpole Forage)

No effects on tadpole survival were detected* where retention averaged:

- ~80% *(Bull & Hayes 2000)*
- ~50-60% *(Adams et al. 2009)*

32-41% lower survival of tadpoles in grazed wetlands

Tadpole diversity and abundance was significantly reduced where retention averaged:

- ~70-85% *(Schmutzer et al. 2008)*

  - Detritus was markedly higher in ungrazed wetlands than grazed wetlands (70-85% herb retention)
  - Tadpole diversity & abundance were sign. lower in grazed wetlands (70-85% herb retention) than in ungrazed wetlands.

*This does not mean there were no effect

Forage for Tadpoles

Percent Canopy Cover of Relatively-Intact Veg.

100% 80% 60% 40% 20% 0%

100%

75-88%

Large Proportion of Forage-Based Maintained

50-76%

25-65%

Moderate Proportion of Forage-Base Maintained

0-53%

0-41%

0-29%

0-18%

Large Reduction in Forage-Base

Retention

near-100%

90%

80%

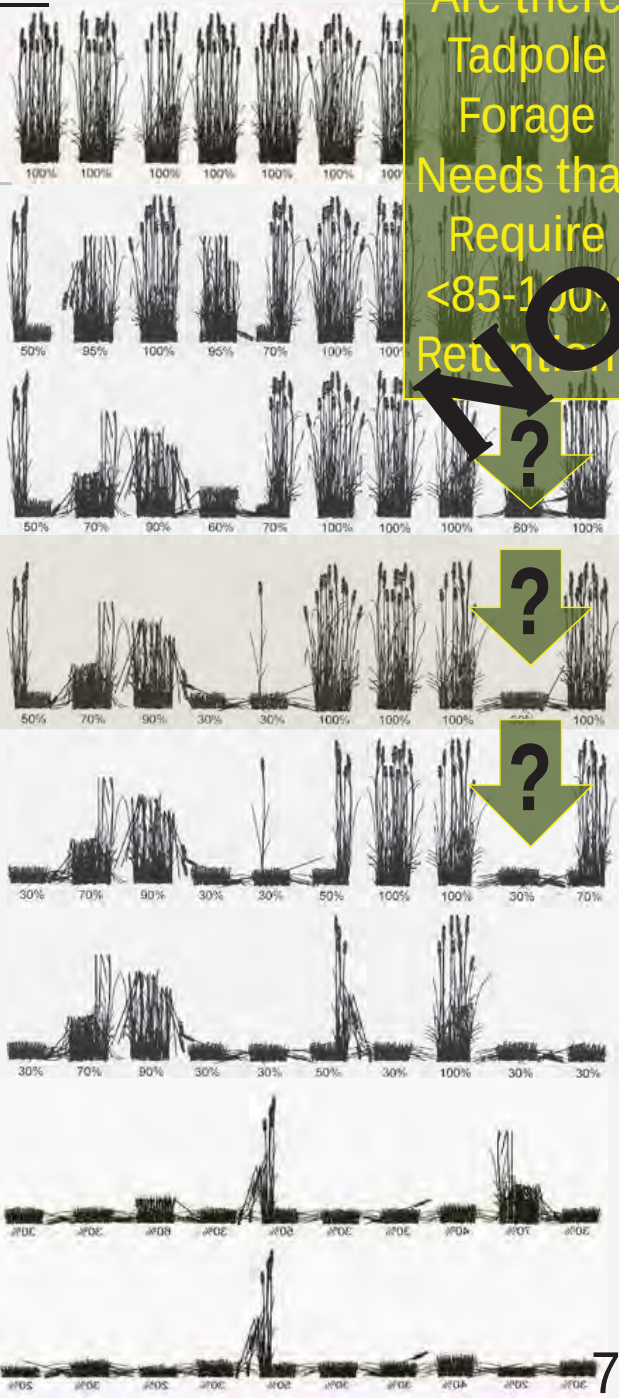
70%

60%

50%

40%

30%



Are there Tadpole Forage Needs that Require <85-100% Retention?

NO

A.5 — Insect Forage, Cover, & Substrate

- Spotted frogs are opportunistic predators, and variety appears to be an important aspect of their prey base. They feed on a large variety of insects, spiders, and worms.

  (several studies cited in: *Patla and Keinath 2005, Reaser and Pilliod 2005)*

- Wetlands, wet meadow, and moist terrestrial habitats are important for spotted frogs for feeding.

  (Patla and Keinath 2005, Reaser and Pilliod 2005, Bishop et al. 2014)

- Boreal toads feed on a wide variety of insects, spiders, and worms in terrestrial habitats.

  (Campbell 1970, Barrentine, 1991, Leonard et al. 1993, Luce et al. 1997, Keinath and McGee 2005, Muths 2005)

- At two study sites, boreal toads fed nearly exclusively on ants and beetles (but it is not clear how this affects survival and reproduction).

  (Bartelt 2000)

A.5 — Insect Forage, Cover, & Substrate (cont'd)

- There is little scientific info. demonstrating native insect-communities are enhanced by grazing levels above natural levels.

- The number of insect species and their abundance in tall, dense plant communities decline with reductions in height, density, and availability of needed plant parts.

  (Morris 1983, Welch et al. 1991, Morris 2000, Kruess and Tscharntke 2002, New 2004, Poyry et al. 2004, Ringwood et al. 2004, Foote and Rice Hornung 2005, Samways 2005, Janz et al. 2006, Baur et al. 2007, Black et al. 2007, Black et al. 2009, Yamamoto et al. 2007, Littlewood 2008, New 2009, Kimoto 2010, Black et al. 2011, Bennett and O'Grady 2012)

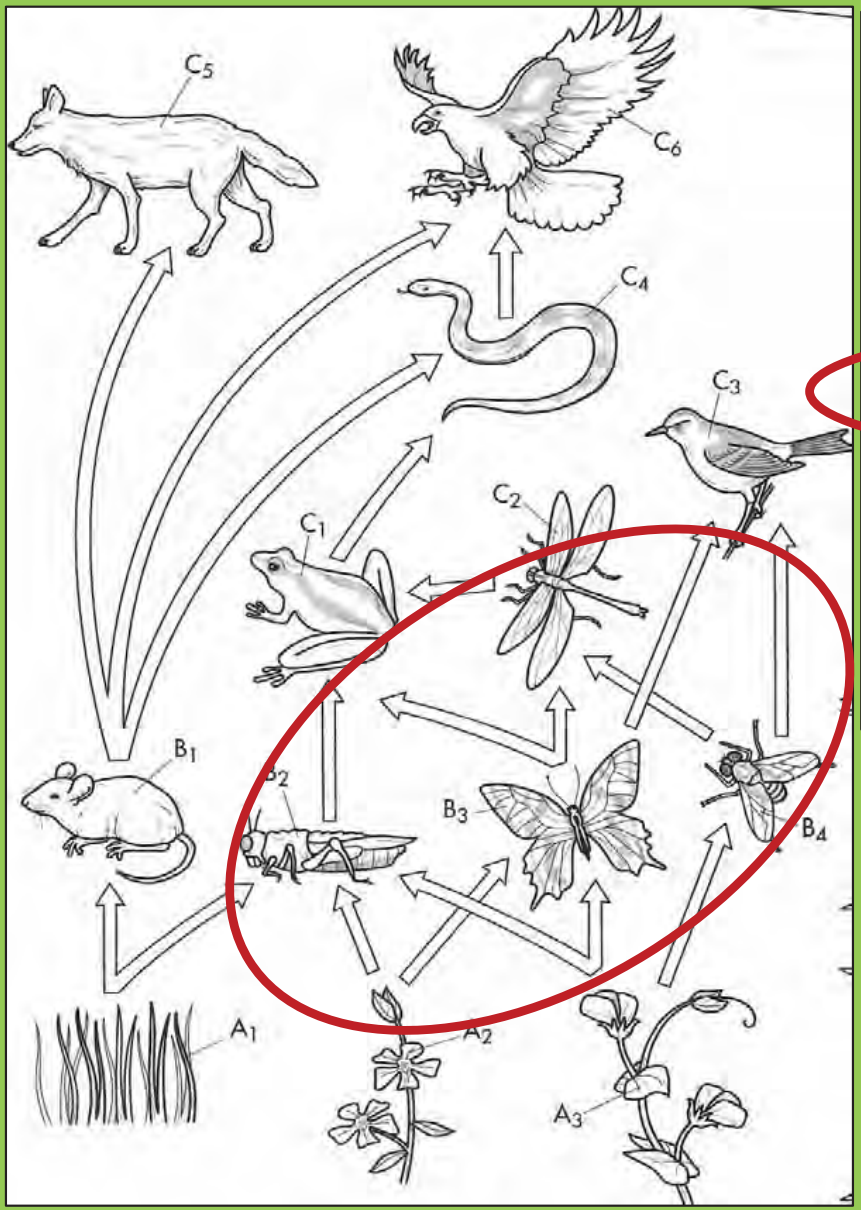
- For some taxa, rapid declines begin at / shortly after ~80% retention.

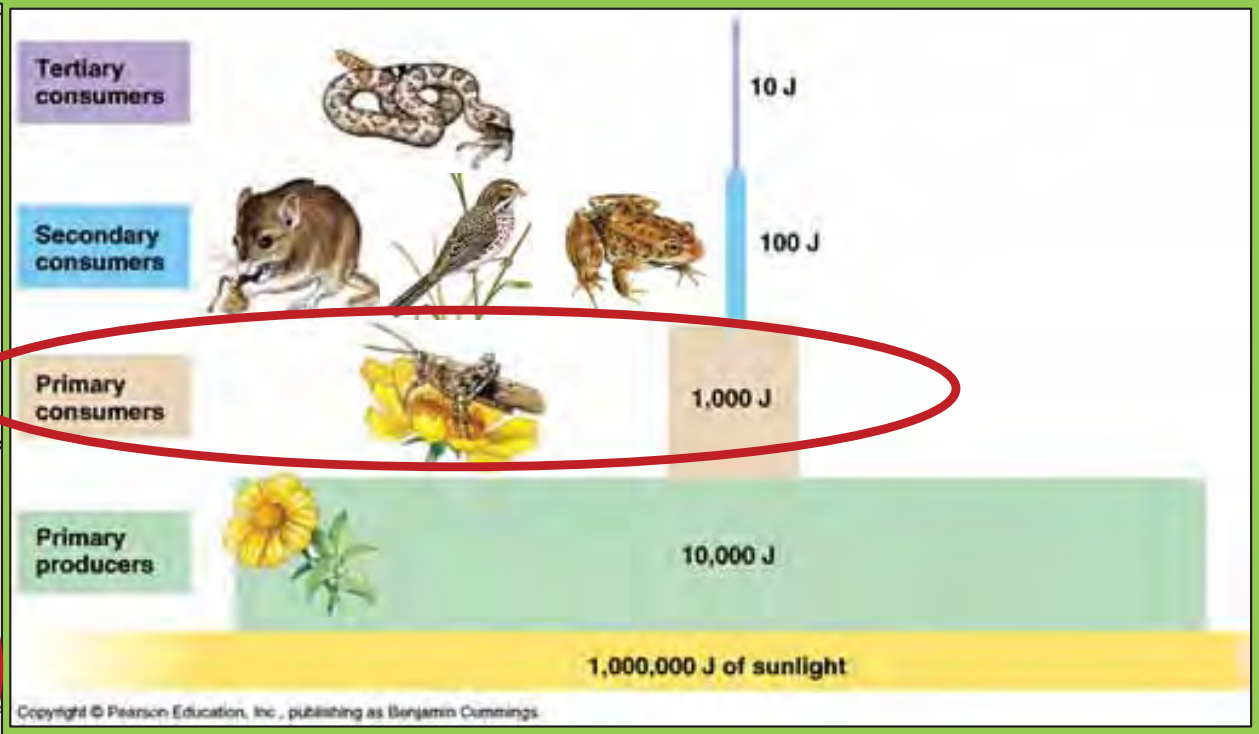
  (Hornung and Rice 2003, Foote and Rice Hornung 2005, Kimoto 2012)

- Light grazing can be neutral or beneficial to many insect species.

  (Samways 2005, Vulliamy et al. 2006, Littlewood 2008, Black et al. 2011)

A.5 — Insect Forage, Cover, & Substrate (cont'd)





Numerous species of amphibians, reptiles, mammals, and birds (and invertebrates) depend on insects for food, maintaining habitat, and for other ecosystem services.

- Insect diversity is **HUGE**!
- The best way to conserve all insectivores is to approximate a natural diversity of insects.

(All citations supporting 2012 Planning Rule's coarse-filter approach; and… *Wyo. Partners in Flight 2003, Samways 2005, Nat'l Research Council 2007*)

Native Insect-Diversity

Intensity of Grazing

None → Severe

Retention

near-100%

90%

80%

70%

60%

50%

40%

30%

No / Little Reduction in the Native Diversity of Insects

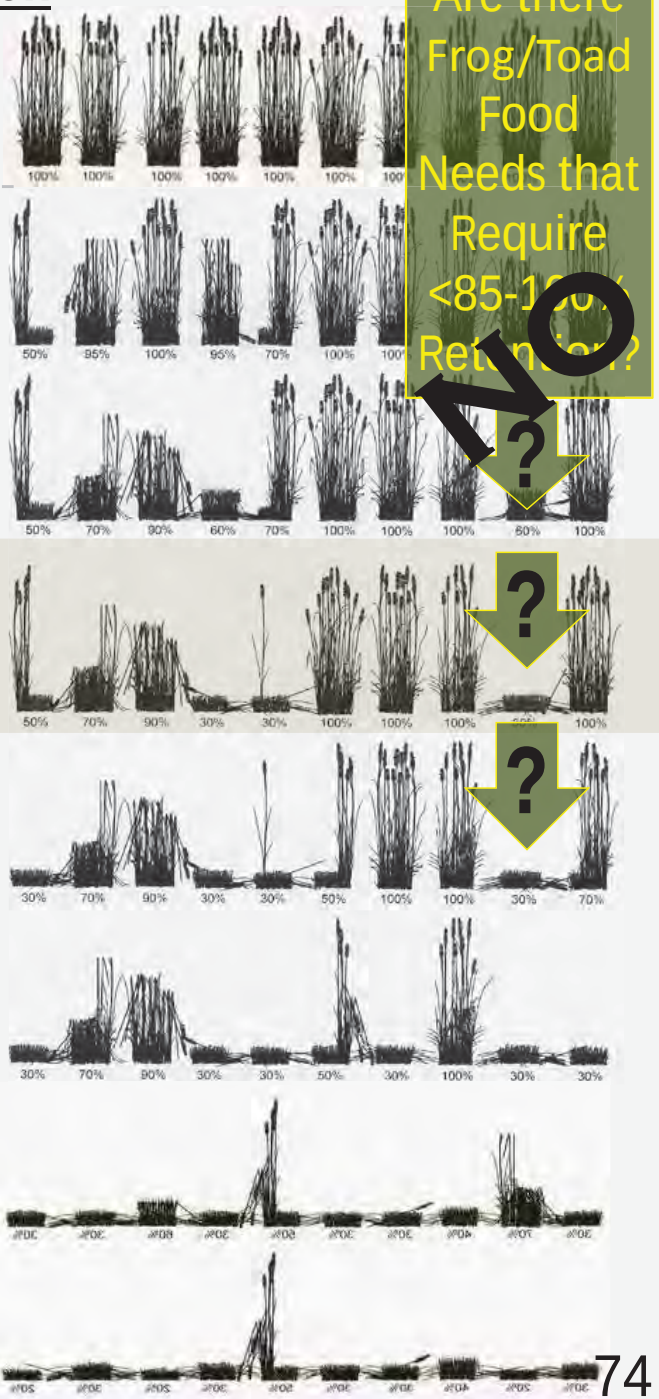
Declining Native Diversity of Insects

Mod. to Large Reductions

No Semblance of the Native Diversity of Insects

Are there Frog/Toad Food Needs that Require <85-100% Retention?

NO



Insect Diversity (SFs & BTs only)

Intensity of Grazing

None → Severe

Retention

near-100%

90%

80%

70%

60%

50%

40%

30%

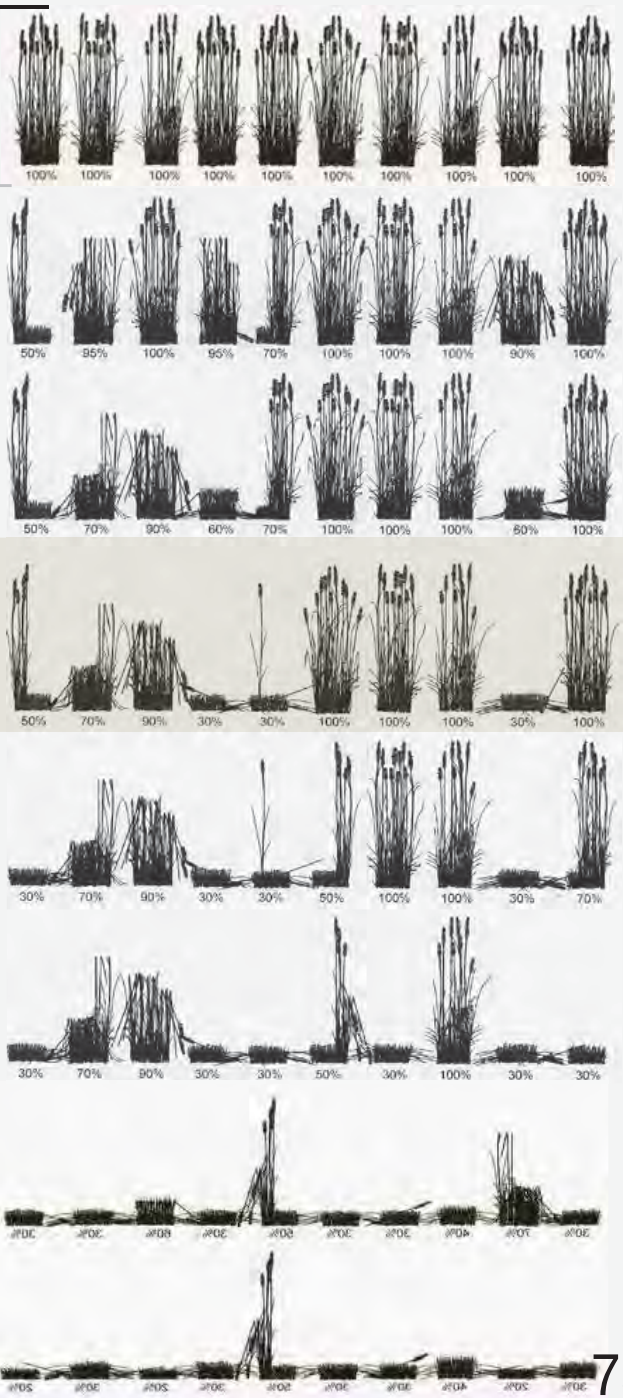
No Reduction in the Variety & Abundance of Insects

Possible Increases in Variety & Abundance

Abundance of Some Prey Species Likely Acceptable

Major Declines in Other Prey Species

Reductions in Abundance of Most Insect Species



A.6 — Open (Sunny) Patches

- Anecdotal observations indicate small open patches are important to spotted frogs & boreal toads in extensive stands of tall, dense veg.

  (Maxell 2000, Watson et al. 2003, Bull 2005, Shovlain et al. 2006)

- Spotted frogs did not select against light grazing in one study.

  (Shovlain et al. 2006)

- However, some studies involving tall, dense sedge cover did not detect avoidance of tall, dense vegetation.

  (Roche et al. 2012, McIlroy et al. 2013)

- Vegetation in most breeding wetlands on the BTNF is not overly dense.

Small Open Patches

Percent Canopy Cover of Relatively-Intact Veg.

100% 80% 60% 40% 20% 0%

100%

No Small Open Patches Provided – No Support

85-100%

Small Open Patches Provided

70-85%

50-65%

Beyond Small Open "Patches"

35-50%

20-35%

Well Beyond Small Open "Patches"

≤15%

≤5%

Retention

near-100%

90%

80%

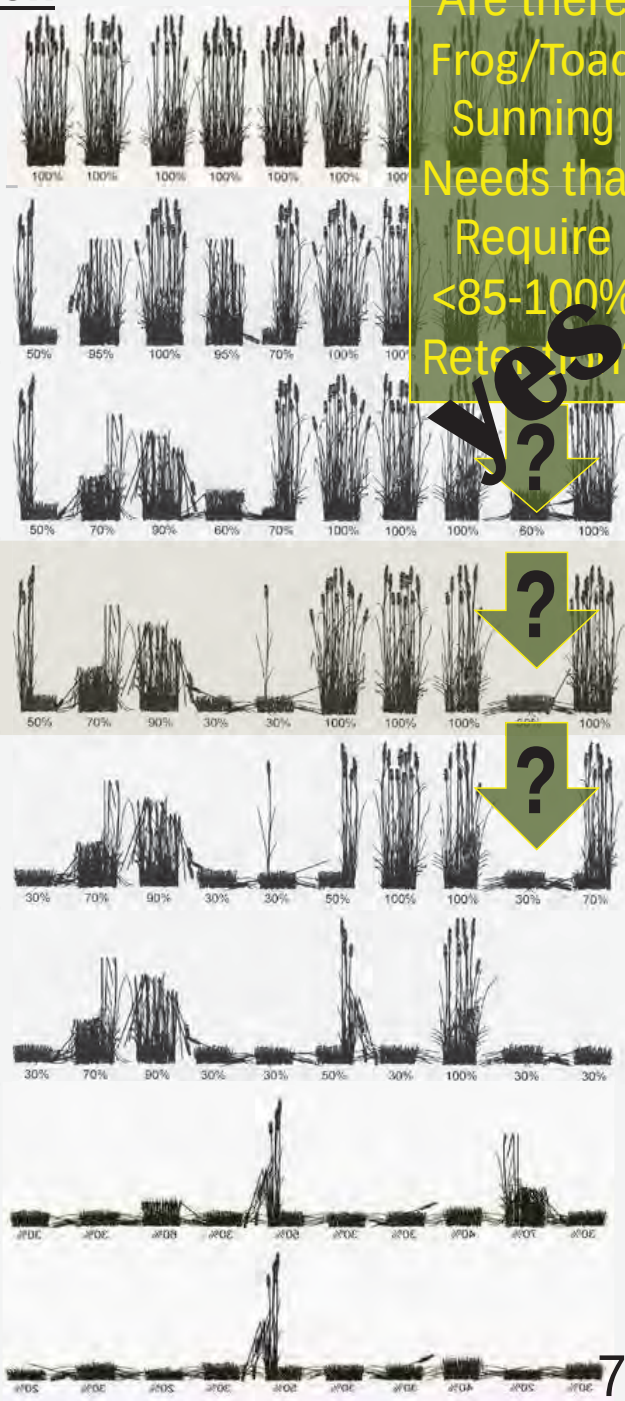
70%

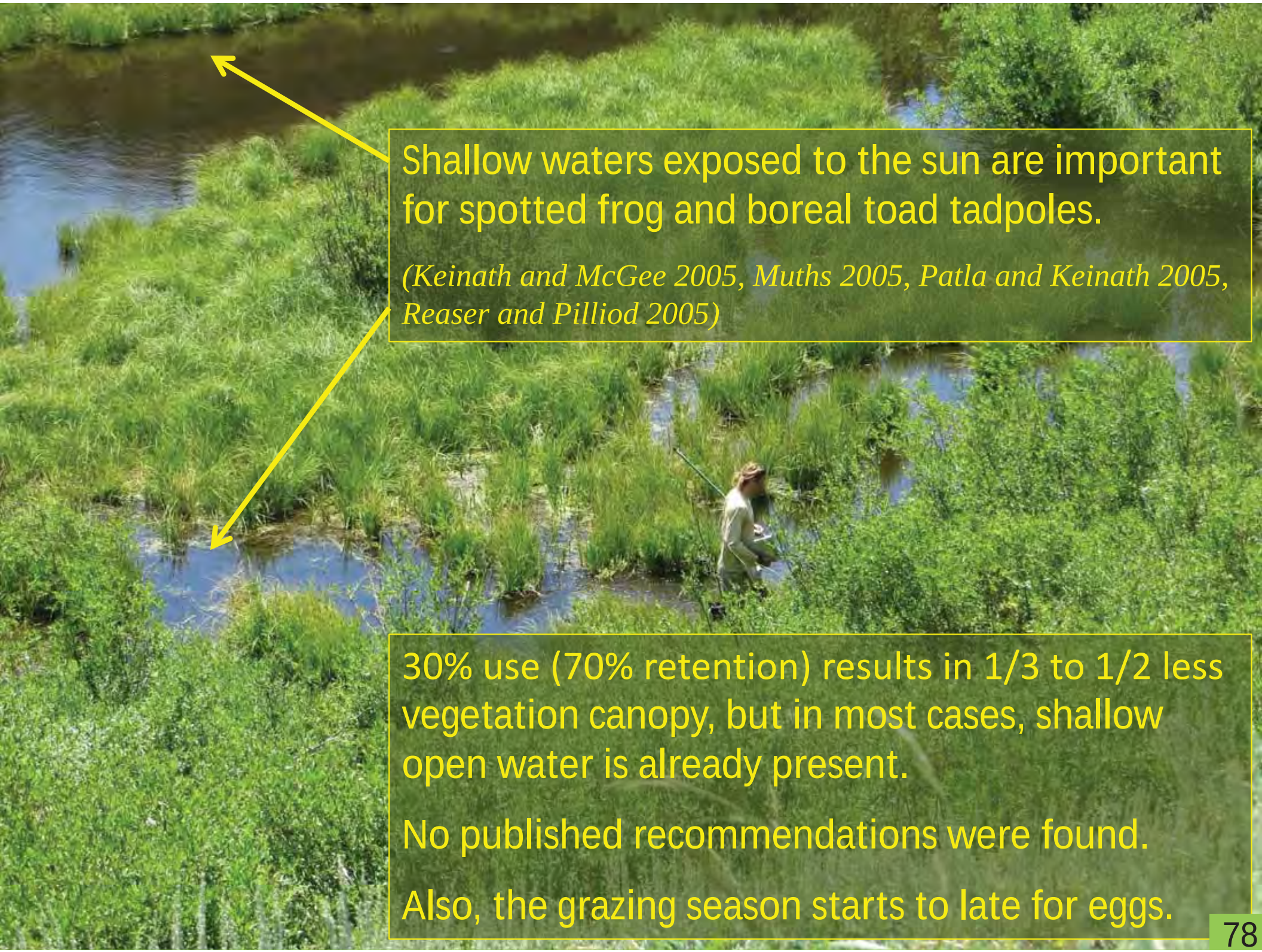
60%

50%

40%

30%





Shallow waters exposed to the sun are important for spotted frog and boreal toad tadpoles.

(Keinath and McGee 2005, Muths 2005, Patla and Keinath 2005, Reaser and Pilliod 2005)

30% use (70% retention) results in 1/3 to 1/2 less vegetation canopy, but in most cases, shallow open water is already present.

No published recommendations were found.

Also, the grazing season starts to late for eggs.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B.1 — Water Quality

- Reduced water quality can impact tadpole survival.

  (Marco et al. 1999, Maxell 2000, Jansen and Healey 2002, Knutzen et al. 2004, Hogrefe et al. 2005, Keinath and McGee 2005, Patla and Keinath 2005, Burgett et al. 2007, Schmutzer et al. 2008)

- Nitrate, nitrite, ammonium, phosphate, dissolved oxygen, and dissolved solids are particularly important. *(see above)*

- Livestock urine & feces increase nitrate, ammonium, and phosphate, and can contribute to lower dissolved oxygen levels.

  (Ball et al. 1979, Miller et al. 1992, Stout et al. 1997, Hubbard et al. 2004, Agouridis et al. 2005, Carpenter et al. 2005, Vidon et al. 2008)

- Livestock trampling in wetlands increases dissolved solids.

  (Jansen and Healey 2002, Schmutzer et al. 2008)

- Water quality declines as livestock use increases.

  (Moore et al. 1979, Mosley et al. 1999, Scrimgeor and Kendall 2002, Holechek et al. 2004)

Effects of Nitrate on Tadpoles:

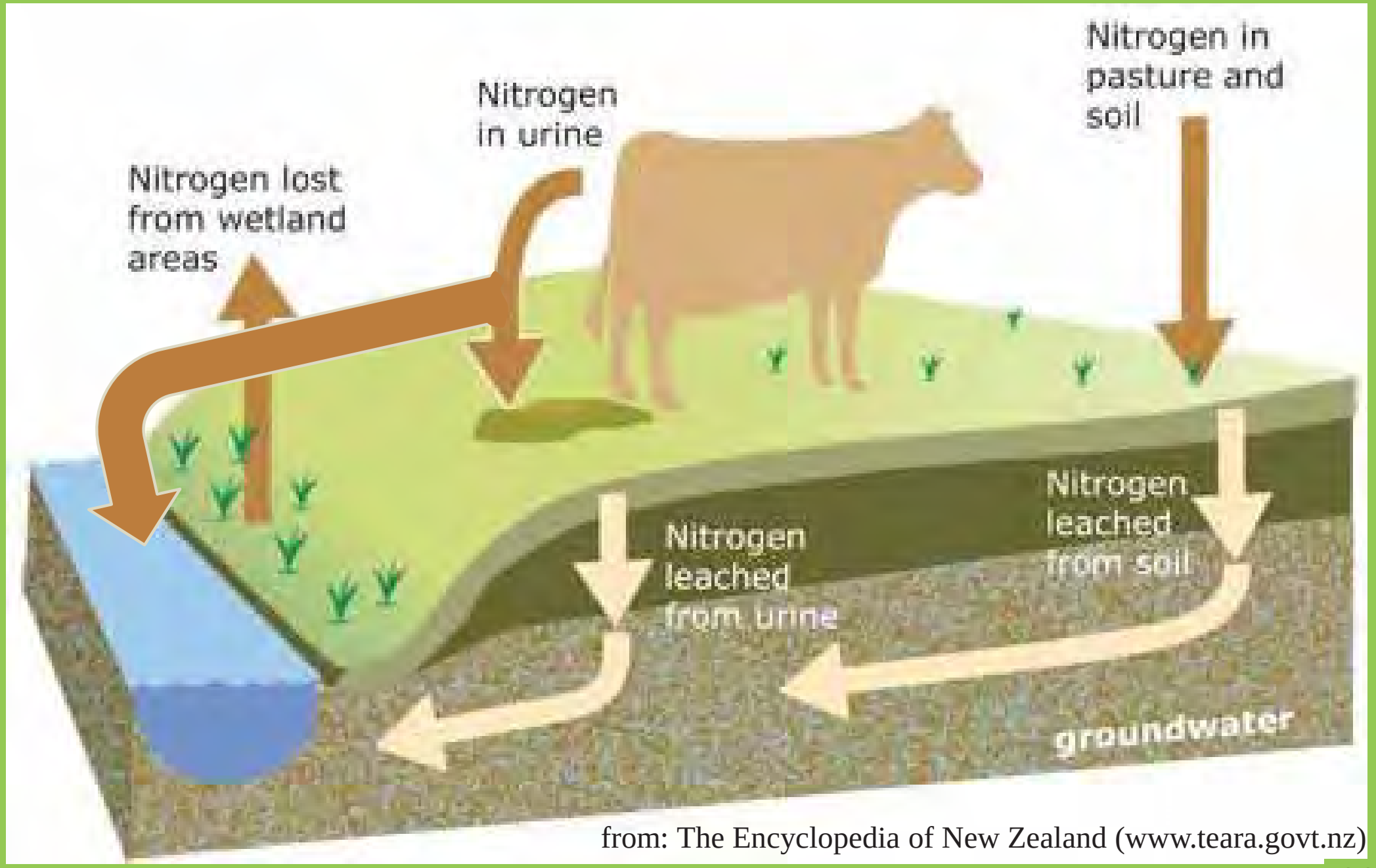
- Altered behavior of tadpoles begins 2.5 mg/L – 10 mg/L.
  (Hecnar et al. 1995, Marco et al. 1999)

- Increased mortality begins at approx. 5 mg/L, with substantial mortality at >10 mg/L (but thresholds may be higher for some toad populations).
  (Hecnar et al. 1995, Marco et al. 1999)

- Ungrazed nitrate levels can range from 1 to 7 mg/L or higher (especially in shallow waters and small pools).
  (Maret et al. 1987, Schmutzer et al. 2008)

- Does not take much of an increase caused by livestock to begin affecting tadpole survival, especially in shallow or small water bodies.

- Major die-offs can occur.



from: The Encyclopedia of New Zealand (www.teara.govt.nz)

Effects of Nitrite on Tadpoles:

- Increased mortality begins well below 1.75 mg/L for spotted frog tadpoles and below 3.5 mg/L nitrite for toads.

  (Marco et al. 1999, Marco and Blaustein 1999)

Tadpoles are also adversely impacted by:

- Elevated ammonium concentrations
- Eutrophication and reduced dissolved oxygen
- Increased turbidity

  (Ricklefs 1979, Mathews et al. 1994, Carpenter et al. 1998, Thomas 2002, Hornung and Rice 2003, Hubbard et al. 2004, Agourdis et al. 2005, Camargo et al. 2006, Adamus 2007, Vidon et al. 2008, Schmutzer et al. 2008)

- Major die-offs can occur.

Effects of Livestock Grazing on Water Quality & Tadpoles

Potential for Reduced Water Quality (– – – –)

High

Low

Level of Effect

Very Consistently No or Low Impacts (no livestock grazing)

Variable Effects

Variability Driven by:

- Water depth & volume
- Level of Veg. decomposition
- Temperature
- pH
- Geological history & soils
- Chemical make-up
- etc.

Hornung & Rice (2003)

Schmutzer et al. (2008

Roche et al. (20

Bull & Hayes (20

Foote & Rice Hornung (2005)

Adams et al. (2009)

High

Low

Degree of Variability in Effects from Wetland to Wetland (——)

100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%

Percent Retention of Herb Vegetation